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Research Paper

World War I: A Watershed for Medical Progression

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ABSTRACT: *Throughout history, progress in medicine has been intrinsically linked to the dynamics of warfare, driving innovations and transforming medical practices for the civilian population. This paper examines how World War I, characterized by the unprecedentedly large-scale utilization of trench warfare and modern mechanized weapons, catalyzed the development of medical technologies and techniques, fundamentally transforming medical practices thereafter. Key areas of medical progress discussed in this paper include facial reconstruction, vaccination for infectious diseases, mobile medical imaging, and blood preservation and transfusion, as well as their immediate and far-reaching impacts on society thereafter. Drawing upon a broad range of historical evidence such as first hand account books, oral accounts, museum resources, and primary documents in French and English, this paper not only provides a comprehensive review of the major innovations in medical technology during World War I but also reveals the diverse personal perspectives that soldiers developed in response to the implementation of novel medical technology in that time, revealing the complex challenges associated with rapid medical and technological advancements. Overall, this paper explores the revolutionary impacts of important medical development during World War I and offers new insights into the interplay between wartime devastation and medical progress.*

KEYWORDS*: Facial Reconstruction, Vaccination, Mobile Medical Imaging, Blood Preservation, Medical Advancement, World War I, Military Medicine, War and Medicine*

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I. Introduction

In the crucible of World War I, the convergence of modern weaponry and the grim reality of trench warfare forged a cauldron of unparalleled destruction and despair. As the deafening roar of artillery reverberated across the battlefields of Europe and soldiers battled the horrors of life in the trenches, the crucible of conflict served as a vital catalyst for unprecedented advancements in the field of medicine.

Among the defining features of this epochal conflict was its unprecedented scale of devastation which left in its wake a trail of carnage and despair and posed an unparalleled challenge to the medical progression of the early 20th century. The brutality of the war was epitomized by the Battle of the Somme in France, where British troops experienced a staggering 57,470 casualties on the first day alone (*What Happened*, n.d.). The toll of this war, encompassing both military combatants and civilian populations, would amount to an estimated 40,000,000 souls, a grim testament to the horrors unleashed upon the world (Mougel, n.d.).

The main reason behind this large number of casualties was the convergence of two elements: the production of modern weaponry and the atrocious sanitary conditions on the battlefields and inside the trenches – soldiers were either obliterated instantly or tormented by the pain of infection in the dirt of the trenches. The colossal destruction of World War I and the unparalleled injuries it introduced through industrialized modern weaponry and trench warfare marked a turning point in history as it necessitated rapid medical innovations like facial reconstruction, treatments and prevention measures for infectious diseases, improved mobile medical care infrastructure like ambulances, which all had both far-reaching impacts on human lives and the field of medicine. The two main types of medical innovations served as major turning points in medicine and warfare: inventions and techniques that arose in response to the unprecedented modern military technology in WWI as well as solutions created in response to the unique challenges typical in trench warfare. These innovations, as well as their impact on battlefield care and modern medicine, are explored below.

Modern Ammunition and Facial Surgery

The introduction of industrially-produced types of weapons like more explosive and powerful long-range machine guns, bullet shells, and bombs, forever changed warfare and necessitated the development of new surgical techniques. This transition occurred when countries popularized using more efficient heavy artillery with automatic quick-firing and advanced propellants, which achieved maximum damage in open areas (*How Modern*, n.d.). These new lethal weapons killed a shocking one million men in just 1914 alone–the very first year of World War I (*How Modern*, n.d.). Among these new lines of machine guns and high explosive weapons, shells filled with shrapnel were the primary cause of facial and head wounds, and their explosiveness disfigured a considerable number of soldiers. As soldiers' faces healed and tightened, many ended up being locked in permanent grimaces that prevented them from drinking, eating, or even breathing regularly (*The Birth*, n.d.). Thus, the new, powerful weapons of WWI introduced terrifying and widespread new injuries that called for new medical technologies to help soldiers not only survive but regain healthy functioning (Gillies, 1920).

Harold Delf Gillies, a New Zealand surgeon motivated to treat the horrific facial damage caused by the new style of war, pioneered skin grafting. In 1917, Gillies established the Queen's Hospital dedicated to treating facial injuries, after setting up a ward at the Cambridge Military Hospital for men with such injuries (*The Birth*, n.d.). Gillies invented the "tubed pedicle" technique, which connected a pedicle, or a flap of skin, to the site of injury to improve blood supply as well as to a tube, in order to reduce the rate of infection. The unparalleled extent of success in the restoration of appearance and functionality signified a revolutionary change in the lives of disfigured soldiers (Gillies, 1920).

However, the soldiers' reactions to the outcomes of these surgeries encompassed multiple, distinct perspectives. For some, Gillies's renovative skills gave soldiers their identities back and empowered them to enjoy life with music, football, and dramatic performance in the community of patients at the Sidcup Hospital (May, 2017). While others who were significantly disfigured with nonrepairable tissue losses would "suffer[] from nerves", alcoholism, and even suicide, as a veteran from Melbourne described (Daley, 2014). Empathy towards the latter was shared by medical workers like World War I surgeon Fred Houdlett Albee, who remarked, "it is a fairly common experience for the maladjusted person to feel like a stranger to his world… It must be unmitigated hell to feel like a stranger to yourself" (Klein, 2024).

World War I revolutionized the nature of skin surgery on battle wounds and blazed a new trail in enabling surgeries to restore healthy bodily functioning and aesthetic appearance. This large-scale application of refined reconstruction techniques (now called plastic surgery) can be traced back to Gillies' innovations. According to the American Society of Plastic Surgeons, 15.6 million cosmetic procedures and 6.8 million reconstructive procedures took place in 2020, indicating the widespread utilization and lasting repercussions of this World War I medical creation (*2022 ASPS*, 2022). Overall, shrapnel wounds experienced by thousands of soldiers, although devastating, opened new opportunities for medical innovators like Dr. Gillies to open new specialties in surgery, transforming reconstruction surgery from a necessity to a luxury for the public.

Trench Warfare and Infectious Diseases

Trench warfare was a defining feature of World War I. Although the defense advantage of trenches "protected flesh and blood from the worst effects of the firepower revolution of the late 19th century," historian Sir Hew Strachan explains that the non-lethal but unsanitary conditions spread infectious diseases resulting in sizable losses in military efficiency (A British, n.d.).

A common solution to wound infections at the time was amputation; however, this procedure would cause life-long disabilities in the soldiers. Fortunately, Leonard Joyce, a British surgeon from Reading, Berkshire, found a bacterium that could break down and remove the infected flesh that prevented the healing of the wounds. This bacterium removes infection while promoting recovery without the need for amputation (Dano, 2015).

Yet, many infectious diseases, such as trench fever, gas gangrene, typhoid fever, tetanus, and others left soldiers in more complicated medical situations. Trench fever, also known as Quintana fever or five-day fever, was a widespread problem, since the incapacitation and dizziness caused by the Trench fever diminished soldiers' abilities to fight. Historians estimate that "more than 1 million troops were infected with trench fever during World War I, with each affected soldier unfit for duty for more than 60 days" (Anstead, 2016). In addition, trench fever caused a fifth to a third of all illnesses in the British Army and a fifth in the armies of the Central Powers (Pennington, 2019).

Nonetheless, medical workers couldn't significantly improve patients' conditions after infection, though many tried alternative physical and chemical therapies in response to the extensive spread of disease in the unhygienic trenches. For instance, Major A. J. H. Iles used electrotherapeutics to treat trench fever's telltale shin pain, by passing an electrical current through the body. Patients claimed that it almost relieved all pain and reduced recurrence. In France and the United Kingdom, chemical insecticide was used to kill the louse that carried the disease. A. W. Bacot, an entomologist at the Lister Institute, researched and found that a chemical

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consisting of ninety-six percent naphthalene, two percent creosote, and two percent iodoform was the most potent, killing lice within two hours. Additionally, the 'Russian Pit' hot air delouser, though not particularly effective, also boosted the progress of delousers inventions and brought up new technology for future sanitation development (Atenstaedt, 2006).

Besides trench fever, gas gangrene was another trench nuisance. Caused by the anaerobic bacteria *Clostridia*, which grew in the deep underground and thrived in lands previously used for agriculture, it plagued soldiers who churned up the soil to dig trenches. The bacteria quickly produced toxins, causing severe pain, myonecrosis, and gaseous swelling. These symptoms greatly influenced the soldiers' abilities to mobilize starting in the first year of the war and 12% of the wounded members of the British expeditionary force developed it (Pennington, 2019).

Luckily, field medics facilitated the rapid evacuation of the wounded and urged speedy wound debridement, saving many soldiers from gangrene-related deaths (Dano, 2015). Developed by Belgian medic Antoine Depage, debridement, or the removal of infected and non-viable injured tissue, involves applying carbolic lotion-soaked gauze and bismuth iodoform paraffin paste ("bipping") to infected wounds. Thanks to this technique, the number of soldiers affected by gas gangrene fell to 1% of the British force by 1918 (Dano, 2015).

The treatment of another disease, typhoid fever, spread by food or water contaminated by bacterium *Salmonella enterica serovar Typhimurium* present in trench soils, also impelled the innovation of effective treatments. Robert Koch, a German pioneer in microbiology and bacteriology, viewed screening and isolating suspected carriers and livestock as preventive strategies when looking at large populations instead of individuals. German planners quickly adopted Koch's preventive strategies, and soon after, the UK and France instituted preventative measures such as identifying carriers and inoculation in their armies (Gradmann et al., 2019).

Another influential solution, the combined TAB, or typhoid plus paratyphoid A and B, vaccine was introduced in 1916 and was administered to soldiers in Britain. During the last three years of the war, more than 90% of British soldiers were inoculated. Vaccination played a key role in reducing typhoid deaths from a rate of 118 per 100,000 soldiers at the end of 1914 to one of 0.3 deaths per 100,000 by 1917 (Gradmann et al., 2019). The value of inoculation in preventing the spread of typhoid was seen as a successful public health intervention (Gradmann et al., 2019).

How this success was achieved, however, exposes the British military's punitive measures and coercive inoculation of those who resisted. For most soldiers, inoculations were considered compulsory with ramifications par for the course in military life (Walker, 2019). As Leonard Stagg, a British orderly who worked between 1916 and 1918, recalled, there was one "only person [he] ever heard of who refused [inoculation]" (Smith & Stagg, 1985). A 1915 debate in British Parliament revealed that, even for soldiers who outrightly refused vaccination because of the alleged side effects, resistance was futile as they were "punished in various ways for exercising their right," namely being denied promotion and eventually forcibly inoculated "whilst technically and legally no compulsion exists" (George, 1915). Despite the differing voices, the acceptance of "mandatory" inoculation by most soldiers and the uncountable urgent cases during World War I provided a vast platform for testing, allowing a turning point of success in disease control and the development of new technologies, such as vaccines, in medicine.

Another acute infectious disease that arose from the trench soils, tetanus, was also later prevented by injecting tetanus antitoxin into wounded soldiers (Rogers, n.d.). In the 1930s, toxoid was produced as an efficient vaccine as a preventative measure (Rogers, n.d.). The fact that both typhoid vaccines and tetanus vaccines were later improved and pervasively administered today demonstrates how the war marked a transition in the history of preventative medicine.

Medical Imaging

One of the less obvious medical innovations of World War I was in medical imaging, a technology developed before the war but utilized on a greater scale during it (Martin, n.d.). The large number of injuries demanded quick diagnosis near the front lines, while traditional X-ray services were impeded by their need for consistent electricity.

However, the Polish-born scientist Marie Curie, convinced the French government to set up the country's first military radiology centers and equipped several hundred ambulance vehicles with X-ray machines, building a steady, reliable, and mobile radiological service for frontline soldiers and providing timely on-site diagnosis. These ambulances were nicknamed "petites curies," meaning "small Curies"(Agence Rol. Agence photographique (commanditaire), 1914).

The scale of this service increased as the war continued; by 1918, approximately 300 "petites curies" managed by 400 radiologists were in service, helping one million wounded soldiers. Increasingly, X-ray machines were set up in base hospitals and, in 1916, Curie continued her work training women as X-ray

assistants to empower women medics and nurses on the homefront (Progress in Medicine, n.d.). Today, X-rays and other types of imaging prevail as a non-invasive method to examine the human body and assist with mobile and in-hospital diagnosis.

Blood Preservation and Transfusion

The sizable amount of blood shed by the destructive modern ammunition in World War I also bolstered blood transfusion advancement. Previously, transfusion required both the donor and recipient to be present (Hospital Archives, The Hospital for Sick Children, Toronto, Canada, n.d.). This was impractical for frontline soldiers, and transportation of wounded soldiers from the battlefield to base hospitals would have taken too long–often twenty-four hours or longer. For many soldiers, however, their massive blood loss could result in shock within a short period. To address this issue, medical workers saw the need to collect and store blood in advance, but the propensity of blood to clot became a major obstacle for storage (Pierce, n.d.).

Pressured by the war's insatiable demand for blood, doctors discovered that citrate could be an effective anticoagulant. Additionally, medics on the frontline found that collecting blood using glass collection vessels with a film of paraffin could also delay clotting. This allowed blood to be stored for up to twenty-six days and transported to where it was needed (Bell, 2018). Using preserved blood allowed for easy storage, stockpiling, and ready usage when needed (Pierce, n.d.).

By 1918, blood transfusions could be performed close to the frontlines with coordinated blood deployment, which improved the survival rate of soldiers experiencing hemorrhage, shock, carbon monoxide poisoning, and other afflictions (Bell, 2018). Later, standardization procedures were brought home, becoming widely available in civilian medicine. While blood transfusions were infrequent before World War I, the efforts made by wartime doctors, especially those from Canada and America, used wartime patients to hone and improve the storage and diffuse transfusion techniques (Aymard & Renaudier, 2016).

In the years after the Armistice, the British surgeon Geoffrey Keynes and the London Red Cross even founded a blood banking system in 1921, allowing 1,500 patients to be transfused with the citrated stored blood by 1930 (Keynes, 1983). This opened the door to the wider application of blood banks in regions around the world like Chicago and New York City in 1939, saving more lives in the Second World War (Hedley-Whyte & Milamed, n.d.).

Lasting Influence

World War I marked a critical turning point in the ever-progressing field of medicine owing to its revolutionary influences on battlefield medicine. The uniqueness of the Great War's modern weaponry and trench warfare demanded drastic developments in numerous areas of medical treatment and technology, pioneering developments that benefited from the unprecedentedly immense testing scale offered by the war's destructiveness.

Many medical techniques and treatments extensively ordinarily practiced nowadays date back to World War I (Bell, 2018). Facial reconstruction innovations in response to explosive shrapnel not only saved the dignified lives of soldiers but also opened the gate to the present-day, multibillion-dollar cosmetic plastic surgery industry. Novel drugs, treatments, and preventative methods created in response to infectious diseases thriving in the trenches raised awareness for vaccination and social isolation of disease carriers, both fundamental prevention and treatment methods used in modern medicine. In addition, the magnitude of battlefield wounds necessitated the application of instant-care devices such as ambulances outfitted with mobile imaging machines, as well as the discovery of new blood preservation and transfusion techniques that played critical roles in the healthcare infrastructure of our current societies. Significant casualties and damage were the cost of the Great War, but in turn, the carnage produced a watershed of medical advancements that would continue to benefit future generations.

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