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- Tudor Ships, Warfare and Medicine
- Autologous Fresh Whole Blood Transfusion Training a narrative review and report of U.S. Military Experience
- Casualties in Australian Military and Indigenous Para-Military Units in Papua New Guinea during the Second World War

The Journal of the Australasian Military Medicine Association





TAILORED MEDICAL AND HEALTH SERVICES FOR DEFENCE AT HOME AND ABROAD









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Journal of Military and Veterans' Health

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STATEMENT OF OBJECTIVES

The Australasian Military Medicine Association is an independent, professional scientific organisation of health professionals with the objectives of:

- Promoting the study of military medicine
- Bringing together those with an interest in military medicine
- Disseminating knowledge of military medicine
- Publishing and distributing a journal in military medicine
- Promoting research in military medicine

Membership of the Association is open to doctors, dentists, nurses, pharmacists, paramedics and anyone with a professional interest in any of the disciplines of military medicine. The Association is totally independent of the Australian Defence Force.

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Editorial

Inaugural Perth AMMA Conference

The first AMMA Conference in Perth will be held from 12-15 October 2023. Perth. and wider Western Australia (WA), has had long links to Australian military history and to past and contemporary military strategy. From the initial deployment of the Australian Imperial Force through Albany in 1914 to key submarine bases, special forces training and RAAF Catalina links to Asia and Europe during the Second World War, WA has played a significant role in Australia's military history. The submarine base at Fremantle, established in 1942, became a significant hub for the operations of Allied submarines patrolling the Indian and Pacific Oceans, disrupting enemy supply lines and conducting reconnaissance missions. The Catalina flying boats, based in Matilda Bay, Perth, played a critical maritime patrol, reconnaissance, and anti-submarine warfare role. The ongoing key Defence capabilities at HMAS Stirling, RAAF Base Pearce, and Campbell and Irwin Barracks have ensured that Perth remains an important part of Australia's defence.

The Australia, United Kingdom, and United States (AUKUS) agreement is a trilateral security partnership aimed at enhancing defence and security cooperation among these nations. The pact, announced in September 2021, involves Australia's acquisition of nuclear-powered submarines, with



Graham 'Doc" Searle PTE served with 3 RAR in 1971 and then transferred to RAAF in 1980 as MEDIC.

HMAS Stirling poised to play a crucial part in housing and supporting the new submarines. This development underscores the strategic importance of Perth in the regional security landscape and highlights its role as a hub for naval operations. The AUKUS pact and its implications for Perth's maritime significance have sparked discussions about defence priorities, regional dynamics, and Australia's place in the broader Indo-Pacific geopolitical context. As military health practitioners, understanding these developments and their likely impacts on Defence health services remains an important consideration.

Australia was involved in the Vietnam War between 1962 and 1973, with over 60,000 Australian army, navy and air force personnel serving during the period; 523 died during the war and almost 2,400 were wounded. Australia's participation in the war formally ended when the Governor-General issued a proclamation on 11 January 1973, with the last combat troops, a platoon guarding the Australian embassy in Saigon, withdrawing in June 1973. With the 50th anniversary of the ending of the Vietnam war for the Australian forces, the cover pages commemorate the service of these individuals and the sacrifices made.

Our third issue of 2023 contains a range of articles on diverse topics spanning infectious diseases, clinical medicine, clinical and operational training, and military health history. We continue to attract a good range of articles, including from overseas. Other military and veterans' health articles, however, are always very welcome, and we would encourage all our readers to consider writing on their areas of military or veterans' health interest. We would particularly welcome papers based on presentations planned for our 2023 conference in Perth, but welcome any articles across the broader spectrum of military health.

I look forward to seeing you in Perth.

Dr Andy Robertson, CSC, PSM Commodore, RAN Editor-in-Chief

- Cairns L. Secret Fleets: Fremantle's World War II Submarine Base. Western Australian Museum; 2011 Sep 1.
- 2. Cleworth R, Linton JS. RAAF Black Cats: The secret history of the covert Catalina mine-laying operations to cripple Japan's war machine. Allen & Unwin; 2019 Sep 3.
- 3. Vietnam War 1962–75 | Australian War Memorial (awm.gov.au)

Tudor Ships, Warfare and Medicine

N. Westphalen

Introduction

Previous articles describe the development from prehistory to the end of the Viking period, of a cycle whereby increasing trade necessitated larger and more efficient ships to transport merchandise and better weapons to defend or attack, both of which facilitated more trading opportunities.^{1,2,3,4,5} However, it was not until the 18th century that Western medicine had sufficiently developed for this cycle to be recognised, thereby making possible the European settlement of Australia.⁶

While the technical developments in ships, weapons and medicine often developed independently in multiple regions worldwide, they remained closely linked throughout Western history in particular. This article continues this series by updating a previous two-part paper regarding the developments in ships, warfare and medicine during the English Tudor period from 1485 to 1603.^{7.8}

Tudor ships

The previous article in this series describes how the post-Viking 'knorrs' (also 'knarrs') had evolved into 'cogs' and then 'carracks' by 1400. By 1500, these were three- or four-masted, with at least two square sails on the fore- and mainmasts, and fore-and-aft 'lateen' sails on the aft mast(s) to balance the sail plan and assist heading upwind. Their hulls were carvel-built, with a central rudder, integrated foreand-aft 'castles' and an 'orlop' deck below the 'main' or weather deck. Many could stow sufficient crew supplies and cargo to either make viable commercial voyages worldwide or transport large numbers of troops and their stores over shorter distances.

This allowed carracks to displace the smaller, faster and more manoeuvrable 'caravels' used by Portugal from 1415 to trade with West Africa, and then bypass the Venetian and Genoese dominance of the Mediterranean trade routes to India and China. To this end, Bartholomew Diaz reached the Cape of Good Hope in 1487,⁹ followed by Vasco da Gama reaching India in 1498.¹⁰ Meanwhile, in 1492, the Spanish monarchy gave Christopher Columbus three ships to find another route to China by sailing west (only to discover America),¹¹ while Ferdinand Magellan used five ships for his 1519–22 world circumnavigation.¹² Magellan was followed by explorers such as Alvaro de Mendana, who discovered the Solomon Islands in 1568 (followed by a failed colonisation in 1595), and Pedro Fernandes de Queiros in 1605–06, whose search for Terra Australis led to Luis Vaz de Torres passing Cape York in northern Australia.¹³

Hence by 1600, Portugal, Spain, England, Holland and France had ships that were technologically capable of voyaging anywhere worldwide in search of colonies, trade and/or plunder. These enabled the Spanish colonisation of central and south America, the Philippines and Portuguese colonies in modern Brazil, Africa, India and the East Indies. The following century saw Portugal lose most of the East Indies to the Dutch, and England and France take some of Spain's Caribbean colonies while establishing new colonies in northeast America. However, the developments in seagoing sanitation, victualling, water quality, ventilation, personal hygiene and conditions of service necessary to reliably keep the crews alive that made these events possible, lagged behind until after the 1740s.



Figure 1. Replica carrack c.1500, Vila do Conde, Portugal.¹⁴ Note the carvel-built hull, three masts each with yards for one or more sails, integral bow and stern castles, and no gunports.



Figure 2. Replica caravel Boa Esperança used by Bartholomew Diaz to round the Cape of Good Hope in 1488.¹⁵ Note the finer hull and fore-and-aft lateen sails.

The previous article describes how, besides their use for crew accommodation, the carracks' foreand-aft castles also provided a height advantage for their crews to defend against or conduct peacetime piracy, or for soldiers to fight from in wartime. Although sea battles were still mostly fought with blade- and torsion-type weapons, these were slowly being displaced by handheld firearms. At the same time, the weight of crew-served 'great guns' meant very few could be carried on their weather decks without compromising stability. Hence, like their cog predecessors, carracks were used interchangeably for warlike and peacetime purposes.

Henry VIII therefore initiated a naval revolution when he commissioned the Mary Rose in 1511. Following her capsize off Portsmouth in the Solent in 1545 and salvage in 1982, the surviving hull structure comprises a half-section from bow to stern, with the port side missing. The lowermost level was the hold, containing ballast, stores and a brick galley. Above the hold was the orlop deck, which contained more stores and equipment such as longbows and other hand weapons. The main deck above the orlop had gunports for at least seven 'great guns' per side, and four surviving cabins including one for a barber-surgeon. The weather or upper deck had more 'great guns', smaller anti-personnel guns and archers shooting behind protective blinds under anti-boarding netting.¹⁶

As the first ship with hull gunports, the *Mary Rose* carried more and larger 'great guns', thereby making grappling and boarding more difficult. This initiated the eventual elimination of soldiers as the ship's primary armament in favour of more sailors, which also facilitated better ship handling.¹⁷ As this also rendered height advantages moot, English carracks had evolved into 'race-built' galleons by

the 1570s, with lowered fore-and-aft castles on longer and narrower hulls enhancing their speed and manoeuvrability. Hence, although all ships still had to defend themselves, galleons begat the differentiation in Europe between bespoke warships and merchantmen.^{18,19}



Figure 3. Henry VIII's Mary Rose, c. 1520.²⁰ Note the bluff carrack hull with high (two-storey) fore-and-aft castle, four masts, the anti-boarding nets and (in particular) the hull gunports.



Figure 4. Henry VIII's Mary Rose post-salvage isometric diagram.²¹



Figure 5. Francis Drake's Golden Hind c.1577.²² Note the longer and narrower 'race-built' galleon hull, lowered (single-story) fore-and-aft castles, gunports... and her small size.

Tudor naval medicine

Physicians and surgeons

The previous article described how English medieval medicine gradually aligned with the Galenic model used by the rest of western Europe.^{23,24} Although the Royal College of Physicians of London was not established until 1518, the relationship between university-educated physicians and apprenticeship-trained apothecaries already entailed a select group of the former catering to the nobility who could afford them while supervising the latter selling their wares to the masses.²⁵ On the other hand, after a somewhat precarious existence since its founding in 1363, the Fellowship of Surgeons that was intended likewise to supervise barber-surgeons, was subsumed into the London Barber-Surgeons Company in 1540.²⁶

The ensuing split in the English medical profession led to numerous naval disasters over the next three centuries: the physicians' higher social status meant they rarely went to sea, while 'sea-surgeons' lacked the legal authority and expertise to manage the medical cases that comprised most of their clinical workload.²⁷ The fact that surgeons began their careers as apprentices also led to confusion regarding their roles. Despite having been separated within the same company since 1376, barbers could still perform 'procedures' such as trimming corns, while sea-surgeons had to obtain barber's tools and learn how to use them.²⁸

Even so, further shipboard technical improvements led to incidental health benefits. Better bilge pumps had already enabled drier and hence healthier ships, while in 1578, Sir William Wynter advocated large stone ballast rather than gravel to help keep ships' holds clean (although the French continued to bury their dead in their ships' ballast until the 18th century).^{29,30} The French introduced hammocks for bedding in the 1550s, with Sir Walter Raleigh driving their use in English ships from $1597.^{31}$ In 1590, Sir John Hawkins followed Wynter's suggestion to move his ship's galley from the hold to the upper deck, thereby reducing food contamination from bilge water.32 However, sanitary arrangements comprised 'necessary seats' over the ship's bow, while tubs were used below deck-albeit not always by passengers or troops—as combined urinals and fire buckets.33

This combination of technological advances and a split medical profession meant seagoing living conditions were controlled by ship's captains, whose authority and practical experience meant they were often met with some success. From there, it was only a small step for them to take over all non-surgical health issues, leaving the surgeons with only the actual hands-on application of their skills. In 1519, surgeon Thomas Roos wrote that these included controlling haemorrhage, trephining, couching for cataract, removing sequestra, suturing wounds, lancing abscesses, reducing fractures and dislocations, dental extractions and bloodletting.³⁴

Some of these skills were acquired via the four executed criminals received annually by the London Barber-Surgeons for dissection purposes from 1540. However, most surgeons' medical education came from books by authors such as Thomas Vicary (c1490-1561) and Thomas Gale (1507-1587).35 The true father of English naval medicine, however, is William Clowes (1544-1604), who wrote A Prooved Practise for all Young Chirugeons in 1588, which he updated in 1596 into A profitable and Necessarie Booke of Observations for all Those that are Burned with the Flame of Gun Powder, and also for Curing of Wounds made with Musket and Caliver shot, etc. Having qualified at age 19, Clowes served at sea for several years. In 1570, he treated a boatswain with two fractured ribs aboard the 200-ton Aid (half the size of a modern Cape-class patrol boat) by removing a bone sliver abrading the pleura. He also recognised the primary and secondary stages of syphilis as the only time it could be treated using an external application of mercury, and even associated scurvy with the seamen's diet. For below-knee amputations, Clowes used an operating table on which an assistant sat astride the patient holding both arms down, another astride to secure the thigh and a third to hold the distal limb. He used a tourniquet for both haemorrhage control and analgesia; as it was released, he found and stopped each bleeder, a technique that, with adding four cross sutures to cover the stump, was used at sea for the next three centuries.36

The Mary Rose medicine chest

Clowes also advised his students on what a medicine chest should contain, using his own as a model. This was probably similar to one retrieved from the *Mary Rose* in 1980, which was made of walnut with dovetailed corner joints, with a solid bar pierced for rope handles at each end. Measuring 1330 x 485×460 mm, it has no internal partitions apart from a shallow lidded shelf on one side. The 64 objects within included eight wooden containers of ointments and another containing peppercorns. One had a resinous substance that may have been frankincense, complete with scoop marks from the surgeon's fingers. The chest also had five ceramic jars that may have contained linseed oil, resins, henbane, quince or belladonna. Other contents included a pewter bleeding bowl, a small brazier for warming a chafing dish, a mortar for grinding drugs and several sausage-like rolls of unguents, made with a 2:1 ratio of Fuller's earth and frankincense that may have been used as plasters.

The chest also had a brass and a pewter syringe, with small rounded nipples at their needle tips. Ambrose Paré (1510-90) referred to using small urethral syringes for bladder stones and gonorrhoeal strictures and 'glisters' or large syringes for the 'flux' (diarrhoea) and constipation. It had also had surgical instruments: although their blades had corroded away, eight handles were found similar to 17th-century cauteries, with a larger handle that may have been part of a large knife or amputation saw. Consistent with the surgeon also being the ship's barber, there were eight cut-throat razors, a brass shaving bowl and a whetstone. Apart from the chest, his cabin had additional wooden and glass containers, a low wooden bench that may have been used for applying plasters, and personal possessions, including pewter plates, wooden bowls, shoes and a purse of silver coins. A highlight was his coif, a hat made of fine silk velvet. Even so, the fact that he had two combs (within and without the chest), indicates even he was not immune from acquiring his own tonsorial livestock.37



Figure 6: Mary Rose barber-surgeon's chest and a selection of contents.³⁸



Figure 7. Mary Rose barber-surgeon's coif, made of black velvet.³⁹



Figure 8. Painting by Hans Holbein the Younger (1497–1543), commemorating Henry VIII's 1540 Royal Charter to the London Barber-Surgeon's Company.⁴⁰ Note the barber-surgeon's headwear.

Hospitals

The previous article noted that, notwithstanding the secularisation of medical practitioners from the 13th century, accommodation for the English sick and disabled was provided by up to 800 monasteries through their 'houses of pity' and bespoke sailors' 'masyndews'.41,42 However, the Wars of the Roses (1455-1485) led to a period of economic disruption that rendered many smaller monasteries financially non-viable, which was followed by their dissolution by Henry VIII in 1536. As this forced the closure of nearly all 'houses of pity', including the masyndews, parishes began funding secular hospitals from the 1550s, supplemented by the privy purse, levies (such as those on ships entering Bristol for the local mariner's hospital) and lay benefactors such as Sir John Hawkins, who provided a ten-bed mariner's hospital at Chatham in 1594. However, it was only from 1597, when benefactors like Hawkins could

make such donations without royal approval, that these hospitals provided even the limited medical care previously offered by the monasteries.^{43,44}

Meanwhile, permanently disabled mariners depended on begging licences, or competed with other sick and poor for whatever charitable accommodation remained. This was until the medical aftermath of the 1588 Armada campaign led Lord Howard, Sir Francis Drake and Hawkins to organise the Chatham Chest in 1590. This was an independent mutual benevolent fund to which every seaman in the royal ships contributed sixpence a month, usually in exchange for a one-off payout rather than a pension. Despite multiple embezzlement scandals, the Chest endured until its merger with the Greenwich Hospital naval pensioner scheme (introduced in 1691) in 1814.⁴⁵



Figure 9. The original Chatham Chest, built c.1625.⁴⁶ Note the false central lock (the actual lock is in the lid) and four padlock hasps, the keys to which were putatively held by different people.

Hence, the Tudor wars were fought with minimal medical care for anyone, let alone sailors. Human remains from 179 individuals from the Mary Rose (including 92 fairly complete skeletons) indicate they were primarily aged in their late teens and early twenties with an average height of about 171 cm. Many adult teeth had enamel hypoplasia indicating previous malnutrition, consistent with a famine during the winter of 1527-28. Other findings included rickets, scurvy, anaemia, non-reduced fractures, avulsion injuries and osteoarthritis. Given the restrictions on removing clothing at sea, the 81 combs suggest less-than-ideal hygiene standardsall except two were made of boxwood, double-sided and fine-toothed, indicating their use for delousing.47 Even so, direct evidence of infectious disease was limited to tuberculosis.48

A separate finding was a 12.5% incidence of mostly left-sided os acromiale (non-union of the acromial epiphysis), compared to a modern incidence of only 3–6%. One possible reason relates to Henry VIII enforcing a 14th-century law that all fit males from 7 to 60 practice using the longbow. Tests of 172 bows from the *Mary Rose* indicate that they had draw forces of 50 to 75kg, compared to 20kg for modern bows. As longbows are also drawn differently (for a right-hander: *extending* the *left* arm and shoulder rather than *flexing* the *right*), the technique may have been responsible in addition to the forces involved.⁴⁹



Figure 10. Right scapula with a normal acromion (left), and one from a Mary Rose crewman with os acromiale (right)⁵⁰



Figure 11. Re-enactor Mary Rose archer with a replica longbow.⁵¹ Note the strain on both shoulders (especially on the left used to draw the bow rather than the right).

Tudor naval warfare

Before the Armada

The first known disease outbreak to influence an English naval campaign occurred in 1544, when a French fleet was defeated, not by Henry VIII's ships but by food poisoning. Besides losing the Mary Rose the following year, another 11 of his ships sustained a 'bloody flux' (diarrhoea) that killed a quarter of his 12 000 men in 10 days.52 In 1553, Sir Hugh Willoughby took three ships and 63 men in search of a route to China via northern Russia, with only one making it to Archangel. Having been frozen in off Lapland, the other ships were found the following spring with no survivors from starvation, scurvy, exposure and possible carbon monoxide poisoning.53 The same year, Thomas Wyndham's expedition to Benin in West Africa lost 100 men out of 140 to yellow fever.54,55

The Anglo-Spanish war from 1585 followed 20 years of English interference with Spain's colonial trade, not only for plunder but also to deny funding for its wars against the Netherlands.56 As her own fleet lacked the numbers, Elizabeth I's maritime power was based on privateers, beginning in 1562 when John Hawkins carried manufactured goods to West Africa, slaves to America (the infamous 'middle passage') and agricultural products back to England. This 'triangular trade' contributed significantly to English prosperity (and the naval power that defended it) over the next 250 years. Even so, although Hawkins' first voyage was disease-free and only 20 crew were lost on the next in 1564, his third in 1568 ended in disaster when he and his kinsman, Francis Drake, were ambushed in the West Indies.⁵⁷ This led Drake to carry surgeons on his later voyages, who proved their worth when he was wounded in 1572 while raiding the Caribbean.58

In December 1577, Drake left England with 164 men in five ships to raid the Pacific. Having passed through the Straits of Magellan, his ship *Golden Hind* was alone and her master surgeon had died, while his mate was no more than 'a boy, whose goodwill was more than any skill he had'. Hence, Drake himself had to treat nine wounded men despite having been grazed under the eye by an arrow. By obtaining fresh supplies while looting Spanish America, Drake kept 85 men fit until he reached California in April 1579. On abandoning a search for a Northeast Passage back to England, he returned home via the Moluccas in September 1580 with 59 survivors.^{59,60}

The first English expedition to the East Indies and China via the Cape of Good Hope left in 1582, but returned the following year, having failed to leave the Atlantic. Its surgeons included the future lecturer, anatomist and (highly unusually) physician John Banester (1540-1610), who lost 45 of 135 men, of whom only three were surgical cases.⁶¹ In 1585, Elizabeth lent six ships to Drake to raid the West Indies with 2400 men. He lost 300 from malaria raiding the Cape Verde Islands and another 500 by taking the mosquitoes with him to Dominica, the epidemic only ending in the colder latitudes on the way home.^{62,63} On the other hand, Thomas Cavendish left for the Pacific the same year with three ships and 123 men. He lost only one man in action (shot by an arrow, of which only the shaft was removed as he refused to have the head removed), two from scurvy and one from possible dengue, before his two surviving ships arrived home in September 1588.^{64,65}

The Armada campaign

The Armada campaign began when Drake attacked the Armada's base at Cadiz in 1587, thereby delaying its sailing that year.⁶⁶ Elizabeth's reliance on privateers meant that 83% of her 197 Armada ships were either privately owned warships or armed merchantmen.67 Most were 'race-built', with half of their 16 000 men being both seamen and gunners, thereby enabling new tactics based on long-range gunfire rather than boarding.68 By comparison, the Armada had 130 ships, including 25 purposebuilt warships of the 'high-charged' type to facilitate boarding. They carried 30 000 men, organised similarly to land fortresses with bespoke soldiers, gunners and sailors. As the latter only comprised 8000 men, these ships were overcrowded yet had too few seamen to be handled effectively.69

The Armada crisis overtook an England enfeebled by years of poverty and malnutrition. No processes existed for recording or disseminating the preventive health lessons learned from the 1544-45 or 1558 campaigns, while the Divine Right of the sovereign meant any attempt to apply instructions not directly emanating from the Crown was considered treasonous.⁷⁰ Embarked landsmen failed to comply with the basic hygiene standards now accepted by experienced seamen, none were allowed to undress on board and no clothing was supplied, allowing lice and fleas (hence typhus) on board.⁷¹ Even so, it was the victualling that created an English medical catastrophe even before the Armada left Spain, with dysentery and toxic food poisoning taking their toll after as little as a fortnight at sea. For example, the Elizabeth Jonas lost 200 out of 500 men in three weeks in Plymouth; on sending the survivors ashore and replacing her ballast, she lost even more during the Armada pursuit. Although the Privy Council asked

the College of Physicians to send four physicians to the fleet, they achieved little, and, rather than the victuals, they ascribed the outbreak to the beer (drunk instead of water as it kept better).⁷²

Although it was ready to depart Lisbon on 25 April, the Armada did not get to sea until 30 May, whereupon bad weather and an inability to beat upwind meant it did not enter the English Channel until 19 July. This delay combined with poor food preservation meant their victuals likewise decomposed, but without resupply. Water was limited to three pints per man per day, even before many casks were found empty or leaking. The soldiers were kept below in overcrowded typhus-spreading conditions, while the rough weather led to their vomit and excreta washing over their rotting food and tainted water into the bilges. The resulting effluvia was only pumped out as far as the upper decks, where it either found its way overboard or recycled itself back below.⁷³

The following week saw a series of running battles up the Channel, during which the English long-range gunnery tactics initially proved indecisive, apart from preventing the Spanish from either boarding their ships or landing troops ashore. Only after the Armada's cohesion was disrupted by a fireship attack on 28 July off Calais, did they find shortrange gunfire more effective. On running out of ammunition, the English left the Armada to its fate on 13 August off the Firth of Forth, having lost no ships and less than 100 men in action.⁷⁴ However, as they dispersed to the east coast ports, their administrative system broke down completely, while their own typhus epidemic revealed the limitations of the Laws of Oléron in finding enough accommodation for large casualty numbers since the demise of the 'houses of pity' and masyndews.75

Meanwhile, the Spanish had 3000 typhus cases in addition to their wounded. Even in the bestprovisioned ships, three or four men were dying daily from starvation and thirst. Many ships disintegrated in the north Atlantic autumn without survivors, and at least 26 were wrecked on the Irish and Scottish coasts. In total, up to half of the Spanish ships never returned, and about 20 000 men died, comprising 1500 killed in action, 6000 shipwrecked or lost at sea, 1000 murdered after shipwreck and the remainder by starvation and disease.⁷⁶



Figure 12. Battle of Gravelines, 29 July 1588.⁷⁷ Although alliterative, this depiction shows the battle being fought in multiple melee-type actions.

After the Armada

In 1589, Drake led a 'counter-Armada' to attack Spain via Lisbon with 140 ships and 13 500 men. After another victualling debacle resulted in its abandonment, he cruised between the Azores and Vigo before returning to Plymouth with little accomplished, having lost half his men from disease. The £253 allocated for medical supplies had proved inadequate, as was the surgeons' experience and expertise.^{78,79}

In 1591, James Lancaster left for the East Indies in three ships and 200 men, returning in 1594 via the West Indies with no ships and only 25 survivors. His next voyage in 1594–95, with 275 men in three ships, was more successful, capturing 29 ships and holding Recife (in modern Brazil) for a month.^{80,81} Both voyages well-prepared Lancaster for his next voyage in 1601, the first by the new English East India Company.

Meanwhile, in 1591, the Spanish caught an English fleet under Lord Howard off the Azores with half his men sick after yet another victualling failure. Having off Sir Richard Grenville's *Revenge*, she held off the Spanish for 15 hours despite having 90 of her 190 men ill in her hold, killing 400 to 1000 men in exchange for 40 killed and most of the rest wounded before exhausting her ammunition. On surrendering, *Revenge*'s hold flooded, drowning her sick, and she sank in a storm with all her survivors and prize crew.^{82,83}

Cavendish's second voyage to the Pacific in 1591 with five ships and 76 men was less lucky than his first, with scurvy killing him and 48 men before they reached the Straits of Magellan. Having recovered by eating 'scurvy-grass' and penguins, another 11 died on the way home (possibly from 'wet' beriberi), and, with only five men fit to work the last remaining ship, she was run ashore on arrival. $^{\rm 84,85}$

In 1593, John Hawkins' son, Richard, sailed for the Pacific with three ships. Scurvy developed near the equator, and despite having seen '10 000 men with this disease' and recognising the value of fruit juice as a cure, he failed to link the two amid a plethora of other theories, such as the sea air, having a dirty ship and lack of exercise. By the time he reached Brazil, rats had eaten 80% of his victuals and he only had 24 fit men. Nevertheless, his crew recovered with oranges and lemons and remained well until they met two Spanish ships off Chile, where they surrendered after a two-day battle. Despite missing most of their instruments, English surgeons lost none of their own 40 wounded and even treated the Spanish casualties after their surgeons proved incompetent.86 This was probably the first time naval surgeons made a positive difference in battle casualty care. 87

Like scurvy and fresh food, the link between dysentery and water quality was missed for centuries. This was evident when Drake and John Hawkins left Plymouth for the West Indies with 21 ships and 2500 men in August 1595. The medical preparations appear to have been very good, with surgeon James Wood, several assistants and medical chests, slop (spare) clothing and advice from Hugh Platt (1552-1608) regarding water and other stores. Years later, Platt wrote Certaine Philisophical preparations of Foode and Beuerage for Sea-men, in Their Long Voyages, which anticipated the development of tinned food 200 years later, and suggested macaroni as a cheap, fresh and lasting staple for use at sea.⁸⁸ However, John Hawkins died off Puerto Rico om 12 November, followed by Wood and then Drake on 28 January 1596. By 6 February, another 500 men had joined them, and the survivors sailed home after scuttling some ships to man the rest.⁸⁹ While another 1595 expedition to raid the Canary Islands and capture Puerto Rico was likewise forced back home by 'a bloody flux and other distempers', a second attack on Cadiz the following year was moderately successful, with no illness and only a few wounded $.^{90,91,92}$

Elizabeth's 1600 Royal Charter to the East India Company begat the corporatisation of England's transoceanic trade. Its first expedition, led by Lancaster, comprised 480 men in five well-found ships, each with a barber and two surgeons, the latter receiving allowances of between £20 and £32 for their chests. Even so, his success in establishing 'factories' in Sumatra and Java cost over half his men dead from disease by the time he arrived home in mid-1603. Yet, despite over 100 scurvy deaths across his ships, he kept his own relatively scurvyfree by issuing his men three teaspoons of lemon juice daily. Hence, although this success was again lost (as was his linking dysentery with water quality), Lancaster is credited as the first seaman to use lemons to prevent scurvy.⁹³

As the Company fought the Portuguese and Dutch for the East Indian markets, it became policy for its ships to carry a surgeon and a mate, whose provision by the London Barber-Surgeons soon became just as important a role as doing likewise for the navy and army. In requiring its surgeons to write journals to develop a scale of medical equipment for use at sea, it was the 'John Company' rather than the navy that soon became England's central repository for nautical medical knowledge.⁹⁴

Conclusion

The disruption of the English social order and the demise of the religious orders destroyed many of the rudimentary health institutions that existed at the end of the Middle Ages. Ironically, the demand for them increased as English sailors ventured overseas.

Tudor overseas trade was fraught with health risks, both at sea and ashore. The seeds for destruction from scurvy, typhus and dysentery were often sown even before the ships left England, resulting from poor victualling and worse hygiene practices. Even if these had been better, little could probably be done regarding diseases that wreaked so much havoc, such as yellow fever and malaria, given the inability to differentiate, let alone diagnose them. There was also a lack of natural immunity to illnesses imported from overseas, although indigenous peoples exposed to diseases exported from Europe did even worse.

Furthermore, sea-surgeons existed only to treat wounds rather than illness and were further hamstrung by legal constraints on their training, which actively prohibited their acquiring any expertise in internal medicine. Even if this had been otherwise, the level of therapeutic support was often limited to hiding rather than treating the cause. In any case, the physicians' reliance on humoral medicine further militated against their effectiveness. As a result, it is hardly surprising that mortality rates sometimes reached almost universal proportions. Although connections had been made between diet and scurvy, water quality and dysentery, and mosquitoes and malaria, these were lost not once but several times over the next 200 years, caused by a lack of peer support and a naval medical administrative system to record and promulgate them.

The story of Tudor naval medicine is therefore one of multiple disasters among occasional successes, the latter including Cavendish's 1585–88 circumnavigation and Richard Hawkins' post-action casualty care in 1593. Since the period essentially defined the medical problems associated with going to sea, it would be up to their successors (seaman and medical) to develop the solutions.

Disclaimer

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Autologous Fresh Whole Blood Transfusion Training - a Narrative Review and Report of U.S. Military Experience

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Introduction

Haemorrhage remains a leading cause of preventable deaths in conventional land warfare and, more recently, counterterrorism operations. From the Vietnam and Korean Wars to the contemporary battlefield in Iraq and Afghanistan with the Global War on Terrorism, haemorrhage accounts for 50–87% of potentially survivable casualties.^{1, 2} The implementation and ongoing development of Tactical Combat Casualty Care (TCCC), among other improvements in casualty care as part of a continuum of damage control resuscitation, has been shown to reduce preventable combat deaths significantly.³

The goals of damage control resuscitation in severely injured trauma patients are directed towards restoring intravascular volume and preventing or reversing acidosis, hypothermia and coagulopathy. This is understood to be a result of the combination haemorrhage and austere environments of associated with the battlefield and casualty evacuation. This is not limited to the tyranny of distance, logistics and communications constraints and enemy threat. Blood transfusion is an essential pillar of damage control resuscitation. Intravascular volume replacement with component blood products in casualties requiring massive transfusions is targeted in a 1:1:1 ratio of packed red blood cells (pRBC), plasma and platelets, with the addition of cryoprecipitate or fibrinogen concentrate to augment the fibrinogen content of plasma.⁴ Although this ratio attempts to replicate whole blood (WB), a massive transfusion of components cannot precisely replicate the physiologic ratios of WB with dilutions in haematocrit, platelet count and fibrinogen.⁵

While component blood products are preferred in civilian settings to maintain the sustainability of blood services and limit transfusion to identified needs when prompt laboratory services are available, WB transfusion has a long history in military medicine. WB has become the preferred product for resuscitation in severe traumatic haemorrhage in certain military contexts, especially in prehospital environments and early damage control resuscitation⁶ when diagnostic tests are unavailable or when waiting for results is inappropriate. Fresh whole blood (FWB) refers to the collection of WB on an emergency basis from a 'walking blood bank' (WBB). Resuscitation with FWB has been born of necessity to treat severe combat injuries and in potential mass casualty situations. In addition to overcoming the logistical constraints of blood component storage in forward environments, FWB reduces the reliance on diagnostic testing, delivering rapid lifesaving treatment without the reliance on sophisticated technology or personnel required for its operation. The Joint Trauma System Clinical Practice Guideline (JTS CPG) further discusses the use of autologous transfusion training sessions to build competency with a mechanism addressed in several journal articles and blogs.7-10

Autologous FWB transfusions are increasingly used in the training of many military units to prepare for effective WBB activation in combat operations, as well as other operations in which traumatic injuries are likely.^{8, 11} This narrative review summarises the published literature describing the potential opportunities and challenges of this training methodology, and compares this with our recent experience of autologous FWB transfusion training in a deployed US military Role 3 hospital.

Materials and methods

A literature review of relevant published studies was conducted using PubMed/Medline and EMBASE electronic database searches, and a Google Scholar internet search conducted in October 2021. A customised search strategy was built around the MeSH terms and the keywords for 'autologous transfusion', 'walking blood bank', 'fresh whole blood', 'training', 'education', 'simulation', 'remote', austere', 'military', 'battlefield' and 'deployed'. There were no language restrictions. An example of the PubMed electronic database search is: '(((walking blood bank) OR (autologous transfusion) OR (fresh whole blood)) AND (education OR training OR simulation)) AND (remote OR austere OR military OR battlefield OR deployed)'. Reference lists from identified full-text articles were hand searched for any additional references relevant to the review.

A description of program establishment, experiences and integration with other trauma training from a deployed multinational military hospital (US Army Role 3 Health Center) from February to October 2021 is presented. The autologous FWB transfusion training program aimed to train CPG-compliant FWB collection and transfusion without degrading our available WBB donor pool. The number of autologous FWB transfusions, both successful and unsuccessful, is recorded.

Results

Risk of adverse events

Autologous blood transfusion training has been safely utilised as a training tool for more than a decade in the US military, yet autologous transfusion training continues to be met with scepticism and reluctance.8 Concerns range from risk of iatrogenic hypocalcaemia to allergic reaction and acute haemolytic transfusion reaction due to inadvertent human error. Donham et al. reported an experience of 3408 autologous transfusions in training with no major adverse events.8 Their adverse events reported were a vasovagal episode in 14 volunteers (0.41%), ocular blood exposure in two participants (0.06%) and urticaria in one case (0.02%). Their series had no reported anaphylactic or major or minor haemolytic transfusion reactions. This compares favourably to FWB transfusion in a WBB context, with two (2.3%) transfusion reactions noted in a series of patients from the 31st Combat Support Hospital in Iraq, 2004.12 The reported reactions were one case each of febrile non-haemolytic transfusion reaction and transfusion-related acute lung injury, neither of which is theoretically possible with fresh autologous retransfusion.

Risk of blood-borne virus transmission

Infectious disease transmission (particularly of blood-borne viruses (BBV)) is a low but serious risk of blood product transfusion that is virtually absent in autologous transfusion training. Retrospective blood sample analysis of 2831 samples of FWB transfusion in Iraq and Afghanistan during 2003-06 indicated three cases (0.11%) of positive hepatitis C virus (HCV), two cases (0.07%) of human lymphotropic virus (HTLV) and no cases of either human immunodeficiency virus (HIV) 1/2 or hepatitis B virus (HBV).¹² Comparatively, the rates of BBV in deployed military donors were lower than in non-deployed military and civilian donors in the US. There were no positive cases in any of the prescreened donor pool of 406 personnel in 2004. Australian blood supply is among the safest in the world, and BBV transmission risk is generally lower than the US and other international risk estimates. The residual risk is now so low that mathematical modelling is required to predict risk, estimated at 1 in 7 299 000 for human immunodeficiency virus.13

Repeated donation

Of interest, a Norwegian Special Operations study on the potential haematologic effects of repeated autologous FWB transfusion training demonstrated significant reductions in haemoglobin and ferritin over time.9 This reduction is attributed to cumulative blood loss through multiple blood samples and the transfusion process in volunteers with up to five autologous transfusions. This blood loss was estimated at 380 ml. The clinical relevance of this statistically significant reduction is unclear. An earlier Norwegian study did not find any significant decrease in combat readiness skills after donations of one unit of blood (450 ml).14 This volume of blood donation and statistically significant haemoglobin ferritin reduction may prove clinically and insignificant and therefore have little bearing on donor operational capability.

Observations of experience in a US-deployed Role 3 hospital training program

This program served as a high-fidelity 'full-dress rehearsal' for our WBB staff to learn and validate the screening of donors and collection of blood. To further capitalise on the autologous training sessions, the FWB transfusions were conducted by our Role 3 assigned combat medics who are likely to perform prehospital FWB transfusions and train non-medical personnel on the collection of FWB in future assignments. This training also served as a force multiplier to facilitate hyper-realistic, immersive trauma and mass casualty simulation training. Figure 4 shows an example of such a scenario with autologous FWB transfusion training embedded within a simulated night trauma scenario onboard a UH-60 Blackhawk aeromedical evacuation helicopter and, later, the Role 3 facility.

Program establishment

Volunteers for the autologous FWB training program were drawn from the existing WBB donor pool. This pool was established from almost 100 base-wide volunteers (both military and civilian contractors) who were prescreened for blood type and BBV (HIV, HBV, HCV and malaria). Volunteers were sought at an information and recruitment stall at the basewide dining facility. There were no restrictions on the type of employment of personnel, and the robust size of the donor pool was facilitated by the Role 3 facility existing within an established military base.

We intentionally employed non-clinical personnel as our WBB collection team, including those without trauma resuscitation responsibilities in the hospital and with limited phlebotomy experience. This commitment was voluntary, and our WBB collection team included the physical therapist and dietician intrinsic to the health facility, and an extrinsic veterinarian and logistics officer. Collection team members received informal hands-on training through the laboratory and emergency medicine team staff.

Experience

During our deployment, we recorded 32/37 (86.5%) successful autologous transfusions for training over eight sessions. Five volunteers were unsuccessful, as the required minimum amount required for autologous transfusion was not achieved. This was generally due to venepuncture failure. Of these personnel, three returned for successful transfusions at a later session. There were a maximum of six volunteers in a single session. Blood collectors would collect from 1–2 personnel per session, with a total of 6–10 total personnel completed during the program (Figure 1).

Our safety protocol included blood sampling, predonation, immediate post-transfusion and 2-day post-transfusion laboratory tests (including a full blood count and electrolyte panel) to ensure all volunteer participants remained available for donation. Standard equipment for the FWB collection is shown in Figure 2. Repeat autologous transfusion participation was generally avoided in our training due to a surplus volunteer donor pool.



Figure 1 - Autologous blood transfusion volunteers per session



Figure 2 - Fresh whole blood collection equipment for autologous blood transfusion training

There were no adverse events reported in our series. In particular, there were no reported thrombophlebitis or deep vein thrombosis events. As mentioned, our autologous transfusion training volunteers were drawn from the WBB donor pool and were therefore prescreened for BBV. Additionally, given that the volunteers received their own FWB per JTS CPG, the risk of BBV or other infectious disease transmission was negligible.

The time from the volunteers' activation to the first unit of FWB delivered to the emergency medicine team was recorded as a surrogate marker of the efficiency of the process. Over the program, the average time recorded was 55 minutes (range 38–75 minutes). As Figure 3 shows, there was an improvement from the initial session (75 minutes), to the mean time of 41 minutes in the last three sessions.

Training opportunities and considerations

Our early training sessions utilised volunteers with high-titre O and A, B or AB blood types, as determined during the prior mentioned pre-screening. These



Figure 3 - Time from activation to first unit of blood delivered



Figure 4 – Autologous blood transfusion training during simulated night trauma scenario onboard UH-60 Blackhawk aeromedical evacuation

volunteers were deemed less likely to be called for WBB donations to prevent the loss of low-titre O donors from the donation pool. Under logistical constraints, the preference for low-titre O donors for FWB transfusion in life-threatening haemorrhagic shock is acknowledged.¹⁵ Unsuccessful autologous transfusions, such as incomplete collection or incomplete transfusion, would potentially remove the volunteer from the WBB donor pool for 56 days. Once skills and processes were refined and our donor pool was optimal, we allowed low-titre O volunteers to participate in the autologous transfusion process.

Discussion

The use of FWB transfusions in prehospital resuscitation of trauma casualties as far forward as the point of injury (PoI) is recognised in the updated JTS CPG for Prehospital Blood Transfusion.¹¹ Autologous FWB training is essential to achieve and maintain proficiency in FWB transfusion, which is expected to reach closer to the PoI of prehospital casualties. The utilisation of safe autologous blood donations for training competency can directly impact patient care where logistics and supply have limited or no ability to immediately respond

to demand increases. At the PoI, medical personnel have limited ability to carry a small volume of coldstored blood products, most likely cold-stored lowtitre O WB at the time of this publication.

While this has been a common practice in US special operations forces to date, a FWB WBB is likely the only mechanism to resuscitate a trauma casualty at PoI or in the Role 1 facility of conventional forces. Once evacuated, subsequent treatment facilities have storage capability for WB and blood products, which are managed at the theatre blood service detachment level. Even in the most robustly supported environments, products can be rapidly consumed in treatment and outpace resupply. A reported common practice at minimally staffed Role 2 damage control surgery locations is to mobilise the WBB at the first notification of an inbound trauma casualty, decreasing the time between the order to collect FWB and its bedside delivery. This may also offer the ability to maintain somewhat lower blood supply levels by managing occasional spikes in consumption with the FWB WBB.

A proficient and well-rehearsed WBB can manage risk during interim periods of low supply volume while the resupply chain mobilises. The success rate of autologous transfusions completed also improved with later sessions in our experience (Figure 1). Though not a direct performance indicator, the average time recorded from activation to the first unit of blood delivered was reduced from 75 minutes in the first session to a mean time of 41 minutes in the last three sessions in our autologous training program. It should be noted that these timings were achieved in a controlled setting, emphasising safety and process and not an end goal of the training. These success rate and timing improvements reflect the WBB collection team gaining proficiency and maturity in the administrative process from activation to blood transfusion. Autologous FWB transfusion training allowed for high-fidelity simulation of the complexities of varied donor vascular anatomy and the effect of perspiration on securing vascular access devices, among other challenges. To our knowledge, no simulated training aid or mannequin currently exists to replicate this process.

There is limited literature on autologous FWB transfusion training, let alone the risks of such training. Although this literature exists within broader literature on FWB transfusion risks, and though the two are similar in concept, there are distinct differences in risk profiles due to the autologous nature of transfusions. In the most extensive case series to date, there were very few minor adverse events and no major anaphylactic or haemolytic

transfusion reactions.⁸ This reflects our experience, with no adverse events noted in our small series. The autologous nature of transfusions may also explain the lower risk of transfusion reaction noted when compared to rates seen in FWB transfusion in a combat WBB context. In addition, BBV or other infectious disease transmissions from donor to recipient are eliminated. There are no case reports of BBV or other infectious disease transmissions in autologous FWB transfusion training. Our training also avoided repeat autologous transfusion due to a surplus volunteer donor pool. The intent was to continue avoiding repeat autologous transfusion at the US Role 3 hospital, given the literature on significant haemoglobin and ferritin reductions with repeated autologous FWB transfusion training,⁹ and the benefit of exposing the WBB collection team to the variability among the volunteers.

This narrative review article highlights the available literature and compares it to our recent deployed experience. With appropriate safety processes, autologous FWB transfusion training is feasible, high-fidelity, low-risk training. However, when there is not an excess of volunteer donors available for training, further prospective research is required to better define the clinical significance of any haemoglobin, ferritin and biochemistry changes with repeated donations or delayed transfusion.

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Casualties in Australian Military and Indigenous Para-Military Units in Papua New Guinea during the Second World War

G D Shanks

Military casualties wounded or killed due to enemy action or disease are part of the warfare's inevitable cost that has a continuing impact after the war is over. World War II in Papua New Guinea is nearly beyond living memory. Nevertheless, it justifies a brief review of the highly variable mortality figures to remind current military medical personnel of their heritage and the awful consequences of failure during wartime. Tropical diseases took a tremendous toll on both combat and support units in New Guinea; whether infections with malaria or dysentery killed the soldier largely depended on the availability of medical support. Combat in the jungle tended to be brief and violent but only affected groups immediately in contact with the enemy. Military limitations in Papua New Guinea were dominated by extraordinarily difficult terrain and logistical problems beyond anything ever imagined before the War. All available resources were mobilised, often by conscription from various local ethnic groups who largely had little, if any, political affiliation with the conflict. Death was the cost of failure, sometimes due to tactical mistakes but more often simply the adverse consequence of handling lethal weapons over great distances in an unforgiving environment.

An initial word about comparing military casualty statistics is appropriate. Although mortality is a hard endpoint that is usually accurately recorded in military units, this is not always true in paramilitary units such as the large labour forces mobilised by the Australian and New Guinea Administrative Unit (ANGAU) during World War II. Records for units destroyed during the invasion of Rabaul in January 1942, as well as those during the Kokoda Campaign, were at best fragmentary.^{1, 2} There is no intention to imply that some unit's sacrifice was less in quality because its casualties were lower in quantity. Different units had different functions, and combat casualties in support units were obviously lower than in front-line infantry or those designated for guard or reconnaissance duties. In the Pacific region, the Australian Army's official statistics list 6294 killed in action (KIA), 1090 who died of wounds (DOW), or about 8000 all-cause deaths occurring in the Pacific, with an overall estimated 2–3% dead.³ This does not count prisoner of war (POW) deaths. A baseline casualty value for the Pacific War is suggested by one Indigenous infantry unit that did not actually serve in Papua but did have a limited combat role in Dutch New Guinea. The Torres Strait Light Infantry Battalion had 13 wartime deaths (one in combat) or 1.5% mortality, which likely indicates a minimum value for wartime military service during World War II.⁴

There were three major forms of military-type service for Papuan or New Guinean people during World War II. The Royal Papuan Constabulary (RPC), with 2476 total recruited, was a police force that performed vital service in maintaining civil order as well as searching for downed aircraft and the crews (see Figure 1).⁵ The Papuan Infantry Battalion (PIB) was initially raised in 1940 and expanded during the War to three battalions by adding New Guinea for a total of 3850 recruited (see Figure 2). Officers were all from the Australian Army, and the PIB's primary war utilisation was as patrol scouts for other combat units in the Sepik and Bougainville campaigns.6 ANGAU, with 2026 Australian officers, many from the prewar civil administration, recruited tens of thousands of local men initially as load carriers in mountain areas without roads whose function later moved more towards construction and other logistics duties. At the peak in September 1944 more than 35 000 men were involved in ANGAU, and it is difficult to establish a total denominator for wartime service given incomplete records (see Figure 3).7



Figure 1: Members of the Royal Papuan Constabulary march in formation with weapons about 1943. Australian War Memorial photo 016116, now in the public domain.



Figure 3: Papuan carriers from the Australian New Guinea Administrative Unit (ANGAU) moving supplies across the Brown River in the Owen Stanley Range in November 1942. Australian War Memorial photo 027050, now in the public domain.



Figure 2: Members of Papuan Infantry Battalion in the forward area celebrate a successful clash with Japanese soldiers in New Guinea. Australian War Memorial photograph 016085, now in the public domain.

Casualties for the RPC are listed as 28 combat deaths, with 63 other deaths or about 3.7% overall.⁵ In the PIB (including later added New Guineans), there were 81 combat and 75 other deaths or 4.1% wartime mortality.⁶ Twenty-four ANGAU Australian officers died from enemy action with two known disease deaths or 1.2% mortality. Numbers are more difficult for the ANGAU labourers who were scattered far and wide; however, it is known that 46 died from enemy action, and another 91 were wounded despite their supposed non-combat roles. At least 2024 ANGAU carriers/labourers died during the War, mainly of infectious diseases such as malaria and dysentery, giving an estimated mortality of about



Figure 4: Members of B Company, New Guinea Volunteer Rifles display a Japanese flag they captured on 21 July 1942 at Mubo, part of the Salamaua–Lae campaign. Australian War Memorial photo 013147, now in the public domain.

5%. This would have been much higher in those participating in the 1942 Kokoda Campaign.⁷ A 4-5% mortality rate would seem to be an overall average for Papuans and New Guineans participating directly in World War II.

Higher casualty rates were seen in Australian infantry units directly fighting the Japanese. The 39th Infantry Battalion was an Australian militia unit that took the brunt of the early fighting during the Kokoda Campaign. The 39th BN recorded 118 KIA, 13 DOW and five disease deaths for a total of 8.2% dead and another 266 wounded in action (WIA). Attrition due to disease and exhaustion was also

exceptionally high. Following 6 months in combat during the Kokoda Campaign, it was reported that only seven officers and 25 other ranks remained (2%) on duty of those originally deployed. The New Guinea Volunteer Rifles (NGVR) was raised as mainly white, but with a few Chinese as well, local militia in New Guinea from 1939. There were 95 deaths recorded in the NGVR before it was disbanded in 1943, most of which occurred in the fall of Rabaul or the sinking of the Montevideo Maru with POWs aboard.8 The 12% mortality estimate should not be relied on heavily due to loss of records and movement into other units such as ANGAU. One of the worst instances of an Australian Army unit being essentially eliminated entirely occurred with the 2/22nd Battalion AIF, which was garrisoning Rabaul as part of 'Lark Force' when the Japanese South Seas Detachment arrived in January 1942. At least 603 22 Battalion members died either on New Britain or in the sinking of the Montevideo Maru; roughly three-quarters of the unit perished, with only a remnant escaping across the mountains and then by boat to Papua.²

It is useful to compare some non-Australian units also fighting in New Guinea. The US Army 32nd Infantry Division carried a heavy combat burden during the Papuan Campaign around Buna-Gona. The 32nd Division suffered 2520 battle casualties, of which 586 KIA and another 100 died of disease or other causes for about 7% mortality.9 Perhaps more significant in terms of resources were the 7125 non-battle casualties, of which 2952 required hospitalisation (41%), largely from malaria and dysentery. The total casualty count of 9956 exceeded the division's entire battle strength due to replacements received. The Japanese military fared even worse than the Allies. The South Seas Detachment consisted of marine infantry and led the invasion of Rabaul, the pursuit of the 22nd Battalion across New Britain and then the Kokoda Campaign across Papua.² Nearly the entirety of a component unit consisting of 1 BN/144th Regiment developed malaria, and 5% likely died of the infection while on New Britain.¹⁰ Only a quarter of the South Seas Detachment survived the retreat from Kokoda back to Lae. Based on the 11 500 surrendered Japanese personnel that repatriated from Muschu Island at the War's end in 1946, it appears that 79% of the Japanese soldiers who landed in Papua New Guinea did not survive the War.11 Uncertainty exists in the total numbers deployed and due to the mixing of units, but the casualty rate was clearly catastrophic. Most deaths were not in combat but resulted from disease and starvation after they were cut off from food supplies and medical support. In 1943, General Douglas MacArthur said, 'The jungle will finish them for us', and he was correct in his assessment.

How should we think about the wide range of unit casualties in Papua New Guinea during World War II? Some units restricted to local duties with little contact with the enemy did relatively well; however, being a conscripted Papuan load carrier was still risky, especially when the villagers remaining at home had to manage without most of their able-bodied men, taken by ANGAU.⁷ In the infantry battalions, some units were sacrificed by military necessity to hold the line against the Japanese offensiveonly barely, as it turned out in Kokoda or failing, as in Rabaul. Extreme casualties occurred when defeat or capture caused unit disintegration, as no military force can function long in the jungle without supplies and medical support. Graphic accounts of military collapse reflect that one cannot expect garrisons to survive cut off on a tropical island. We need to ensure that the Australian Defence Force of the future is never presented with such impossible situations as faced by the Rabaul garrison with a clear appreciation of what is or is not possible when armed conflict occurs. Close collaboration with all our allied forces needs to be a priority for the ADF of the future as well as in its historical past.

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Critical-skills Acquisition and Maintenance in Medical Officers (CAMMO) Project – Stage 2

R. McCarthy

Abstract

Background: The Royal Australian Air Force's Health Services Wing (HSW) continually seeks to improve the training and credentialing of medical officers in order to provide a high-quality healthcare capability. The CAMMO Project aims to inform an evidence-based approach to the training and credentialing of General Duties Medical Officers (GDMOs).

Purpose: Stage 2 of the CAMMO project is a scoping review of the medical literature on the acquisition and maintenance of the critical care skills GDMOs may require to be proficient in, as identified in Stage 1 of the project.

Method: A systematic search of the medical literature was conducted, and data pertaining to the acquisition and maintenance of the identified critical care skills was analysed.

Results: A total of 2401 titles and abstracts were screened, identifying 21 studies that were appropriate for analysis.

Conclusion: Based on the literature search results, there is limited relevant literature available to guide the learning curve and appropriate skill maintenance intervals for many critical care skills. However, there is a sufficient literature base in other areas to provide some guidance. Literature on the rate of skill degradation and recommended retraining intervals may have particular relevance to RAAF, where deployment length must be considered.

Introduction

The Critical-skills Acquisition and Maintenance in Medical Officers (CAMMO) Project is an initiative of Headquarters HSW seeking to inform appropriate training and credentialing of General Duties Medical Officers (GDMOs) expected to perform critical care skills. It is one of several projects currently being undertaken by HSW and the wider defence force attempting to optimise medical officer training. Stage 1 of this project¹ identified a list of critical care skills that GDMOs may be required to be proficient in (Figure 1). Stage 2 of the CAMMO project involves a systematic review of the medical literature to define the training requirements for proficiency in those skills and the retraining requirements for maintaining proficiency. Stage 3 intends to explore and recommend alternative systems for training and credentialing of GDMOs based on the findings in Stage 2.

- 1. Bag valve mask ventilation
- 2. Laryngeal Mask Airway (LMA) placement
- 3. Endotracheal intubation
- 4. Emergency surgical airway or cricothyroidotomy
- 5. Decompressive thoracostomy (finger thoracostomy)
- 6. Chest tube insertion
- 7. Intravenous (IV) cannula placement
- 8. Intraosseous line placement
- 9. Focused Abdominal Scan in Trauma/Focused Assessment with Sonography in Trauma (FAST)

Figure 1: List of critical care skills identified in CAMMO Stage 1^1

Methods

A systematic search of the CINAHL and MEDLINE databases utilising the CKN platform was conducted in May 2016 and repeated in August 2021. Search terms were used for each critical care skill listed in Figure 1, including equivalent terms combined with terms relating to skill acquisition and maintenance (e.g. 'Laryngeal Mask Airway' OR 'LMA' OR 'Supraglottic Device' AND 'skill acquisition' OR 'skill maintenance' OR 'learning curve' OR competence OR CUMSUM). To broaden the search, reference lists of all included articles were reviewed for other potential studies to include. Of the 2401 titles and abstracts screened, 10 were not available in English, and a

further 2332 were irrelevant to the critical care skill, skill acquisition or maintenance. Full texts of the remaining studies were evaluated, and the following exclusion criteria were applied:

- No objective measure utilised to measure skill acquisition or maintenance
- Evaluating a proprietary product rather than a skill.

Fifty-nine papers were assessed for eligibility, with 21 included in this review (see Figure 2). Relevant information from included articles was organised according to the critical care skill and presented in results.



Figure 2: Flow Diagram of study selection.

Results

Table 1 shows the results of the systematic literature search organised for the critical care skill evaluated. A wide variation in the volumes of available literature was identified across the different skills, with the highest number of search results and ultimately relevant articles found for Endotracheal Intubation (ETI) at 1677 and 7, respectively. Decompressive/ finger thoracostomy failed to identify any relevant studies.

Skill acquisition

Several relevant studies were identified pertaining to skill acquisition in LMA placement, ETI, emergency surgical airway/cricothyroidotomy, IV cannula placement and intraosseous line placement. The data from these is displayed in tables 2–6. In addition, Buis et al.² authored a 2015 systematic review defining the learning curve of ETI using direct laryngoscopy, which included 13 articles (including Toda et al. in Table 3). They concluded 51–75 cases were required to reach a success rate of >80% with a single attempt, 1–43 cases were required to reach >80% success with two attempts. At least 50 cases were required to reach a >90% success rate with two attempts. The authors also noted that the learning curve in the prehospital setting was much steeper and did not plateau as quickly (>30 attempts to plateau prehospital vs 20–25 in the elective setting).

Some studies utilised CUSUM (cumulative summation) and LC-CUSUM (learning curvecumulative summation). CUSUM and LC-CUSUM are statistical tools designed to track competence in a procedure. Participants log their attempts and successes, and algorithms are used to determine the adequacy of performance. They differ in that CUSUM considers successive successes and failures, and that successive failures may cause the participant's performance to be deemed inadequate. It detects a deviation in performance from adequate to inadequate and places a greater emphasis on failures. In LC-CUMSUM, successive failures cannot cause a participant's performance to rise above 0 (defined as inadequate performance), thus placing less emphasis on the series of failures that may occur when a new skill is being learnt.3

Critical care skill	Total identified in search	Not available in English	Not relevant to critical care skill	Testing a proprietary product	Doesn't objectively measure skill acquisition or maintenance	Included
BVM ventilation	33	0	32	0	0	1 ^a
LMA placement	209	0	190	15	0	4
ETI	1677 ^b	6	1661	0	3 ^b	7 ^a
Cricothyroidotomy	158	1	144	4	4	5
Decompressive thoracostomy	0					0
Chest tube insertion	183	1	178	0	4	0
IV cannula placement	8	0	3	0	3	2
IO placement	109	2	103	1	0	3
FAST	24	0	20	0	4	0

Table 1: Results of the systematic literature search according to critical care skill

^a Includes 1 article pertaining to both BVM ventilation and ETI

^b Include 1 article identified from review of reference lists

Table 2:	Skill	acquisition	in Lar	yngeal	Mask	Airway	(LMA)	placement
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Study	Setting	Cohort	Parameters	Outcome
Mohr et al.4	German hospital, operating theatres	Ten anaesthesiology residents at the beginning of their training, undertaking their first 40 LMA insertions	Success defined as ability to ventilate through LMA. Number of attempts to success documented. Attempts were divided into groups of five consecutive placements for analysis.	Participants showed a statistically significant improvement in the number of attempts required for success between the first five (1.45±0.82) and after 40 (1.16±0.37, p <.03). However, there was no difference between the first five and the rest on average, suggesting quite a flat learning curve.
Lopez-Gil et al. ⁵	Paediatric hospital operating department. Residents underwent didactic training in placement of LMA in children, followed by demonstration during an operative case. Participants were supervised by and received feedback from consultant anaesthetists.	Eight third-year anaesthesia residents with no prior experience in LMA placement. Initially 10 participants, but two failed to complete the required number of cases.	Participants were supervised in LMA placements in 75 cases each that were deemed acceptable based on aspiration risk, likely airway pressures required and surgical factors. Complications for each attempt were recorded. Analysis was based on grouping attempts chronologically into five series of 15 attempts each.	A total of 189 complications occurred in 121 children. There was a significant decrease in complication rates between each period of training from 62% in the first series of 15 to 2% in the final series.
Hein et al. ⁶	Australian skills development laboratory utilising part task trainers (PTTs)	Fifty-five first-year paramedic trainees with no prior LMA placement experience.	Participants were shown an instructional video and underwent guided practice with four attempts each on three different PTTs (total 12 attempts). Success was defined by ability to ventilate the PTT. Success and time to success were recorded.	PTT 1—Success improved from 34/55 participants in attempt 1 to 55/55 in attempt four with mean insertion time dropping form 54.3 sec to 26.8sec; PTT 2—success improved from 41/55 at attempt one to 51/55 in attempt four with mean insertion time improving from 44.1–27.6 sec; PTT 3— there was no statistically significant improvement in success (55/55 to 55/55) but an improvement in mean insertion time 24.9 to 20.2 sec from attempt one to four.

Table 3: Skill acquisition in Endotracheal Intubation (ETI)

Study	Setting	Cohort	Parameters	Outcome
Ishizuka et al. ⁷	Paediatric patients, in hospital but outside the operating theatre	10 Paediatric Fellows	CUSUM analysis. Acceptable standard defined as >90% success rate with unlimited attempts	39–60 intubations required to reach standard.
Young, A et al. ⁸	Operating theatre in Madigan Army Medical Centre, Tacoma, Washington	11 PGY 1 surgical residents. Supervised by consultant anaesthetists.	CUSUM analysis, >95% success rate (correct placement, confirmed by capnography within 30 sec)	Determined it takes 19 attempts to get off the learning curve (i.e., starting to have a series of successes). However, >95% success rate not reached by any candidates (21–37 attempts each).
Toda et al. ⁹	Operating theatre on ASA 1 or two patients.	32 Paramedics following a training course.	Observational study. No predetermined success rate defined. Up to 2 attempts allowed per patient.	<13 intubations led to no improvement. 87% Success rate was reached after 30 attempts
Je et al. ¹⁰	Two Urban Emergency Medicine Departments in the USA.	Three emergency medicine residents in their first 2 years of residency in a hospital in the USA.	LC-CUSUM. Adequate performance >90% success rate, inadequate performance <80% success. Two attempts allowed per patient, no immediate complications allowed.	A total of 342 intubations were recorded. A mean number of cases to adequacy was 74.7 (95% CI of 62.0- 87.3). 80% success rate reached after mean of 30 cases.
Ospina et al. ¹¹	Operating theatres, Columbia	Four anaesthetics trainees	CUSUM, >95% success rate within two attempts per patient	Trainees each required a different number of cases: 41, 55, 83 and 152 to reach the determined success rate.
Kim et al. ¹²	Observational study in emergency department resuscitation rooms in single centre in Seoul, South Korea. Patients in cardiac arrest over 2 years.	11 emergency medicine trainees. 110 intubation experiences included in the study.	Cohort divided into five groups according to their experience in ETI. Qualified success defined as ETI within 60 sec without complication. Highly-qualified success defined as ETI within 30 sec without complications. Other parameters measured included first pass success, oesophageal intubation, endo- bronchial intubation and time of interrupted chest compressions.	The most experienced group (Q5) had a mean of 103 previous intubation experiences, compared with 26 in the least experienced (Q1). First pass success was 81.8% in Q5 compared with 36.4% in Q1 (P = 0.004). Qualified success improved from 13.6% in Q1 to 63.6% in Q5 (P = 0.020). Highly- qualified success was 0% in Q1 and 31.8% in Q5 (P = 0.002). A linear regression analysis estimated a rate of 80% qualified success required 137 ETI experiences and 90% qualified success required 157 ETI experiences. For highly-qualified success in 80% of cases 220 ETI experiences would be required and 243 for 90% highly- qualified success.

Table 4: Skill	ll acquisition in	emergency sur	rgical airway/	cricothyroidotomy
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Study	Setting	Cohort	Parameters	Outcome
Wong et al. ¹³	Airway model used, no equipment set-up required, time and success were recorded over 10 successive attempts, utilised percutaneous dilating cricothyroidotomy set (Seldinger technique).	One hundred and two anaesthetists	Success defined as <40 sec to successful cricothyroidotomy.	Improvement in time plateaued after four attempts, from a mean time of 41 sec to 30 sec. Improvements in success plateaued after five attempts, with a success rate of 96%.
Buopane et al. ¹⁴	Air way model used, Following a 1-day training session participants were timed to successful cricothyroidotomy using either a Melker or QuickTrach set, over five successive attempts	Forty volunteers including anaesthetists, residents, paramedics and nurses	No explicit definition of successful cricothyroidotomy given.	Statistically significant improvement in mean time to cricothyroidotomy between the first (48.7 sec) and fifth (27.8 sec) attempts. No significant difference between the fourth and fifth attempts.
Shetty et al. ¹⁵	Designed to mirror the method of Wong et al. Airway model used, equipment for Seldinger technique (Melker). Participants provided with study materials and demonstration. Time to successful insertion was recorded for five successive attempts.	Thirty volunteers with varying levels of medical experience (resident to specialist).	Success defined as <60sec to successful cricothyroidotomy. Time from skin preparation to lung inflation.	Statistically significant improvement in insertion times seen across all five attempts. Mean time for initial attempt was 62.1 sec and 39.1 sec for the fifth attempt. The rate of improvement decreased across the attempts from -23.0sec between attempts 1 and 2 and -6.1sec between attempts four and five (P < 0.001).

Table 5: Skill acquisition in intravenous cannula placement

Study	Setting	Cohort	Parameters	Outcome
Murgatroyd & Jones ³	Single teaching hospital in UK; real patients, supervised practice	Ten medical students	Successful IV cannulation with a single puncture of the skin. CUSUM and LC-CUSUM were used. Acceptable failure rate was defined as 20% and unacceptable as 40%.	Students had between 50 and 65 attempts each. Using CUSUM analysis five did not meet the threshold, the average number of attempts to reach the threshold was 41. Using LC-CUSUM all participants reached an acceptable level of competence with an average of 25 attempts required.
Ault et al. ²²	Single hospital in USA. Nursing staff underwent a didactic and practical training program utilising mannequins to teach peripheral IV cannulation using ultrasound prior to being allowed to utilise the skills on real patients.	Eight nurses selected to undergo training in ultrasound guided peripheral IV cannulation, based on experience in cannulation and lack of experience with ultrasound	Allowed up to three attempts at two sites. Successful cannulation defined by the ability to aspirate blood and flush saline using the cannula. Patients were selected based on previous requirement for the use of ultrasound for cannulation or a lack of visible or palpable veins.	Seven out of eight participants completed training. Average number of encounters required for 10 successful IV cannulations was 25 with a range of 18–30.

Table 6: Skill Acquisition in Intraosseous placement

Study	Setting	Cohort	Parameters	Outcome
Ong et al. ²³	Simulation using a bone model and the EZ-IO device. Training provided on the device using the same model prior to the study attempt.	25 medical students, nurses and physicians with no previous experience using the device.	Allowed multiple attempts to gain successful IO access. However, success was not explicitly defined.	23 of the 25 (92%) participants successfully gained IO access in the first attempt. Overall 24 of 25 successfully gained IO access with a mean time of 13.9 sec.
Polat & Oguz ²⁴	Cadavers used in hospital in Turkey. EZ-IO device used. A demonstration of the use of the device was given prior to the participants' attempts.	50 interns from a single hospital, with no previous experience in gaining IO access.	Participants attempted insertion of the IO in 10 cadavers tibias. Time to success and success rate recorded.	Significant decrease in the time required to gain IO access at each attempt between the first and eighth attempts, with a reduction in mean time from 84.64 secs to 39.48 secs. No significant improvement in the time to gaining access in subsequent attempts. Authors suggest that the first three to four attempts at gaining IO access should be supervised.
Levitan et al. ²⁵	Cadaver study in American Hospital. EZ-IO device used. A 5-minute presentation including one demonstration on the use of the device.	99 practitioners (42 emergency medicine consultants, 13 other physicians, 31 emergency trainees, 13 non-physicians)	Participants were allowed three tibial insertions on cadavers following training. Success was defined as insertion with stable bone position without extravasation of fluid.	Success at first, second and third attempts was 96.9%, 94.9% and 100% respectively. Median insertion time was 6 sec.

Skill maintenance

A limited number of papers relating to skill maintenance of critical care procedures were identified. These were primarily related to LMA placement and emergency surgical airway/ cricothyroidotomy.

Ander et al.¹⁶ studied a cohort of 39 emergency medicine residents in a single centre in the USA. They were trained on the insertion of LMAs, Fastrach intubating LMA and the Combitube and tested on the time taken to insert the three devices in a mannequin successfully. They were then retested 6 and 12 months later. The ventilation of the mannequin defined success. Their study demonstrated a small, statistically significant increase in individuals' time to ventilation using the LMA (3.3 sec, 95% CI 2.67-4.33 sec) and Combitube (2.9 sec, 95% CI 0.33-5.0 sec) over the study period and a small decrease in the Fastrach insertion time (-3.3 sec, 95% CI -6.27 to -0.32 sec). The authors suggest that this demonstrates retention in skills using a rescue airway device at 12 months.

Hein et al.⁶ split the original cohort of 55 paramedic students (described in Table 2) into two cohorts and tested their skill retention at 6 months. Those with interval experience in LMA placement were excluded. One cohort underwent retraining (similar to the initial training) before undertaking a scenario, and the control group had no retraining. Both groups showed a significant increase (P < 0.05) in time to successful ventilation compared with the end of their initial training. The intervention group was significantly faster than the control group (94sec vs 209sec; P = 0.029).

Boet et al.¹⁷ studied the skill retention of cricothyroidotomy using the Melker kit. Thirty-four anaesthetists were trained on how to use the kit using mannequins. They were tested following the training and then at 6 or 12 months, depending on randomisation. The study showed no significant drop in performance at the 6 or 12 month test in either group (P < 0.05). However, participants were tested against their own standard and were not made to achieve a defined standard. It also showed a greater, although still not significant, drop in performance at 6 months compared to 12 months, which leads to some questions regarding validity.

Kuduvalli et al.¹⁸ performed a similar study on 25 anaesthetists using simulations of a 'can't intubate can ventilate (CI)' and a 'can't intubate can't ventilate (CICV)' scenario. They were tested at either --8 weeks or 6–8 months after the initial scenario and assessed for adherence to the Difficult Airways Society (DAS) guidelines. In the CI scenario, there was a decrease in deviation from the DAS guidelines in both followup groups. There was a statistically significant increase in the mean time taken to place an LMA in the 6–8 month follow-up group (P < 0.05) compared to their initial testing. Such degradation was not seen in the 6-8 week group. In the CICV scenario, both follow-up groups maintained a significant decrease in deviation from the DAS guidelines (P < 0.01). An initial improvement in the time taken to effective jet ventilation was seen in the 6-8 week group (P < 0.05); however, it was not maintained in the 6–8 month group. There was a significantly longer period of oxygen desaturation in the 6-8 month followup group, compared with the 6–8 week group (P =0.029). The authors recommended training intervals of less than 6 months based on their study.

Youngquist et al.¹⁹ tested ETI and BVM ventilation in paramedic students after initial training and an interval of 7–21 months. Participants were randomised to different forms of retraining or control in the interim and tested against a predefined list of skill components to determine a grade (fail, pass, high pass or honours). The odds of scoring among the higher grades on ETI testing were statistically lower for each additional month elapsed since initial training, with an OR of 0.93 (95% CI = 0.87-0.98). However, performance in BVM ventilation was maintained across the study time. It was noted that the paramedics in the study regularly performed BVM ventilation in their duties but not ETI.

Conclusions

Based on the literature search results, there is limited relevant literature that guides the learning curve and appropriate skill maintenance intervals for many critical care skills. However, in other areas, such as LMA placement, ETI, emergency surgical airway, IV cannulation and intraosseous placement, there is a sufficient literature base to provide some guidance.

The results for LMA placement showed a relatively flat learning curve, with participants able to place the LMA successfully most of the time with very little practice (<5 attempts), particularly in mannequins. However, participants in both included studies utilising real patients^{4,5} showed improvements in the success rate of placements and decreasing complications after 40 and 45 attempts, respectively. The different definitions used for successful placement may account for the difference in the number of attempts to succeed. Alternatively, the contrasting results may indicate a different learning curve between placement in mannequins and humans. Ander et al.¹⁶ suggest that the skill is maintained for 12 months; however, their data, showing an improvement in the time to insertion of a Fastrach airway during the study period, suggests that some interval experience may have been gained (data was collected on interval experience but not presented). Hence, the conclusion regarding skill maintenance must be questioned.

Hein et al.⁶ produced a somewhat conflicting result, with increased time to successful LMA placement after a 6-month interval. However, the scenario testing skill retention was more involved and on a different mannequin than the initial training. Hence, while the study demonstrates improvement in skill retention following retraining, it is not definitive proof of skill fade at 6 months in its own right.

The highest number of studies and perhaps the most robust data on learning curves was related to ETI. Drawing firm conclusions remains hampered by the small number of participants in most studies and the heterogeneity of methods and definitions of success. Overall, the studies showed that a greater than 80% success rate with two attempts could be achieved with relatively little experience. However, most studies suggested that around 50 cases were required to improve that success rate to >90% with two attempts. Wong et al.¹³ showed a steeper learning curve for prehospital intubations. Data from Je et al. and Kim et al., compared with Buis et al., suggest that it may take more attempts to learn the skill of intubation in the prehospital or emergency department setting compared to the operating theatre. This conclusion is supported by other studies comparing success rates of trainees in different environments.20 Other skills were not studied in the prehospital environment. However, it seems likely that success rates for other skills would follow a similar trend.

The study design of Kim et al.¹² differed significantly from the other studies on intubation by grouping participants based on their previous experience in ETI. The use of real patients undergoing CPR was also unique. It is unclear what resulted in the higher number of experiences with ETI required to achieve the competence suggested. The most likely explanation is that successful ETI is more difficult to achieve in patients undergoing CPR. Other factors may include the low number of intubation experiences across the cohort during the 2-year study period (average of 10 each), the resuscitation room environment compared with the operating theatre and the statistical analysis applied to extrapolate estimates for proficiency. However, it could again be argued that the challenging circumstances for the participants in this study may more accurately reflect those faced by GDMOs when they are called on to perform intubation.

The studies regarding emergency surgical airway suggest a flat learning curve in simulation models, with five or fewer simulations required for the success rate to plateau. It is unclear how this translates from the simulation environment to clinical practice. Kudavalli et al.¹⁸ suggest that a minimum retraining interval for this skill should not exceed 6 months. Prahbu et al.²¹ are widely quoted as recommending a training interval not exceeding 3 months at the Difficult Airway Society Meeting in 2001 after showing skill fade with the Melker kit over that period.

The studies on IV cannulation suggest that it may be a relatively difficult skill to attain and maintain a high success rate. Murgatroyd and Jones³ defined a relatively large tolerance for failure compared with the other skills, and half of the participants failed to reach that standard with CUSUM analysis. Ault et al. allowed three attempts at cannulation at two different sites (albeit in a complex patient cohort), and participants still required an average of 25 encounters for 10 successes.²² In contrast, IO placement had a very flat learning curve, demonstrated in simulation environments.²³⁻²⁵

Discussion

The frequency at which GDMOs are required to perform critical care skills on a patient in extremis is low; however, the consequences of failure may be dire. GDMOs may be disadvantaged in several ways in attaining and maintaining these skills. Firstly, for skills with a significant learning curve, they may not have the opportunity to climb that curve and reach a level of mastery where skills plateau. Also, these studies suggest infrequency of the practice of these skills will lead to a degradation in performance. In essence, all these skills could be considered for GDMOs in the same way preparing for a 'Can't intubate, Can't oxygenate' scenario is for an anaesthetist-a low-frequency occurrence with potentially catastrophic consequences of failure. In light of this, and considering that the best evidence available for retraining critical care skills comes from studies surrounding emergency surgical airways or cricothyroidotomy, an ideal scenario would be that the interval for all the critical care skills GDMOs are required to be proficient in would not exceed 3 months.

There is further support for narrow retraining intervals of infrequently used skills in the wider medical literature. Studies have shown significant degradation in transthoracic echocardiography and some surgical skills 1 month after training.^{26,27} Laparoscopic surgical skills and advanced life support skills show deterioration at 6 months.^{28,29} Some protection in skill retention has been shown with experience and regular practice.29 Several studies have shown that teaching skills with distributed training (teaching a skill over a number of sessions spaced out over weeks to months) as opposed to massed training (teaching a skill in a non-interrupted block of training), was significantly protective against skill degradation.^{27,30} This was tested using surgical skills and was true across different regimes of distributed training.^{27,31}

The retraining intervals discussed above are significant when the lengths of deployments are taken into consideration, as many are 6 months or greater, and there is good evidence of skill fade within that period. It may also have relevance to specialist deployments with low-frequency requirements for procedural skills; however, that topic is beyond the scope of this discussion.

Many of these studies were undertaken in a simulation environment. While it is difficult to practice many of these skills outside the simulated environment, it is also unclear exactly how well skills gained in this environment translate to patient care.³²

It is recognised that individual specialist colleges set retraining intervals for some of these skills as part of Continuing Professional Development (CPD) requirements. In ML-3, GDMOs must belong to the Royal Australian College of General Practitioners (RACGP) or the Australasian College of Rural and Remote Medicine (ACRRM) and, as such, are bound to their CPD requirements. Regarding critical care skills, RACGP requires BLS in each triennium,³³ and ACRRM requires ALS and specific training requirements based on areas of special skills (e.g. anaesthetics or emergency medicine).³⁴ There is obviously discordance between these requirements and those suggested above. Although an in-depth review of the CPD requirements of the specialist colleges in Australia is beyond the scope of this review, the author is unaware of any colleges with requirements as stringent as those suggested.

While the review conducted was unable to identify a broad base of evidence for the required training and retraining for all the critical care skills that GDMOs potentially require, a number of key points and recommendations could be formulated based on the data:

- 1. The literature provides guidance on the volume of practice required to become proficient in some critical care skills, although it is lacking in others.
- 2. There is variation in the learning curve for different critical care skills and different environments.
- 3. There is some guidance in the literature on the skill degradation that critical care skills suffer.
- 4. For many critical care skills, the recommended retraining interval may be shorter than typical deployment durations.

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A Case Series Evaluating the Long-Term Efficacy of Botulinum Toxin in the Treatment of Painful Neuropathy

X. Du, D. Patel

Abstract

Background: Uncontrolled neuropathic pain can negatively impact quality of life and daily activities. Many treatments have been proven effective, but a significant number of patients still experience uncontrolled pain or intolerable side effects.

Purpose: A small crossover trial has suggested the efficacy of botulinum toxin (BoNT), but the long-term benefits are unknown. This study aims to report the long-term treatment benefits of BoNT in initial responders with refractory neuropathic pain.

Methods: This study identified five male veterans treated with regular intradermal BoNT injection for more than 3 years for painful peripheral neuropathy. The 11-point Likert numeric scale was used to assess neuropathic pain severity before and after the treatments.

Results: One patient had idiopathic neuropathy, while the remainder had diabetic neuropathy. They were initial responders to BoNT and continued injections ranging from 3.5 to 12 years. All reported sustained improvement with an average pain reduction of 7.4 points on Likert scale. No side effects were reported except for mild discomfort associated with the injection.

Conclusion: In this case series, intradermal injection of BoNT every 3 months offers effective, sustained and well-tolerated neuropathic pain reduction in initial responders with either diabetic or idiopathic neuropathy.

Introduction

Diabetes is highly prevalent among adults in the UnitedStates and has an even higher rate of occurrence in veterans, with an estimated prevalence of 20.5%.1 Neuropathy is the most common complication of diabetes and affects approximately 50% of diabetic patients. Pain is a frequent complaint and can be debilitating. The exact epidemiology of neuropathic pain is not clearly defined. However, it is estimated that up to 25% of type 2 diabetic patients suffer paraesthesia, described as a prickling and tingling sensation, hyperesthesia or overt pain described as burning, sharp, electric shock-like and lancinating.² Untreated pain often leads to significant disability, such as reduced physical activity, poor sleep quality, and worsening anxiety and depression.³ These complications can lead to significant financial burdens on patients and the healthcare system.

Neuropathic pain pathophysiology has multiple potential mechanisms that have been investigated but lie with peripheral and central sensitisation.⁴⁻⁵ Peripheral sensitisation is the amplification of peripheral nerve responsiveness. Possible mechanisms include upregulation of nociceptors, altered ion channel function, regeneration of damaged nerves and decreased nerve fibre density. Central sensitisation causes distorted pain perception, possibly through facilitation within the spinal cord's dorsal horns and the loss of antinociceptive inhibition from the brain.

Sufficient management of neuropathic pain remains a challenge. The American Academy of Neurology (AAN) has a well-published guideline for treatment that includes gabapentinoids, anticonvulsants and antidepressants.⁶ Despite the availability of multiple pharmacologic therapies, many patients continue to have uncontrolled pain or cannot tolerate side effects. In addition, a 2017 systematic review showed that many medications have highly variable dropout rates. $^{7}\,$

BoNT has been used successfully in the management of chronic migraine. Two studies have been conducted to evaluate the use of BoNT in treating painful diabetic neuropathy.⁸⁻⁹ Patients in both studies experienced an improvement in their pain; however, neither study examined the long-term responses. This study aims to evaluate the sustained efficacy of BoNT in the responders and explore its potential as a chronic therapeutic option for neuropathic pain.

Methods

The study was exempt by the institutional review board of the Central Virginia VA Health System due to the small number of patients involved and being an observational study. Patients were selected based on a known diagnosis of painful peripheral neuropathy, having failed an adequate trial of standard neuropathic pain medications and initially responding to BoNT.

For the injections, we followed a similar protocol as reported by Yuan and colleagues.⁸ One hundred units of BoNT type A (from Allergan pharmaceuticals) were reconstituted with 2 mL of preservative-free normal saline. The skin of the injection site was cleaned with a 75% alcohol wipe. Fifty units of BoNT were injected intradermally to the distal portion of the dorsum of each foot in approximately 10 sites (Figure 1). The distal portion was chosen due to more severe pain in the toes and better patient tolerance. We monitored pain severity before and after the treatments using the 11-point numeric rating scale along with the presence or absence of night-time waking by neuropathic pain.

Results

Five male veterans were identified for the study. One patient had idiopathic neuropathy, while the remainder had diabetes. Neuropathic pain is the primary complaint in all patients with only minimal large fibre symptoms. The average duration of neuropathic pain was at least 20 years. The pain was described as constant pins-and-needles, a burning sensation with intermittent brief stabbing, electricshock and shooting pain. The pain predominantly affected the feet, with the most severe pain localised to the toes. The pain severity was rated at 10 by all patients. They stated that it interfered with their mobility and sleep and caused significant distress. All patients had tried and failed five or more conventional agents recommended by the AAN



Figure 1

practice guideline. All except one participant took at least one oral medication in addition to BoNT.

Table 1 summarises the key characteristics and responses of all patients. The injections were well tolerated, and all five patients reported notable improvement following the first round of injection, choosing to continue with the treatment due to the significant pain relief. The therapeutic effect was sustained over subsequent treatments ranging from 3 to 12 years. The reduction of pain severity reached more than 60% and seemed to affect the intermittent shooting/stabbing/electric pain followed by the constant burning pain (Figure 2). Most reported a wearing-off period, which often ranged from 10-12 weeks following last injection. At the time of our reporting, all five patients are planning to continue with the treatment.

Interestingly, two of the five patients noted almost immediate 'relief and 'reduced pressure in the feet' a few minutes following the injection. The reduction in pain is noted on the same day in three patients, 2–3 days in two patients following the injection.

Neuropathic pain tends to intensify at night. All patients reported reduced waking at night, improved sleep quality and general wellbeing due to better pain control with BoNT injection.

There was no occurrence of skin infection associated with repeated intradermal injection. The injection was safely done even in one patient on oral anticoagulation. The injection was well tolerated, and patients reported no systemic side effects.

Patient	1	2	3	4	5
Age	90	69	79	71	71
Gender	М	М	М	М	М
Race	Caucasian	Caucasian	Caucasian	Caucasian	Caucasian
Diabetes	+	+	_	+	+
Duration of neuropathic pain (years)	40+	20+	20+	20+	20+
Number of medications tried	>5	>5	>5	>5	>5
Number of current medications	1	2	0	1	1
Pain NRS pre-BoNT	10	10	10	10	10
Pain NRS post-BoNT	3	4	2	2	2
Special note	Most relief of sharp stabbing pain in toes	Stabbing pain is most relieved	Most relief of stabbing pain in feet	Eliminated burning, lightening & stabbing pain	Eliminated stabbing & electric-shock pain & pins- and-needles
Night-time waking post- BoNT	infrequent	absent	absent	absent	rare
Duration of benefits	12 weeks	10 weeks	10 weeks	11 weeks	11 weeks
Time BoNT initiated	2011	2009	2019	2012	2018

Table 1. Clinical characteristics of patients in the study



Figure 2

Discussion

This is the first study examining the long-term treatment response of neuropathic pain with BoNT. The study shows sustained benefits of BoNT in relieving neuropathic pain in responders. It supports its use in the clinical management of patients with painful diabetic neuropathy, especially in treatmentrefractory patients. The majority of the responders experienced positive responses following the first round of injections and continued to have persistent improvement with subsequent injections, with the longest treatment duration of up to 12 years. The subtypes of neuropathic pain that benefited the most include the sharp stabbing and electric-shock pain, followed by burning and prickling pain. The benefits last from 10 to 12 weeks, with most patients reporting a recurrence of neuropathic pain at a lesser degree by the time of the follow-up injection at a 3-month interval. The benefits do not decrease with repeated injections. The improvement in neuropathic pain positively affected patients' sleep, quality of life and mood, although not formally scored in the study. No side effects, such as infection, were observed during the treatment, which supports its safety in long-term use. The injection is well tolerated, and the absence of interaction with other medications is a significant advantage.

The results of this study are consistent with the independent trial performed by Yuan et al. in which improvement in pain scale is noted in the treatment group compared to the placebo control following a one-time injection. Furthermore, our study demonstrated sustained improvement in neuropathic pain with repeated injection, opening the door to using BoNT in chronic neuropathic pain management.

Several limitations of our study are recognised. First, this study only included patients whose refractory neuropathic pain improved following an initial trial of BoNT injection. The focus of the study was to examine the sustained benefits, while the exact initial response rate to BoNT was not studied. The small sample size also limits the power of the study due to stringent selection criteria for the initial trial because of the BoNT cost and approval by a local VA pharmacy. However, the positive treatment response is consistently observed with repeat injections (approximately 130). Due to patient selection of only male Caucasian veterans, the extension of the study result to the general population can be limited. Additionally, this single-arm case series study may not provide a confirmative treatment response and eliminate potential placebo effects. However, a unique feature that may help mitigate the potential placebo effects is that the treatment benefits typically wear off 1-2 weeks prior to the next scheduled injection, and the benefits are reinstated following each injection. Another interesting observation is that several veterans had an interruption of BoNT injection during the COVID-19 pandemic. They noted a return of severe neuropathic pain during this equivalent 'washout' period.

Although the study showed clinical improvement in the severity of neuropathic pain, the mechanism of BoNT in neuropathic pain remains unclear. The toxin is injected intradermally rather than intramuscularly, so muscle relaxation from inhibited neuromuscular junction is not involved. The relatively rapid onset of action supports peripheral desensitisation through modulating pain mediators or deactivating iron channels at the nerve ending as potential pain relief mechanisms.

Conclusion

The results of this case series demonstrate that regular intradermal BoNT injections provide sustained relief of neuropathic pain in responders. The procedure is well tolerated with no significant side effects. These findings support the long-term use of BoNT in managing refractory neuropathic pain.

Disclosures

We have no financial interests to report for this study.

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Malaria Epidemics in Refugees During Armed Conflict

G D Shanks

Abstract

Refugees displaced from their usual residence by military conflict may generate malaria epidemics when moving into endemic areas. Examples from the 1980s include Khmer refugees from Cambodia into Thailand and Afghan refugees from Afghanistan into Pakistan. In both cases, civilians with little malaria experience were exposed to both P. vivax and P. falciparum malaria. After military coups, Burmese refugees from Myanmar to Thailand also experienced malaria epidemics when coming from non-endemic areas. When Papuan refugees from Indonesia fled into Papua New Guinea, little malaria resulted as there was malaria on both sides of the international border. However, later transmigrants from Java to Papua experienced lethal malaria epidemics. Previous immunity, access to medical care and ecological disruption promoting mosquito vectors all contribute to a composite malaria epidemic risk. Those conducting humanitarian assistance missions need to be alert to the possibility of malaria outbreaks in refugee populations.

Keywords: malaria, epidemic, infectious diseases, Indo-Pacific, refugees

...severely depleted by malaria and other sickness. A few refugees - the lucky ones, the most knowing, those who still had money to buy and bribe their way out - were able to get to Imphal.¹

One of the horsemen of the Apocalypse following in the wake of war is disease, and often in the tropics, that disease is malaria. Civilian refugees displaced by the fighting flee into the jungle, where they are exposed to various vector-borne diseases, with malaria having the greatest lethal potential. Tens of thousands perished from malaria as ethnic Indians fled the Imperial Japanese Army invasion of Burma in 1942. Most of the British Army retreated into India before the monsoon trapped the refugees in highly malarious valleys as described in the opening quote.1, 2 Even civilians left largely undisturbed in their homes suffered from malaria epidemics when war disrupted established patterns of drug treatment, as during the German invasion of Greece in 1941 and the Japanese occupation of Malaya in 1942-43.3,4

Epidemics, by definition, occur suddenly and often unexpectedly when civilians without previous malaria exposure are displaced into endemic areas. Therefore, humanitarian assistance and disaster relief (HADR) efforts must expect malaria epidemics even when assisting civilians in areas that previously had relatively low malaria transmission but have subsequently been disrupted by armed conflict. Four examples (Thailand, Pakistan, Myanmar, New Guinea) of refugee malaria epidemics from the latter 20th century are briefly examined to remind current medical workers of the complexity of managing public health during complex humanitarian emergencies.

Following the 1979 Vietnamese invasion of Cambodia, more than 500 000 Khmer refugees fled west towards Thailand, many of whom had been forcibly removed from Cambodia's central rice-growing areas by the Khmer Rouge seeking to maintain their support base.⁵ Many of the 30 000 plus who arrived in Thai refugee camps were non-immunes, infected with malaria during their trek through the jungle. Some camps (e.g. Khao-I-Dang) were largely populated by those taking a northern route that avoided most transmission areas and thus had much less malaria. However, in other camps, malaria was the leading cause of death.⁵ It is uncertain how many refugees failed to arrive at the Thai border areas because of acute attacks of malaria and lack of medications, which stopped their journey prematurely. High rates of positive malaria blood smears in other camps noted gametocytes indicating infections of some weeks' duration. Mass drug treatment with single dose sulfadoxine/pyrimethamine (SP) may have rapidly decreased initial mortality rates but soon disclosed falciparum malaria drug resistance.^{5, 6} Multiple drugresistant falciparum malaria became a major public health problem in the refugee camps, which was only partially solved by the subsequent introduction of mefloquine combinations.7 As the acute crisis transitioned into a long-term displacement, medical care systems improved and deforestation limited

transmission in the immediate camp areas. However, malaria remained an ongoing problem until most camps were dissolved following the end of the Khmer Rouge or refugees were resettled in third countries.

Large numbers of Afghans were displaced from their homelands in non-endemic mountainous areas into the Pakistan border region by the Soviet invasion of 1979. Over 2 million people in more than 200 camps were involved mainly in Pakistan's western borderlands of around Peshawar. Epidemic malaria of over 100 000 cases annually resulted from midyear transmission from marginal land used for camps that were often near irrigated fields supporting mosquito vectors. The majority of cases were due to P. vivax producing relapsing malaria and fewer problems with either SP or chloroquine drug resistance than in Thailand.⁸ Over time, treatment protocols have shifted to artemisinin combination therapy, but it remains challenging to deliver 8-aminoquinolines such as primaquine to stop further vivax relapses. Following the stabilisation of the refugee camps over decades into large informal cities, traditional means of vector control such as residual insecticide spraying of walls, insecticide impregnation of tents/bed nets and some less traditional forms such as sponging cattle with insecticide as a means to kill Anopheline vectors were instituted.^{8, 9} There have been reports of blaming Afghan refugees for increasing malaria infections in the host country. However, evidence following the repatriation of many refugees after the Soviet exit from Afghanistan indicates that malaria statistics reflect the health system collecting more data rather than an actual change in epidemiology.¹⁰

Thailand also experienced malaria epidemics involving refugees on its western border with Burma (now Myanmar) from the 1980s.8 Some of this developed from generations-long conflict between the Burmese Army and various ethnic minority/tribal armed groups but was exacerbated when political unrest driven by military takeovers in the centre of the country (1988, 2021) led to large influxes of Burmese refugees.¹¹ Therefore, on a background of ongoing armed conflict across a rugged jungle terrain with ongoing malaria transmission, there have been civilian populations displaced locally across the Thailand border by the Burmese Army as well as intervals with many urban civilians fleeing from Myanmar's centre out to camps on the Thai border. Malaria transmission has generally been low (1-2 infections per person per year) but has fallen over time due to improved medical care and deforestation limiting Anopheline vectors.¹¹ Most refugees in Southeast Asia now encounter malaria only rarely outside of an acute epidemic. Antimalarial drug resistance has been a key feature in the camps

along the Thai border, where the failure of first SP and then mefloquine + SP led to pioneering work with various artemisinin combinations leading to the usual current choice of artesunate + mefloquine.⁸ Public health measures such as a network of village volunteers to diagnose and treat malaria have necessarily included both the Thai civilian and Myanmar refugee populations with good success coming from greatly improving access to known curative treatments.¹² Over decades, many of the refugee camps have become established villages, and malaria varies not only seasonally with the rains but also with the extent of human displacements triggered by armed conflict (see Figure 1).



Figure 1: Long-established refugee camp (Sho Klo) constructed from local materials on the Thai-Myanmar border, circa 1990. Photo by the author.

When 12 000 ethnic Papuan civilians from the Indonesian province of what was then called Irian Jaya (now West Papua) fled east in 1984 into the neighbouring country of Papua New Guinea (PNG), epidemic malaria was not a major problem.¹³ This was primarily due to the Melanesian populations involved being from similar tribal groups that had long lived in malarious areas on the other side of an international border. Integration into the PNG populace was widespread and allowed the local government to handle these refugees as visitors/guests initially.¹⁴ However, malaria became a significant problem in Indonesian civilians (mainly from Java and Sumatra) who were being 'transmigrated' into West Papua under circumstances that suggested they were being used to displace the original Melanesian communities. Transmigrants, not usually malariaexperienced, proceeded to set up villages and rice farming under government support in clearings cut out of the jungle (see Figure 2). Malaria epidemics, including many severe cases and deaths, ensued, suggesting that the key factors were lack of malaria immunity and disruption of the local ecology.^{15,} ¹⁶ Extensive malaria studies were done within the transmigrant groups showing that initial malaria mortality rates, especially in adults, moderated over time. $^{\rm 17}$



Figure 2: Indonesian transmigrant camp in Irian Jaya (now West Papua) in the Arso region bordering Papua New Guinea in 1993. Photo by the author.

Armed conflicts in the tropics often involve malaria, where the epidemiology can radically change when wartime exigencies rearrange populations. The risk factors that promote malaria epidemics in refugees include forcible translocation into endemic areas, ecological disturbances promoting Anopheline vectors, lack of previous infection, poor medical access and antimalarial drug resistance. East Timor was not highly malarious in 1999 when disputes over an election escalated into armed conflict and mass civilian displacements. However, malaria exploited the intersection of human, vector and parasite populations driven together by armed conflict. The resulting malaria epidemic has taken 20 years to eliminate within the civilians of East Timor. The ADF experienced its greatest malaria event in East Timor since the Vietnam War, which initially required re-learning the old lessons of enforced daily chemoprophylaxis and post-exposure radical cure to eliminate relapsing malaria.¹⁸ The potential for future HADR missions involving malaria in refugees exists regionally in the Melanesian, Indonesian and Philippines archipelagos; anywhere with any degree of endemic malaria transmission has the potential

for epidemics. The ADF is better prepared now that long-acting weekly chemoprophylaxis is available following the Therapeutic Goods Administration 2018 registration of tafenoquine.¹⁹ Although no chemoprophylaxis is perfect, tafenoquine is a welltolerated medication that is much easier to supervise compliance on a weekly schedule and covers postdeployment vivax relapses without additional medication. Historical examples of refugee malaria epidemics indicate the ADF will likely need both tafenoquine and its institutional experience with malaria in the future.

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Book Review of Warriors Between Worlds: Moral Injury and Identities in Crisis by Zachary Moon

D Cronshaw



Warriors Between Worlds: Moral Injury and Identities in Crisis

by Zachary Moon, Lanham, Maryland, Lexington Books, 2019, 116 + xiv pp., 9781498554619 (pbk).

Reviewed by Darren Cronshaw

Zachary Moon has served as a chaplain and practical theologian who has listened attentively to Veterans and their experience of diverse moral stresses over the last decade. His service as a chaplain included Veterans Affairs hospitals (2010–11), a program for veterans diagnosed with post-traumatic stress disorder (PTSD) (2011–12) and the US Navy Reserve supporting sailors and marines (2011–19). His scholarship as a practical theologian has led him to consult with churches across the USA on postdeployment re-integration, writing Coming Home: Ministry That Matters with Veterans and Military Families (Chalice Press, 2015), completing a PhD at lliff School of Theology, including practical theological analysis of memoirs by veterans, and teaching as Associate Professor of Theology and Psychology at Chicago Theological Seminary. Moon draws and expands on this pastoral ministry and scholarship in Warriors Between Worlds, analysing how moral injury (MI) is complicated by adjustments in moral identity when entering and leaving the military.

Moon collates an outstanding review of the MI literature, evolving definitions, MI's relationship to PTSD and trauma studies, the work of Shay, Sherman, Brock and Litz et al., and the (widely recognised) role of community in recovery. He guides readers through the interdisciplinary treatment of MI — from clinical, ethical and moral philosophy insights and theological contributions.

It is becoming well-recognised that military service and deployments often include experiences of intense stress and trauma that lead to feelings of guilt and shame (towards self), and disgust and contempt (towards others). The distinctive contribution of this volume is that Moon identifies three other periods of stress and possible trauma that need attention from those seeking to prevent or treat MI.

Firstly, soldiers bring a life before military service, and this can have much to do with how they respond and recover from moral trauma or add to the trauma they are escaping. Moon proposes a new model for understanding a person's moral identity — 'moral orienting systems' as the dynamic system of values, beliefs, behaviours and relationships influenced by family of origin, religious and other communities, and significant mentors and experiences, which changes over time.

Secondly, Moon focuses on recruit training. He uses social psychology to evaluate how recruits are systematically transformed in obedience, aggression, team bonding, urgency, attention to detail and mission accomplishment. For example, one soldier reflected, 'Recruit training changed many things about me. The way I carried myself, the way I spoke, my mannerisms, my habits, and my views on life. Everyone commented on how well I carried myself after boot camp.' (p. 62) This is highly orchestrated with intentional training design but can be highly stressful when it involves new values. Nevertheless, recruits need a new 'moral orienting system' that moves them beyond civilian self-centredness and pleasure satisfaction for the sake of survival and battle functioning. Moon's analysis suggests there are ways to build resilience in initial training which help recruits avoid or better recover from MI.

Thirdly, Moon explains that a final focused period of stress and trauma is re-entry to civilian life. He argues that boot camp prepares recruits well for deployment. However, there are limited equivalent 'boots to shoes' training that helps veterans navigate the moral stress of post-deployment transition back to the civilian world. He suggests this ideally includes empathetic professional support, sustaining camaraderie, locating opportunities for community service, and rescripting for non-battle-ready contexts while utilising other strengths of military service in purposeful vocational directions.

Moon also emphasises utilising canine or equine therapy, mindfulness and yoga. Moon critiques the mythology that veterans are either heroes or headcases and urges families, friends and faith communities to supportively hear individual stories beyond naïve questions like, 'Did you kill anyone?' Nevertheless, re-entry may need to include taking responsibility for actions including killing, and soldiers and communities together critiquing the justness of war and the pervasiveness of violence in their values. Soldiers may bear the worse effects of MI, but society must also conscientise their role in war.

Warriors Between Worlds is an insightful deep dive into the lived experience of people adjusting as they enter the military and then re-enter civilian life. It focuses on Moon's American situation but is relevant to other contexts. Moon models valuable practical theological research by drawing on multiple sources, especially the voices of those affected, to understand the moral challenges they are working through and to develop appropriate ministry responses. The book points to the nature of compassionate understanding that will help foster creative and courageous posttraumatic growth. It is highly recommended reading for military members and veterans, chaplains and other caregivers, including healthcare workers and concerned faith community leaders.

The views expressed in this article are those of the author and do not necessarily reflect the position of the Australian Army, the Department of Defence or the Australian Government.

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Treatment at Point of Injury Through the Lens of Capability

J Begley, A Mahoney

Over the last two decades, Australia's asymmetric wars have been characterised by coalition air superiority, unrestricted communications, rapid evacuation, relatively infrequent casualties and well-resourced, readily defended hospitals. In contrast, future peer-on-peer conflicts will likely feature high casualty rates, limited air evacuation, constrained communications, smaller and less targetable health facilities, and strained resources and lines of communication.¹⁻³ Mass-casualty events, prolonged field care and resource limitation would be the norm. As a result, ADF health planners may need to evolve from an evacuation-, doctor- and hospital-centric model of care to a forward, austere healthcare paradigm.

In this context, we welcome the article by Pilgrim and colleagues, who make a compelling case for augmenting the skillset of first responders, who may be best positioned to prevent avoidable deaths in future conflicts.⁴ We would like to explore three of their proposals further while arguing that future discussions should focus not on individual skills but on health capabilities.

Capability is 'the power to achieve a desired operational effect in a <u>nominated environment</u> within a <u>specified time</u>, and to <u>sustain that effect</u> <u>for a designated period</u>'.⁵ The Fundamental Inputs to Capability (FIC) are 'elements or inputs, which in combination, form the basis of capability'.⁵

Pilgrim et al.'s work demonstrates how important it is that commanders and clinicians clearly understand the objectives of operational health support. Best practice capability development must weigh the positive impact of each clinical effect, either in terms of lives preserved or moral advantage, against its associated logistic and training burden, as well as the opportunity costs of not allocating those resources elsewhere.

The paper addresses the capability 'manage tension pneumothorax in the field'. The authors propose teaching finger thoracostomy (FT) to combat first aiders (CFAs). Traditional teaching and ATLS guidance on FT is that the casualty requires either intubation or immediate intercostal catheter (ICC) insertion to avoid respiratory failure from a 'sucking chest wound' open pneumothorax.6 Nonetheless, open pneumothorax is less immediately lifethreatening than tension pneumothorax. JTS TCCC guidelines now endorse FT without either intubation or ICC insertion; the resultant wound can be covered with a chest seal.⁷ Accepting that finger thoracostomy represents appropriate field management of tension pneumothorax, we must consider how this capability might be developed with respect to FIC. Even in high-volume pre-hospital trauma networks, FT is usually restricted to senior paramedics with extensive additional training and ready access to retrieval platforms. This contrasts with the practice environment of the CFA. However, FT's better success rate and robustness may make this a better fit for the nominated environment of prolonged field care capability.

Pilgrim et al. also implicitly address the capability 'resuscitate an exsanguinating trauma patient in the field' when they proposed that medics (soon to be known as 'Health Technicians') should transfuse packed red blood cells (PRBC), and perform Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA).

Many well-established clinical skills already support this capability: field tourniquet application, direct or junctional pressure and avoidance of hypothermia and excessive crystalloids. Moreover, these skills are simple and quick to teach, with inexpensive consumables and negligible waste. The same can't be said for packed cell transfusion and REBOA.

Blood supply logistics are complex. Civilian prehospital transfusion practices are only tenable because paramedics return to supply nodes several times daily. Sustaining forward blood supplies for more than a few hours requires refrigeration, reliable power and temperature-stable transport; this seems inconsistent with the 'long duration in austere conditions ... limited logistic[s] ... and far removed from technical support' missions described by the authors. Blood stocks are also limited; PRBC could likely only be allocated to a fraction of medics.

Returning to the capability of resuscitating bleeding trauma patients, it may be more appropriate for health

technicians to administer volume replacement and haemostatic products such as calcium, tranexamic acid, lyophilised plasma and fibrinogen concentrate. These have favourable supply chain characteristics and arguably better address the coagulopathy associated with life-threatening haemorrhage. Using the lens of FIC, we can identify barriers to capability implementation; for example, the ADF would need to partner with industry and develop supply chains to access these products, which are not universally available in Australia.

Alternatively, training medics in walking-bloodbank whole blood transfusion may be possible. Whole blood may offer other advantages over PRBC beyond the scope of this letter, but, notably, the JTS guidelines endorse the use of pre-hospital whole blood, not PRBC.⁸ Given the initial and annual training burden associated with the authority to transfuse, as well as the potential for wastage, it may be wiser for transfusion to be practised only by select providers, such as medical officers and special operations medics, who are also more likely to be able to provide the other advanced treatments needed by an exsanguinating casualty.

Finally, Pilgrim et al. advocate teaching REBOA to medics (although we understand they were advocating this as a niche skill for highly-select medics). In the high casualty, prolonged field care environment they envision, we feel this skill will not materially contribute to the ADF's capability of managing shocked trauma patients in the field for three reasons. First, whether REBOA offers any survival benefit, even in experienced hands, is controversial.^{9,10} Second, REBOA is an advanced technical procedure, almost exclusively performed by specialist medical practitioners, including in the

several pre-hospital examples cited by the authors and the JTS guidelines.⁹ Finally, REBOA 'should never be undertaken without expedient access to definitive haemorrhage control'.⁹ JST guidelines suggest a time-to-surgery of 15–30 minutes as a reasonable requirement for insertion.⁹ This may be achievable in metropolitan London, but even the authors' suggested cut-off of 90 minutes seems inconsistent with their estimated evacuation times of 1–6 hours. REBOA is an intervention reserved for highly-select patients as judged by a senior medical specialist, with surgical intervention immediately available. REBOA is not a procedure we should be pushing forward to first responders.

We conclude by thanking Pilgrim et al. for their contribution to this discussion. We look forward to further robust debate to help define those skills that best contribute to deployed health capability while remaining practical and cost-effective in a time when there are multiple competing demands on the Defence budget.

(These opinions are those of the authors alone and may not reflect those of their affiliated organisations).

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