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Ready for War? A Comparison of the Anaesthetic and Surgical Services of the Major Combatant Nations in World War Two

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Abstract

A key element of a military's combat effectiveness is the ability to provide efficient management of casualties at all stages from the point of wounding through to rehabilitation, and thus maximise the number of troops returning to fighting condition. Although similar in many underlying principles, the major combatants in World War Two showed differences in pre-war preparation and culture which, combined with differences in technical capability, logistics, and underlying doctrine during the war, led to large variations in outcome for similar casualty groups.

Using firstly anaesthesia and resuscitation, and then triage and casualty evacuation as examples of different national approaches to acute care, this paper demonstrates that underlying differences in professional education and techniques, variations in access to technology concerning acute care, combined with different philosophies and doctrinal approaches regarding the fundamental function of the medical services within the combatant nations, led to quite marked differences in mortality rates for the wounded of each of these nations. The result was that casualties in the Axis forces suffered significantly higher mortality rates compared with those in the Allied forces.

Keywords

Anaesthesia, Resuscitation, Triage, Casualty evacuation, World War Two

Introduction

A nation's success in war is dependent on organisational, moral and material factors. One key material element is the ability to manage casualties effectively at all points along the chain of medical care, from the initial point of wounding through to evacuation and rehabilitation, thereby maximising the number of troops able to return to active duty.

World War Two (WW2) produced huge casualty numbers and offers insights into different models of battlefield medical care and how these differences affected clinical outcomes.

A major determinant of the ultimate outcome for battle casualties is the quality of acute care available. Using the provision of anaesthesia and resuscitation, and then triage and casualty evacuation as specific examples of variations in pre-war preparedness and wartime effectiveness, this article will demonstrate how differences in national approaches impacted on longer term individual clinical outcomes.

Anaesthesia and resuscitation

Pre-war state and consequences during WW2

Prior to World War One (WW1), a typical worldwide model of anaesthesia delivery used junior medical staff or nursing staff working directly under the supervision of the operating surgeon. Training was often rudimentary and relatively few doctors had a specialist interest in anaesthesia. Equipment was limited and highly variable, physiological monitoring rare, and much of the underlying physiology and pharmacology poorly understood. Unsurprisingly, mortality attributable to anaesthesia was higher than today, although difficult to ascertain accurately.[1]

Following WW1, especially in the 1920s and 1930s, anaesthesia increasingly developed in the UK, Canada and the United States as a medically delivered specialty, but this was not the case with the other major combatant nations.[2] Partly, this may have been an effect of socio-economic constraints, but political factors probably also contributed to the slow development of various aspects of healthcare. For example, anaesthesia publications appeared as early as the 1920s in Germany and Austria, but some of the pioneers of anaesthesia were Jewish, and inevitably suffered persecution and loss of influence relatively early, and the regressive, largely anti-specialist nature of medicine in the Nazi state of 1933 onwards also prevented advances in physician delivered anaesthesia.[3] [4] By contrast, surgery was at the top of the German medical hierarchy, with one commentator noting that 'it is no accident that the few natural representatives of the master race usually turn to surgery'. By 1939, 25% of all specialists in Germany were surgeons.[5]

The technical performance of German doctors was at least as good as that in other nations prior to WW2 and indeed the German medical training less than a generation

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[1] Sykes WS. *Essays on the First Hundred Years of Anaesthesia. Volume 1.* Huntington NY: RE Krieger Publishing Co; 1960. p.99-116.

[2] Pöll JS. *The Anaesthetist 1890-1960: A Historical Comparative Study between Britain and Germany.* Rotterdam: Erasmus Publishing; 2011.

[3] Lien J, Docquier PL, Veyckemans F, Reding R. Anesthesia and World War II: When the Battlefield Becomes a Research Field—A Bibliometric Analysis of the Influence of World War II on the Development of Anesthesiology. *Anesthesia & Analgesia*. 2022; 134(1): 216-224.

[4] Kater MH. *Doctors Under Hitler*. Chapel Hill & London: University of North Carolina Press; 1989. p.177-221.

[5] Kater. *Doctors Under Hitler*, 1989 (Note 4). p.12-53.

previously had been held up as an exemplar to others.[6] However, subsequent reductions in medical training, particularly during the war, ultimately led to lower educational standards, resulting in 'ramshackle physicians ... with minimal general training in assembly line fashion'.[7]

In a parallel manner, the successes of the Japanese military medical system during the Russo-Japanese War of 1904-05 had led it to be widely regarded as being the most modern and organised military medical system of the time.[8] But following several decades of complacency, the Japanese military medical system was ill prepared for a large land war in China and even less so for a protracted island-based war in the Pacific. Shortcomings across the whole medical service, including anaesthesia and resuscitation, quickly become apparent and deteriorated as the war progressed.[8]

Russian military medicine prior to WW2 had been heavily influenced by several major historical personalities, such as Nikolai Pirogov (1810-81), a formidable pioneer of both surgery and anaesthesia in civilian and military settings in the mid-to-late nineteenth century.[9] This was supplemented by more recent innovators such as surgeon Alexander Alexandrovich Vishnevsky (1906-75), one of a dynasty of influential nineteenth and twentieth century Russian doctors, who had had recent experience as Chief Surgeon of the army in the war in Finland.[10] He described tumescent anaesthesia (see below), which was ultimately claimed to have been used for field surgery in up to 70% of Russian WW2 battle casualties.

Thus, on the eve of war, although superficially similar, existing differences between the medical forces of the combatant nations were sufficiently established to exert an enduring impact on how anaesthesia and acute surgical care was delivered to battlefield casualties. In many of these, the differences persisted well into the post-war period, with anaesthesia only becoming a medically recognised specialty in the decades after WW2 (Italy 1948, Austria 1952, Germany 1953, Russia c1960).[11] [12]

As a consequence of this varied background in the development of anaesthesia between nations, military anaesthesia during WW2 for many injured combatants was largely delivered by orderlies, medical students and junior doctors, or nursing staff rather than by specialist medically qualified physicians. Throughout the war, the training of

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[6] Flexner A. *Medical Education in Europe. A Report to the Carnegie Foundation for the Advancement of Teaching.* New York: Carnegie Foundation; 1912. p.73-112.

[7] Kater. *Doctors Under Hitler*, 1989 (Note 4). p.150-176.

[8] Hawk A, Sharpe G. The Paradox of the Imperial Japanese Army Medical Department. https://www.academia.edu/2898317/The_Paradox_of_the_Imperial_Japanese_Army_Medical_Department (accessed 6 January 2024).

[9] Hendriks IF, Bovill JG, Boer F, Houwaart ES, Hogendoorn PCW. Nikolay Ivanovich Pirogov: A surgeon's contribution to military and civilian anaesthesia. *Anaesthesia*. 2015; 70: 219–227.

[10] Morgoshiia T, Syroezhin NA, Inkin AV. In memory of academician A.A. Vishnevsky – the chief surgeon of the ministry of defense of the USSR. *Regionarnaya anesteziya i lechenie ostroy boli.* 2021; 15(1): 85-91.

[11] Anesthesia Key. Evolution of Education in Anesthesia in Europe. https://aneskey.com/evolution-of-education-in-anesthesia-in-europe/ (accessed 10 March 2024).

[12] Zhidkov C. History of Anesthesiology in Russia. http://www.csen.com/anesthesia/russia-history-zhidkov.htm (accessed 10 March 2024).

these anaesthesia providers was often minimal, *ad hoc* or entirely self-taught and their limited capabilities likely contributed to excess mortality.[13] [14]

Unsurprisingly, the war placed high demands on military medical services, and the pressure on both medical manpower and logistics only increased as the conflict progressed. Although early war reports suggested the German medical service was adequate, later reports from advancing Allied units considered many of the German military medical establishments they captured to be of very poor quality.[15] [16] [17] This view of the German medical preparation and establishment was perhaps reflective of the wider military performance in the 'German way of war', that is *kurz und vives* (short and lively), namely designed for rapid victories, not attritional campaigns.

At a wider organisational level, although a number of high-level conferences of the medical consultants to the German Armed forces were held throughout the war, anaesthesia was scarcely mentioned during these, and then only in passing.[18]

As with the German system, Japanese medical training suffered very rapidly during the war (which for them, had started in 1937), with a three year medical undergraduate course compressed to six months by 1941, and perhaps of all the major combatants, the Japanese military medical service saw the most precipitous decline in standards and capability.[19] By the war's end, reports of catastrophic levels of failure, including mass euthanasia and suicide of patients following the collapse of deployed hospital services, were encountered.[20] [21] [22]

By way of contrast, physician-delivered military anaesthesia was more common in the UK and Canada (a Society of Anaesthetists had existed since 1893 in the UK, and

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[13] Gott U. Reminiscences of a German Military anaesthetist in World War Two. *Anesthesia History Association Newsletter.* 1995; 13(1): 16-19.

[14] Behrendt KP. *Die Kriegsschirurgie van 1939-1945 aus der Sicht der Beratenden Chirurgen des Deutschen Heeres im Zweiten Weltkreig*. Freiberg: Institut fur Geschichte der Medizin Albert Ludwigs Universitat Freiberg im Breisgau; 2003.

[15] Hartleben H. The Organization of the Medical Service of the German Army and Its Employment in the Campaign Against Poland. *Military Surgeon.* 1940; 87(5): 401–409.

[16] Wiltse CM. *United States Army in World War II. The Technical Services. The Medical Department: Medical Service in the Mediterranean and Minor Theaters.* Washington DC: Office of the Chief of Military History. Department of the Army; 1965. Appendix D. The German Medical Establishment. p.601-620.

[17] US Military Intelligence Service. Observations – German Medical Services. Originally published in *Tactical and Technical Trends*. 1 April 1944, No.45. https://www.lonesentry.com/articles/ttt09/obs-ge-medical.html (accessed 6 January 2024).

[18] German Medical Consultants Conference Collection. University Archives. Uniformed Services University of the Health Sciences, Bethesda, Maryland. https://digitalcollections.lrc.usuhs.edu/digital/collection/p16005coll4/id/5305/rec/3 (accessed 16 April 2024).

[19] Hawk, Sharpe. *The Paradox* (Note 8). p.2.

[20] Hawk, Sharpe. *The Paradox* (Note 8). p.15.

[21] Yutaka Y. The Battlefield experience of Japanese Soldiers in the Pacific War. *Asia Pacific Journal.* 2020; 18(19-2): 1-29.

[22] Condon-Rall ME, Cowdrey AE. *United States Army in World War II. The Technical Services. The Medical Department: Medical Service in the War against Japan.* Washington DC: Center of Military History, United States Army; 1998. p.168-172.

the Canadian Society of Anaesthetists was formed in 1920). Similarly, but to a lesser extent, physician-led anaesthesia was becoming more common in the USA at the outbreak of WW2 (the American Association of Anesthetists had been established in 1932) but was still insufficient to meet the demands of a massively expanding wartime requirement. The first US military medical anaesthesiologist since WW1 started training in 1939, but even by the invasion of North Africa in November 1942, only a minority (10%) were board certified, and 20% had no formal training.[23] The situation in the early phase of the Pacific War was even worse.[24]

This unsatisfactory situation was addressed largely by the work of Ralph Tovell (1901-67), appointed as inaugural US Army Senior Consultant in Anesthesia in 1942.[25] He was instrumental in setting up and standardising training programmes for US anaesthesiologists for the European Theatre of Operations (ETO). In addition to formalising US based training courses, he worked in close conjunction with Canadian and British colleagues such as Stanley Rowbotham (1890-1979) at the Cambridge Military Hospital in Aldershot to improve education for military anaesthetists prior to deployment, and to standardise and improve the quality and interchangeability of anaesthesia equipment across all the western Allies. Despite initial resistance from the Chief Surgeon General Paul Rowley (1891-1965) in the 'battle of the anesthetists' these and other problems and barriers were overcome.[26]

As an indicator of the success in driving through doctrine to improve practice, the rapid decrease in the mortality rate from field anaesthesia fell from about 1 in 1,000 in September 1943 to about 1 in 5,000 by September 1944, which was attributed to this standardised equipment and training, and in part by regular and ongoing communications across all theatres of operations. This was accompanied by a recognition of the importance that anaesthetists played in the successful early management of battle casualties: Henry Beecher (1904-1976) recommended: 'As a working principle, it is always better to give the ablest anesthetists assignment in the combat zone. Unquestionably, it is here that the greatest demands are made on native intelligence, judgment, resourcefulness and technical ability'.[27]

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[23] Beecher HK. Anesthesia for Men Wounded in Battle. In: Coates JB (ed). *Medical Department, United States Army. Surgery in World War II. Volume II. General Surgery.* Washington DC: Office of the Surgeon General. Department of The Army; 1955. p.53-78; especially p.57-59.

[24] Kelley EH. War anaesthesia in the South Pacific. *Californian Western Journal of Medicine.* 1944; 61(2): 63-64.

[25] Tovell RM. Anesthesia. In: Coates JB (ed). *Medical Department, United States Army. Surgery in World War II. Activities of Surgical Consultants Volume II.* Washington DC: Office of the Surgeon General. Department of The Army; 1964. p.581-621.

[26] Waisel DB. The Role of World War II and the European Theater of Operations in the Development of Anesthesiology as a Physician Specialty in the USA. *Anesthesiology*. 2001; 94: 907–914.

[27] Beecher HK. Anesthesia for Men Wounded in Battle. *Annals of Surgery.* 1945; 122(5): 807–819.

Delivery of anaesthesia

The variable status of anaesthesia providers and their clinical capabilities amongst the main combatant nations had a direct bearing on the techniques of anaesthesia used. In addition, national knowledge of advanced technologies and approaches, access to specific drugs and supplemental products, and the ability of industry and logistical chains to deliver the same to the point of use were significant factors affecting how each medical service was able to deliver anaesthesia and resuscitation to the wounded. Examples, which are discussed further below, include anaesthesia drugs, fluids, blood products, and supplemental equipment.

Another significant difference, due principally to the presence of medically trained anaesthetists, was the use of endotracheal intubation and appropriate anaesthetic machines. Endotracheal intubation was much more commonly used in western Allied practice than German, where open drop ether using a Schimmelbusch mask and oropharyngeal airway was a more common approach (Figure 1).

Figure 1. Schimmelbusch Mask. With permission from the Wood Library-Museum of Anesthesiology. https://www.woodlibrarymuseum.org/

Aside from the increased airway protection from gastric aspiration, endotracheal intubation allowed improved control of carbon dioxide levels, better control of respiratory function (particularly during prolonged surgery) and an ability to reinflate collapsed lungs during thoracic procedures. Thus, patients with head, chest and abdominal injuries were able to access more controlled and safer conditions than those anaesthetised with unprotected airways and spontaneous breathing with open drop techniques.

In the UK and ETO, the military adopted the standard civilian models of existing Heidbrink and McKesson anaesthetic machines and developed the Beecher anaesthetic machine specifically for military use to facilitate the delivery of positive pressure ventilation even in forward areas. A miniature version of the Oxford vaporiser, invented

during WW2 by anaesthetist Robert Macintosh (1897-1989) and physicist Hans Epstein (1909-2002), was still in use by British military anaesthetists in the early years of the 21st century (Figure 2).[28] [29]

Figure 2. Oxford vaporiser and blood transfusion. British Army Medical Services in Italy, 1944. Photograph by Captain AR Tanner. © Imperial War Museum (TR2410).

Spinal anaesthesia, initially popular in western Allied forces, fell rapidly out of fashion as the haemodynamic effects and lack of sterility in forward areas made general anaesthesia with pentothal and ether more attractive, although a well-trained anaesthetist could use multiple options (local infiltration, plexus blocks, regional anaesthesia, general anaesthesia) depending on the circumstances.[30] In contrast, Russian, Japanese and German anaesthetists used local anaesthetic extensively either for spinal anaesthesia or plexus blocks, or by local infiltration including a 'creeping technique' of tumescent anaesthesia using 0.25% procaine, first described by Alexander Vishnevsky in the early 1930s, which involved large volumes of dilute anaesthetic drug being injected directly into the tissues being operated on.[31]

[28] Ball C, Westhorpe R. The Oxford Vaporizer. *Anaesthesia & Intensive Care.* 1998; 26(2): 129.
[29] Mercer SJ. Anaesthesia in the Armed Forces – A History of the Triservice Apparatus. *Journal of the Royal Naval Medical Service.* 2008; 94(2): 74-82.
[30] McCuskey CF. Anesthesia at the Front. *Military Surgeon.* 1944; 94(4): 218–222.
[31] Galina A, Kargopoltseva SA, Vasilyev YS, Welch JD. The History of Tumescent Anesthesia, Part II: Vishnevsky's Anesthesia from Russian Textbooks, 1930 to 1970. *Aesthetic Surgery Journal.* 2002; 22(1): 46-51.

Furthermore, the availability of adjuvant drugs to the anaesthetists of each nation was influenced by wider knowledge of relevant technology, national pharmaceutical and industrial capability, and logistical infrastructure. For example, although supplemental oxygen was available to all major combatants, it was infrequently used in German, Japanese or Russian practice, at least in forward areas, yet was a standard element of field-deployable anaesthetic machines by the western Allies.

Intravenous induction agents, including hexobarbital and thiopentone, were more commonly used in western Allied practice, while inhalational induction using ethyl chloride and ether were more common in Russian and Axis practice. Either hexobarbital or a combination of scopolamine, ephedrine and oxycodone known as SEE was used extensively in German areas, particularly as an adjunct to local anaesthesia.[32] Chloroform, a less satisfactory inhalational agent than ether, was used in Japanese military anaesthesia.[33]

In summary, although all the above techniques of contemporary anaesthesia were known to the medical services of all combatant nations, the choice and effectiveness of each technique varied with staff training, equipment availability, and recognition of the impact effective anaesthesia had on patient outcome.

Management of hypovolaemic shock

There were national differences in the management of hypovolaemic shock. This topic had been studied extensively in WW1 and the knowledge gained was generally known internationally.[34] [35] In the western Allied nations, hypovolaemia was widely considered to be a primary contributor to mortality, and techniques concentrating on the restoration of circulating volume, both plasma and whole blood transfusion, were common. In the Axis nations, despite a recognition of the effect of blood volume being important, there seemed to be more emphasis on neurohormonal factors in the genesis of the physiology seen, and consequently more emphasis placed upon drug management of haemorrhagic shock than initial volume replacement.[36] Standard German treatment for shock included stimulants such as cardiazol, coramine, strophantine, camphor, and strychine. Although fluids such as normal saline, Periston (polyvinyl pyridol), and Tutofusin (similar to Hartmann's solution) were available, they tended to be used as supplemental rather than as primary treatment, were given intravenously and in smaller volumes, subcutaneously

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[32] Defalque RJ, Wright AJ. Anesthesia in the Wehrmacht (1939-1945). In: Fink BR, Morris LE, Stephen CR (eds) *The History of Anaesthesia: Proceedings of the Third International Symposium.* Park Ridge ILL: Wood Library-Museum of Anesthesiology; 1993. p.143-146.

[33] Hawk, Sharpe. *The Paradox* (Note 8). p.11.

[34] Medical Research Committee. *Reports of the Special Investigation Committee on Surgical Shock and Allied Conditions. No. 2. Investigation of the Nature and Treatment of Wound Shock and Allied Conditions.* London: HMSO; 1917.

[35] Ryan KL. Walter B. Cannon's World War I experience: treatment of traumatic shock then and now. *Advances in Physiology Education.* 2018; 42(2): 267-276.

[36] Duesberg, Schwieck. Schlink, Koll, Schallock. Shock & Collapse. In: *Report of the Second Conference of Special Medical Consultants from 30th November to 3rd December 1942 at the Military Medical Academy, Berlin.* Trans. Office of the Military Government for Germany (US), Office of the Naval Advisor, Medical Section. March 1948. p.67-80.

or intramuscularly (although this was recognised as sub-optimal for blood volume replacement).[37]

Thus, plasma and blood transfusion was developed on an industrial scale in the Allied forces, as with penicillin, and the transport and storage of dried plasma and citrated group O blood was a great success in both the European and Pacific theatres of operations (Figure 3).[38] The Soviets were also able to reliably collect, transport and deliver large volumes of citrated type O blood and type-specific, unpooled plasma to the battlefield. This was generally available as far forward as the Regimental Aid Post.[39]

Figure 3. US Army medical soldiers administer blood plasma transfusion to a survivor of a landing craft sunk somewhere off the coast of Northern France. (NCP 6496). OHA 250 New Contributed Photographs. Otis Historical Archives, National Museum of Health and Medicine.

[37] Duesberg, Schwiegk. Schlink, Koll, Schallock. Shock & Collapse, 1948 (Note 36); Behrendt. *Die Kriegsschirurgie*, 2003 (Note 14). p.86-89.
[38] Kendrick DB. *The Medical Department, United States Army. Blood Program in World War II.* Washington DC: Office of the Surgeon General. Department of the Army; 1964. xiii-xx.
[39] Cutler EC, Davis L. Appendix A. Surgical Mission to Russia. In: Coates JB (ed). *Medical Department United States Army. Surgery in World War II. Activities of Surgical Consultants Volume II*. Washington DC: Office of the Surgeon General. Department of the Army; 1964. p.953-961.

By contrast, German transfusion services were more rudimentary. Although stored blood was available, this was withdrawn from widespread use in early 1943 due partly to problems with deterioration of the glucose-citrate-rivanol additive causing rigors.[40] In addition, the fragility of the German transport system for such a delicate commodity meant that most military blood transfusion was carried out using available bedside donors, either by direct or indirect methods using Oehlecker's apparatus or similar, for example, Jubé-type apparatus (Figure 4). One disadvantage of this practice, especially in a war of movement, was that individual blood groups recorded in paybooks or on identity discs were frequently inaccurate, and screening for infectious disease (particularly hepatitis, syphilis and malaria) in walking donors was often limited to a personal statement of cleanliness from the donor, which obviously increased the risk to transfusion recipients.[41]

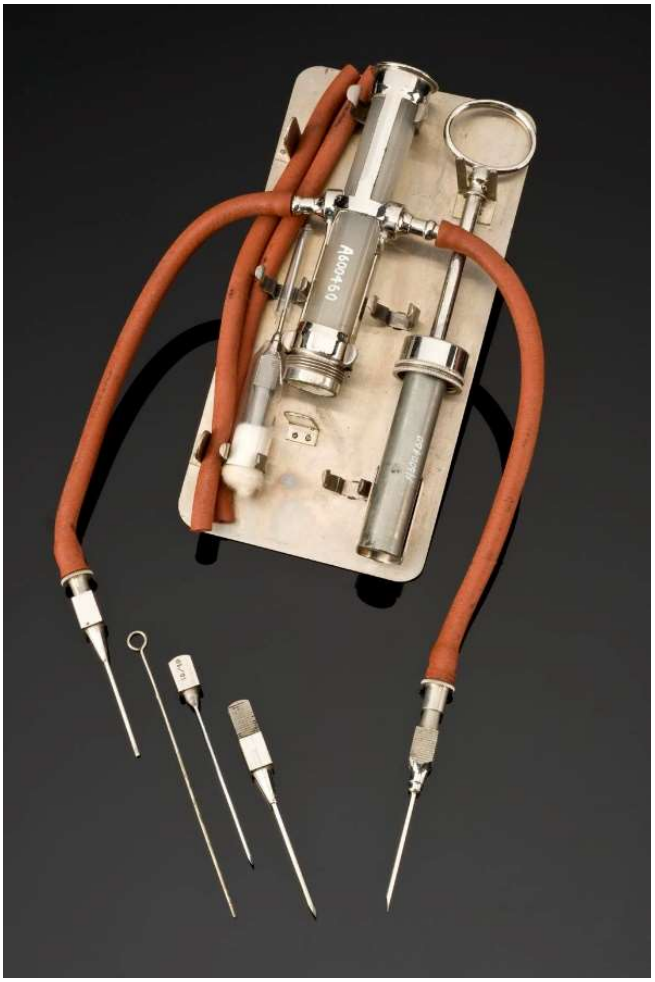

Figure 4. Jubé-type blood transfusion apparatus, Paris, France, 1900-1945. © The Board of Trustees of the Science Museum. CC BY-NC-SA 4.0 Licence.

[40] Behrendt. *Die Kriegsschirurgie*, 2003 (Note 14). p.86-89.
[41] Behrendt. *Die Kriegsschirurgie*, 2003 (Note 14). p.86-89.

Similarly, Japanese practice rarely involved blood transfusion in forward casualty care, and although camphor injections were used to treat shock, there was very limited capability for fluid resuscitation in forward echelons. Direct blood transfusion was available at rear area hospitals, but the attrition of casualties caused by poorly organised evacuation systems (for example, no specific evacuation vehicles were incorporated in the Japanese unit establishment tables) meant relatively few survived to receive this. An additional problem was that although Japanese troops were blood-typed on enlistment, no written records were kept to facilitate compatible transfusion in the field, and relying on the memory of individual troops carried clear risks.[42]

Triage, casualty evacuation and placement of resources

Since the days of Surgeon-in-Chief to Napoleon's Imperial guard Dominic Larrey (1766-1842), methods to improve evacuation and early access to surgical care have been a key part of the structure and function of military medical organisations. Triage can identify a number of different casualty groups, generally using physiological assessment to allocate treatment on a basis that may be described colloquially as 'can't wait, can wait, must wait, expectant', with the intention of providing the greatest good for the greatest number, and how a triage and evacuation system classifies and manages these different groups will alter the overall survival and outcome.

The major combatants had similarities in the conceptual structures of their evacuation chains, in that they used echelons of care, from self-aid or buddy-aid at the point of wounding, through increasingly more skilled and better equipped tiers.[43] [44] Figure 5 shows a comparison between German and American echelons of care during WW2.

Although all nations used an echelon approach to evacuating casualties, the German system streamed off lightly injured casualties into the *Leichtverwundetensammelplatz* (collecting station for lightly wounded) at Field Hospital level, and the *Leichtkrankenkriegslazarett* (military hospital for mild cases) at Army Field Hospital level in rear areas. Combined with *ersatz* (replacement) companies co-located with medical units at Divisional level, this allowed rapid return to the front of this group of wounded.

In contrast, although the Allies sent surgical facilities further forward to treat the most seriously injured, in general, casualties including many of the lightly wounded troops were evacuated further to the rear to Corps level, which delayed or prevented a rapid return to the front.

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[42] Hawk A. Blood Transfusions in the Imperial Japanese Army. In: Australia-Japan Research Project, Remembering the War in New Guinea. June 2004. National Museum of Health & Medicine.
https://www.academia.edu/3644454/Blood_Transfusions_in_the_Imperial_Japanese_Army
(accessed 16 April 2024).

[43] Bellamy RF. Contrasts in Combat Casualty Care. *Military Medicine.* 1985; 150(8): 405-410.

[44] Flucker AK. *Wehrmacht Health and Medical Services during the Italian campaign, 1943-1944: An Army-level Study.* PhD thesis. Glasgow Caledonian University. 2011. p.428.

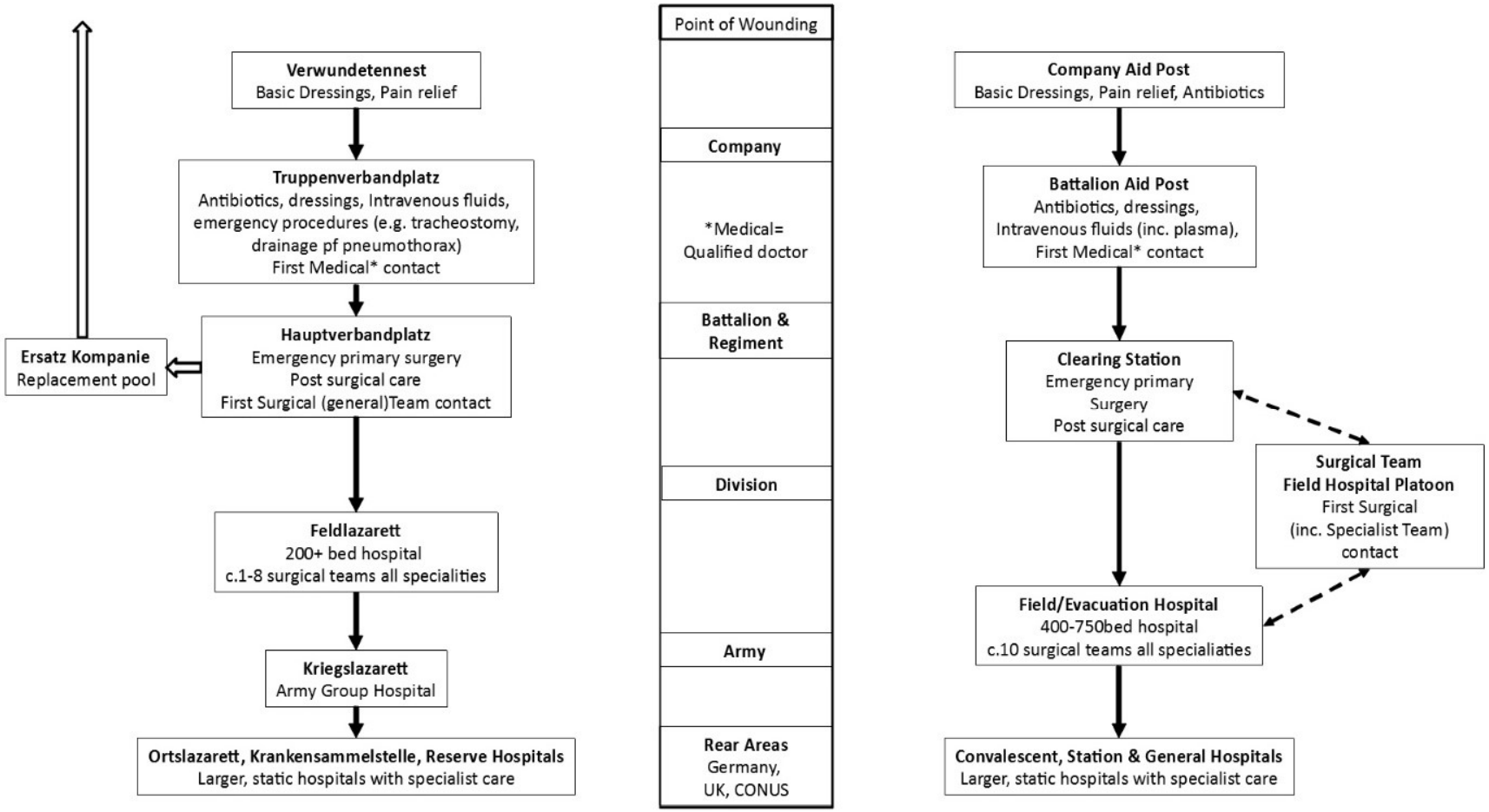

Figure 5. Comparison between German and US evacuation chains: structure & function. *Medical = Qualified Doctor. Adapted from: Bellamy. Contrasts in Combat Casualty Care, 1985 (Note 43); Flucker. *Wehrmacht Health and Medical Services,* 2011 (Note 44).

Abdominal and head wounds

Exploring the role of triage in more detail, using abdominal and head injuries as examples, demonstrates how the threshold for classifying seriously injured cases as 'hopeless' was lower in the German system than in that of the Allies, leading to greater attributable mortality. This was due in part to lesser technical capability for successfully treating serious injuries because of limited staffing, fluid resuscitation, drug availability and endotracheal anaesthesia, and constraints on evacuation capability.

Although the practice of laparotomy for penetrating injuries of the abdomen was well known and officially advocated in the German military – 'Every patient with an injury of the abdomen caused by a projectile ... should be operated on as soon as the circumstances permit and as long as the operation promises success' – the interpretation of the promise of success was undefined.[45]

An analysis using composite figures from wartime texts, quoted abdominal wounds as making up about 20% of battlefield wounds, with an initial mortality of almost 50%.[46] Of the initial survivors, another 50% or more died if subjected to surgery and required prolonged periods of several weeks at a forward location, which was usually the main dressing station. Thus, a policy suggestion that 'hopeless and obviously dying people are stored in isolation, pain relief is provided and are not conveyed' seems pragmatic and utilitarian if the outcome from suboptimal surgery, anaesthesia and immediate post-operative care, let alone return to active duty, was perceived to be very poor.[46]

Similarly, although it was well recognised that early, expert surgery for penetrating head injuries was preferable to delayed intervention, the approach to managing this group of casualties was different between combatant nations. Head injuries in the German system were more often kept at forward locations for extended periods. Rather than encouraging forward surgery by less capable surgeons with a subsequent prolonged holding period (three to four weeks of postoperative bed rest), a policy of evacuation for specialist surgery by experts at Divisional or Army level hospitals was advocated.

The enforced delays in accessing expert management consequent on this approach undoubtedly contributed to excess mortality. This was as much due to a lack of sufficient numbers of adequately skilled surgical teams as to delays in transfer due to the geographical scope of the enormous theatres of war that Germany was involved in, particularly on the Eastern front, and despite attempts to maintain the successes of air-evacuation services developed during the Spanish Civil War.[47]

Similar constraints affected the delivery of other specialist surgery, such as maxillo-facial, ophthalmic, and ENT injuries. German clinicians such as Wilhelm Tonnis (1898-

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[45] Gohrbrandt E. Special points on abdominal surgery and directives on the treatment of gunshot wounds of the abdomen. In: *Report of the Second Conference of Special Medical Consultants from 30th November to 3rd December 1942 at the Military Medical Academy, Berlin.* Trans. Office of the Military Government for Germany (US), Office of the Naval Advisor, Medical Section. March 1948. p.13-14.

[46] Schiel S, Vollmuth R. The palliative medical care of seriously wounded and dying soldiers in the Wehrmacht's front-line medical facilities in the Second World War. *Military Medical Monthly*. 2017; 61(12): 292-299.

[47] Defalque RJ, Wright AJ. Contributions of the Legion Condor to the Wehrmacht's surgical care during WW2. *International Congress Series*. 2002; 1242: 255-260.

1978) and Klaus Joachim Zuelch (1910-88) had done exemplary work in advocating and implementing the principles of far forward medical support and early evacuation for major surgery.[48] However, the nihilistic attitude of '*Bauchschuss oder Kopfschuss-Spritzen!'*, that is the 'belly or head wound-injection!' of a lethal dose of morphine was prevalent in the German military during WW2.[49] [50]

By contrast, Allied medical services were more willing and able to develop and deploy resources to fulfil the need for early expert intervention.[51] Allied surgeons advocated early laparotomy for abdominal injuries, citing survival rates of 70% with such an approach.[52] Head injured patients were often treated by specialists within 48 hours of wounding. Using this approach, the incidence of infection, brain abscess, meningitis and brain fungus (cerebral herniation into the mastoid or middle ear) was reduced from about 25% to 5%, with over 90% of wounds healing by first intention and re-operation rarely being required.[53] [54]

This forward deployment of skilled resource was delivered by the establishment of specialist mobile surgical operating teams, Auxiliary Surgical Groups (ASGs), deploying close to the front lines and involving specialties such as neurosurgery, thoracic surgery, maxillofacial surgery and shock teams. In the ETO, five such ASGs were formed, each with the ability to generate 64 surgical teams.[55]

Thus, on balance, Allied troops with significant head or abdominal injuries could expect to undergo surgery, carried out by specialists, at a closer point to, and shorter period after, the point of wounding, and with a greater expectation of survival than their German or Japanese contemporaries. This principle of forward deployment of specialists, combined with rapid evacuation of wounded, in order to provide early expert medical care persists into current military practice.

Revisiting the conceptual diagram in Figure 5 with a notional 1,000 casualties from contemporary records, Figure 6 shows a comparison between the functional outcomes of German and US evacuation chains during WW2.

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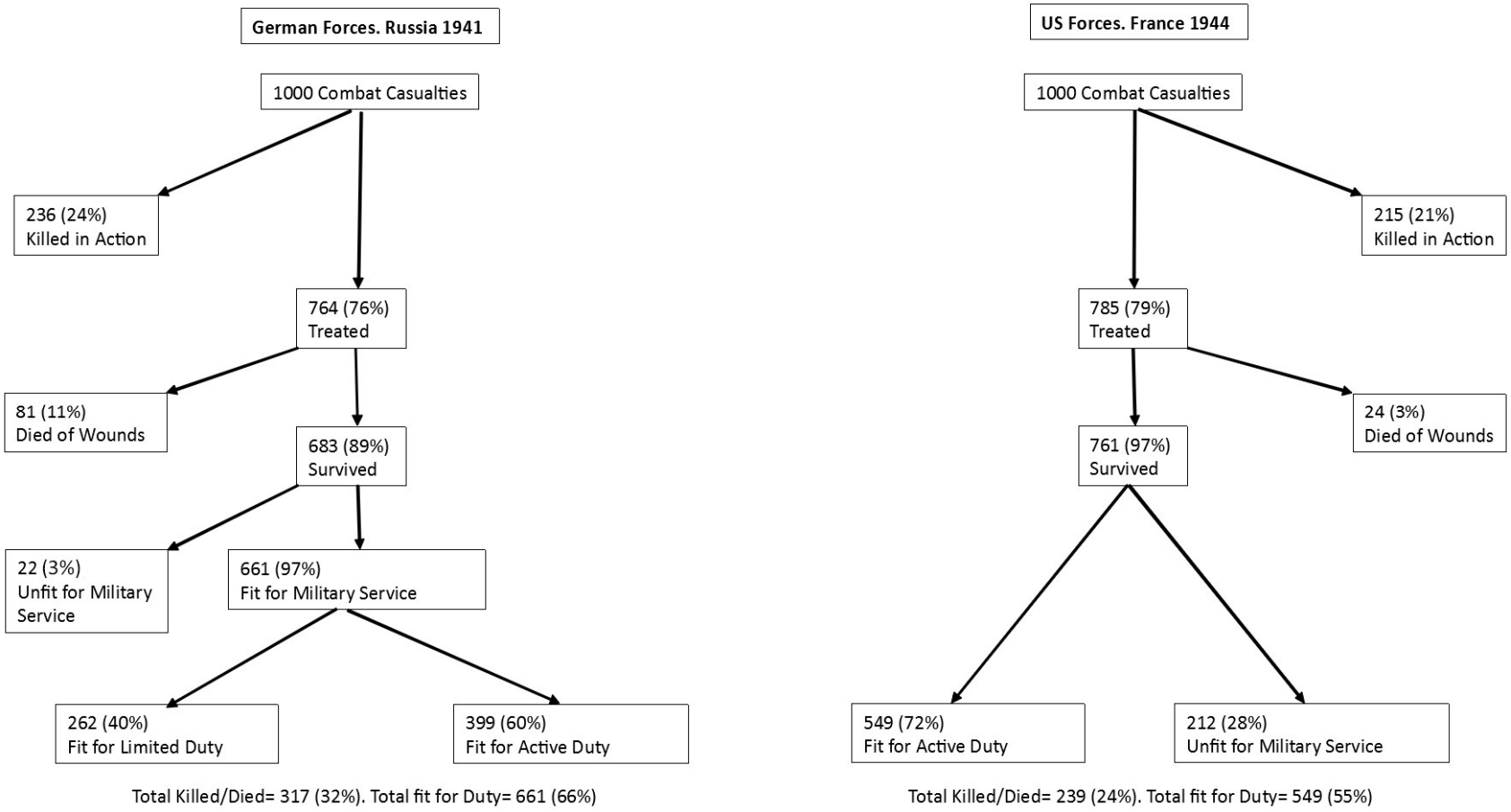

Figure 6. Comparison of outcomes from German and US triage and evacuation chains. Adapted from: Bellamy. Contrasts in Combat Casualty Care, 1985 (Note 43).

Of an initial 1,000 German battle casualties, the proportions killed in action (before entering the evacuation chain) were similar (24% versus 21%). However, 32% of German wounded died compared to 24% of US casualties. This difference (of about 70 to 80 lives lost per 1,000 casualties) was accounted for by those who died of their wounds (11% German versus 3% US) after entering the evacuation chain. Some of these wounded soldiers will have died anyway despite the best available treatment, and some dying due to the triage policy described above.

Reliable information on the Soviet evacuation chain is harder to evaluate as even direct observers of Soviet medical services had varied opinions about how representative their experiences were and how much was Potemkin-like propaganda. In practice, it seems to have had more in common with the German system despite being modelled conceptually on the western Allied system.[56] [57] [58] Forward surgery was prioritised in the Allied manner with up to 70% of operative patients being managed in forward units. However, the lightly wounded were screened out at an early stage, relatively close to the front, and returned to duty via replacement companies more in keeping with the German approach.[59] [60]

The German approach to triage and evacuation prioritised returning as many troops as possible to some form of active duty while the Allied system prioritised saving as many lives as possible. So, in practice, more casualties with serious levels of injury in the German system perished compared with the Allied system, although a slightly greater proportion, mainly the lightly wounded, were returned to duty.

The Japanese had a comparatively poor and rudimentary evacuation chain, along with inadequate forward deployment of medical resource, which together resulted in significantly higher mortality rates at and close to the front lines, with few survivors returning to the specialist hospitals on the Japanese mainland. The highly effective Allied embargo of Japanese shipping further eroded the ability of wounded Japanese soldiers to access adequate care.

Some of this variation in patient outcome may have been due to a fundamental difference between nations regarding what constituted a ‘non-survivable injury’, with the Germans having a lower threshold to regard certain injuries as such. This in turn may reflect the reality of a less capable evacuation and treatment system and/or a different philosophical analysis of the cost/benefit of providing medical care to patients who were unlikely to return to active duty. For example, the German system used about half the staff that was required in the Allied system, so was perhaps more efficient if the goal of the medical establishment was to maintain fighting power rather than to save life.

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Conclusion

The main combatants started WW2 with different physical structures, doctrinal approaches, and deliverable capabilities for provision of acute medical support to combat casualties. This was reflected in widely variable capabilities for anaesthesia and resuscitation, partly due to training differences, and partly due to dissimilarities in the access to technological and knowledge-based solutions for the challenges of traumatic injuries.

Although there were superficial similarities between Axis and Allied evacuation and surgical support services during WW2, closer examination shows that differences in doctrine, available resources and decisions about resource allocation led to different clinical outcomes in the Mediterranean and European Theatres of war, principally a higher mortality in German wounded, with a marginally higher return to active-duty rate for the less severely injured. A similar but magnified difference in casualty outcome was seen between US and Japanese forces in the Pacific Theatre of Operations.

In part, the underlying differences in casualty management were compounded by logistic difficulties caused to Axis and Japanese supply lines by embargoes on air, sea, and land, which not only interrupted supplies of food and medical equipment to the front but disrupted the evacuation of wounded soldiers to rear areas, delayed their treatments and not infrequently also killed or wounded medical personnel. This disruption to the provision of high-quality combat casualty care was magnified as the war progressed.

In summary, the underlying differences in professional education and skills regarding acute care, combined with different philosophies regarding the fundamental function of the medical services within the combatant nations as described in this paper, led to quite marked differences in mortality rates for the wounded of each of these nations.

Military medical practice in western nations since WW2 has continued to develop and practice rapid evacuation and early access to forward, specialist surgery, with ever increasing survival rates of the most severely injured.[61] However, this success cannot be guaranteed in future, large scale, attritional warfare.[62]

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