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LESSONS FROM HISTORY

# Trench Foot: The Medical Response in the First World War 1914–18

Robert L. Atenstaedt, MA, MPhil, MSc, DPhil, MPH, MB, BS, MFPH

*From the National Public Health Service for Wales and Institute of Medical and Social Care Research, University of Wales, Bangor, UK.*

The approaching 90-year anniversary of United States entry into the Great War is an apt time to examine the response to trench foot (now called nonfreezing cold injury [NFCI]) in this conflict. Trench foot appeared in the winter of 1914, characterized by pedal swelling, numbness, and pain. It was quickly recognized by military-medical authorities. There was little debate over whether it was frostbite or new condition, and it was quickly accepted as a specific disease. The major etiologies proposed were exposure, diet, and infection. The opinion emerged that it was caused by circulatory changes in the foot caused by cold, wet, and pressure. Predisposing factors included dietary inadequacy and fatigue. A number of labels were first given to the disease. However, the name ''trench foot'' was eventually officially sanctioned. Trench foot became a serious problem for the Allies, leading to 75 000 casualties in the British and 2000 in the American forces. Therapy for trench foot involved a number of conventional, tried-and-tested, and conservative methods. Some more innovative techniques were used. Amputation was only used as a last resort. Prevention involved general measures to improve the trench environment; modification of the footwear worn by the men; and the provision of greases to protect them from moisture. The medical reaction to this condition seems to have been relatively effective. The causation was identified, and prophylactic measures were introduced to fit this model; these seem to have been successful in reducing the prevalence of the condition by 1917–18.

## Introduction

The approaching 90-year anniversary of United States entry into the Great War provides us with an opportunity to examine the response to diseases that appeared in the trenches of this conflict, such as trench foot. This condition, now renamed ''immersion foot'' [1,2] or ''nonfreezing cold injury'' (NFCI),[3] is still responsible for problems in soldiers,[4] such as in the recent Falklands War.[3] It is also to blame for disease in some rare cases, such as a child wearing a plaster cast,[5] the collapsed elderly,[6] and arctic explorers.[7]

## A New Disease?

Trench foot was first brought to the attention of the medical profession in World War I in the winter of 1914, through an article written by a special correspondent.[8] The report announced, somewhat excitedly:

> *LIEUTENANT-COLONEL A.B. Cottell, P.M.O, hospital yacht* Albion, *informs us that many men are now arriving from the front suffering from frost-bite of varying severity. He has, he states, carried more than sixty of them to England from Boulogne.*[8]

It was observed that the disease largely attacked the toes; but in many cases, the leg became swollen up to the knee. In severe cases, large blisters, filled with clear, ''gangrene smelling'' fluid, were present. Cottell described the history of 1 particular case:

> *G.S, aged 29, . . . was in the advanced trenches from November 14th to 19th, during which time it was raining and freezing alternately. His feet felt very cold and numb on November 19th, but owing to the fighting he never took his boots off. On November 20th he could not stand and was carried back; he was seen by a medical officer, temporarily dressed, and sent to Boulogne. He embarked on November 24th. The frostbite then (11.30 AM) included the toes of both feet, extending up the metatarsus; there were bullae the size of filberts on the big toes. The limb had a dull red irregular blush some 5 in above the ankle, and the legs were edematous nearly to the knees. The temperature was 100°F, and he complained of dull heavy*

Corresponding author: Robert L. Atenstaedt, MA, MPhil, MSc, DPhil, MPH, MB, BS, MFPH, Institute of Medical and Social Care Research, Ardudwy, Normal Site, University of Wales, Bangor, Gwynedd LL57 2PX, UK (e-mail: Robert.Atenstaedt@nphs.wales.nhs.uk).

*pain, but there was no headache or definite constitutional disturbance.*[8]

In the winter of 1914, these cases were included under the category of ''frost-bite,'' ''chilled-feet,'' or ''not yet defined'' (N.Y.D.) feet.

Trench foot also gained the attention of the military-medical authorities. A couple of weeks after the special correspondent's report, there was an important meeting of Medical Officers (MOs) at No. 11 Stationary Hospital, held ostensibly for the purpose of inaugurating a society for the discussion of papers of surgical and medical interest.[9] Present were representatives of all 3 hospitals in Rouen, including some distinguished surgeons, such as Colonels Sir Berkeley Moynihan and Sir Bertrand Dawson, with Colonel B. T. Skinner chairing the conference. Trench foot was chosen as its first topic of discussion, signaling its importance and lending official recognition to the condition.

The medical fraternity had to decide whether this was an existing condition, namely frostbite, or a novel disease, never before described. Obviously, its decision would determine the way in which the condition was tackled. However, there seems to have been little controversy on the matter. By the middle of 1915, the majority of doctors seemed to have taken the view that the disability, by now termed ''trench foot,'' was dissimilar from classical frostbite. An editorial that appeared in the *Medical Press & Circular* at the same time argued strongly in favor of distinguishing between the 2 conditions:

*The exact nature of the condition labelled ''frost-bite,'' from which so many of our soldiers at the front have suffered, is still the subject of much speculation and some investigation. The only point upon which all appear to be agreed is that whatever the cause of the lesion, it is not due to frost-bite.*[10]

The novelty of trench foot was expressed by a number of authors. Captain T. H. Somervell was typical of many when he wrote: ''Trench foot seems to bear such a well defined syndrome of symptoms, resembling several other conditions, but not identical with any, that it may be considered as a clinical entity.''[11] An editorial, appearing in *The Lancet* in April 1915, voiced its agreement. It mentioned the fact that fewer cases of trench foot had occurred with the advent of spring and added: ''We have to consider the possibility of another winter campaign, and we must be prepared in time for a condition, which is new in military surgery, and is produced by the new general tactics and circumstances.''[12]

At the end of 1915, 2 official meetings were held to discuss trench foot, signaling its acceptance as a specific condition. On 11 November, Sir Arthur Sloggett, Director-General Medical Services (DGMS) sent a memo to the Directors Medical Services (DsMS) First, Second, and Third Armies, announcing that it has been decided to hold a conference on the condition at General Headquarters (GHQ).[13] He requested that each DMS select a MO thoroughly acquainted with the subject to represent the Medical Services of the Armies. A meeting of the Third Corps Medical Society in December also chose trench foot as its topic of discussion, reaffirming its importance.[14]

## Search for a Cause

The special correspondent, reporting in December 1914, also commented on the etiology of trench foot.[8] He identified 3 main causative factors: soaking of men's limbs in cold and muddy water, absence of local heat production from leg muscles because of long periods of immobility, and tightness of footwear. He asserted: ''With their legs thus chilled in advance and the whole local circulation already reduced to a very low ebb, it is comprehensible that here and there in superficial areas it [the blood supply] should be arrested for a time altogether.''[8] The causes suggested were all common features in the trenches.

In the discussion on the disease held at Rouen, etiology was hotly debated.[9] Colonel C. B. Lawson wondered whether the condition might be caused by a vasomotor disturbance. In his opinion, cold and fatigue might be slowing the arterial circulation in the lower limb, producing stasis in the peripheral vessels. Lieutenant R. Greenfield also blamed the condition on venous stasis. Major C. Hall agreed, adding that the tight boots and puttees worn would make matters worse. Moynihan, the revered surgeon, argued that the causative factors were cold, damp, and pressure in combination. Cold on its own was not sufficient, because the nose and ears of the men had not been affected. Lieutenant B. T. Land concurred that the condition was not solely produced by cold. He attributed it more to damp, relating an instance where several soldiers had succumbed to a similar condition after standing continuously in water for several days. Taking a completely different perspective, Skinner postulated that the cause was a septic infection, with the water in the trenches serving as a reservoir for the germ. To back up his claim, he referred to a situation in the Boer War, when 900 men fighting in a trench had developed an acute infection of the foot after standing in dirty water for an extended period. Major J. Skeffington disagreed, believing that sepsis played no part in the causation. This important discussion set the debate into the etiology of the condition.

Before reaching the trenches, troops often had to

march several miles along wet and muddy roads. When they eventually arrived, they had to wade through semi-liquid mud and water, often at a temperature only a few degrees above freezing point, and remain motionless at their posts for many hours. Those who believed that trench foot was caused by the environment in the trenches, leading to a deficient circulation in the lower limbs, were conforming to existing medical ideas regarding how temperature and moisture impacted on the circulation. For example, in January 1915, Lieutenant E. G. Fearnsides and Lieutenant M. Culpin listed their causes for trench foot, which included exposure, fatigue, and ''disorganization of the way of life.''[15] In a memorandum issued in the same month, the DMS, First Army, wrote that the condition was a result of the men remaining for days at a time without unlacing their boots or drying their feet.[16] At a meeting of the Clinical Section of the Royal Society of Medicine in London in February 1915, Captain R. J. H. Swan presented a paper on trench foot.[17] All of his patients had spent many hours standing in mud and thawing snow, without the opportunity of active exercise. Most of them possessed only 1 pair of ill-fitting boots and 1 pair of socks. Swan concluded that the pathology of trench foot involved a tissue change caused by vasomotor constriction maintained for some time. The view expressed in this study, termed the ''exposure/circulatory'' theory, proved very popular. Proponents included Dr L. Wainwright, who wrote to *The Lancet* to express agreement with Swan.[18] In his opinion, trench foot was caused by constriction of the blood vessels of the lower limbs caused by wet and contracted garments, with immobility also being another factor. In a letter to the same journal, Sir William Osler, Regius Professor of Medicine at Oxford, emphasized the importance of the latter:

> *Sir—Venous stasis, the anatomical basis of the trench-foot, is not simply an effect of cold or of wet, or of both . . . It is not the cold, nor the wet, not the puttees, nor the type of boot; the damaging factor is the comparative inertia of the leg muscles.*[19]

Lieutenant-Colonel B. Soltau further supported Osler's view in an article published in the *Journal of the Royal Army Medical Corps*.[20] He was particularly impressed by the number of hours that the men spent standing almost motionless in the trenches, meaning that the aid of muscle contraction provided to the circulation was lost. In February 1915, an article, based on research by the Officer-in-Charge, Queen Alexandra Military Hospital, Millbank, appeared.[21] This again stated that the most important causal factors in trench foot were constriction of the feet in tight puttees and ill-fitting boots, combined with exposure to cold water and mud. Captain C. M. Page agreed that exposure was primarily to blame for the condition.[22] He noted that most cases had a history of exposure for periods of 24 to 72 hours and cited other possible predisposing factors as nerve strain and lack of sleep. He described what he regarded as the likely pathological mechanism:

> *The capillary circulation is slowed by surface chill. At the same time the general circulation is sluggish from bodily inactivity. Prolonged standing promotes blood stasis in the feet, and in some cases may be a concomitant factor. This stasis damages the capillary wall and exudation takes place. This will tend further to check the blood supply to the feet, and in severe cases, leads to gangrene of a greater or lesser part of the foot . . .* [22]

In April, Captain C. Miller wrote an account of his observations on 376 cases of trench foot at the British Red Cross Hospital, Netley.[23] In all instances, the men had been standing in mud or water, at a depth ranging from 18 inches to 3.5 feet, for many hours. In his opinion, the important causative factors were cold and immobility leading to venous stasis, impaired nerve conduction, a disruption in vasomotor function, and eventual destruction of the limb's vitality. At a meeting of the Third Corps Medical Society, the view was expressed that pressure on the circulation was a major factor in causing trench foot.[14] An editorial in the *British Medical Journal* put most of the blame on puttees, part of the men's kit, beginning with a definition of this garment: ''The word *patti* is the ordinary Hindustani (Hindi) term for a bandage of any kind, and has now become naturalized in English under the form puttees (plural) to denote the woolen bandages worn round the legs with some forms of uniform.''[24] The British army had adopted these garments in 1870 to protect the soldiers' legs from thorns during marching. However, they gave little protection once wet and constricted the leg's circulation. To back up his ideas, the author referred to a rather obscure passage in a book written by the explorer Sir M. Conway, entitled *The Alps from End to End*:

> *We trudged over snow slopes and a zigzag path to the desolate Col de Cochons or de Berard, which divided the Belvedere from the Buet. No walk was ever so toilsome to me . . . It was only late in the afternoon that a cramp revealed my* pattis *as the cause. They were bound too tightly round my legs. Be warned, therefore, ye who take to* pattis.[25]

This was not a very scientific argument, but would have appealed to some members of the medical profession. Further evidence for this causation was the fact that Belgian soldiers, who rarely wore puttees, were hardly ever affected by trench foot.[25] In contrast, Captain F. G. McLoughnane, Surgeon to the Meerut Stationary Hos-

pital, Boulogne, returned to a broader etiology.[26] He considered the condition was brought about by a number of contributory causes, all tending to produce circulatory stasis, namely cold, wet, fatigue, puttees, and prolonged standing. However, he attributed most blame to the footwear:

> *In regard to boots a vicious circle develops. The wet leather shrinks and presses on the feet, thereby setting up traumatic inflammation and swelling, which swelling in turn increases the pressure from the boots. I think that in most cases ill-fitting and too-tight boots are direct predisposing causes, though they are aggravated and brought into play by constant cold and wet.*[26]

Gradually, the consensus emerged that trench foot stemmed from a compromise to the circulation of the lower limb, with factors such as cold, wet, pressure, immobility, and lack of exercise being contributing factors. These were all conditions common in trench warfare. In addition, the disease could also be exacerbated by the soldiers' trench equipment, with both the putti and the standard issue boot being blamed. The official stamp of approval was placed on what could be termed the exposure/circulatory theory when Sloggett issued an Army Routine Order on trench foot in October 1915, which proclaimed: ''Condition caused by prolonged standing in cold water or liquid mud in the trenches, and their onset hastened by tight boots, tight puttees, and everything calculated to interfere with the blood circulation.''[13] This order was reprinted in *The Lancet* at the beginning of 1916.[27]

Concurrent with the exposure/circulatory theory was the question of whether nutrition played a role in causation. The involvement of diet conformed to pre-war ideas regarding temperature regulation, with experimenters finding that men who were starved were unable to resist the negative effects of cold.[29] An editorial, appearing in *The Lancet* in December 1915, proposed a significant role for dietary factors.[29] The author believed that the heat lost through exposure to cold water might be as great as the total number of calories derived from food in a 24-hour period. He added: ''If the soldier is using his entire food ration to warm the water of the trench in which he stands, he evidently has nothing over for his personal needs. He is exactly in the position of a man from whom food is entirely withheld.''[29] In fact, a number of authors expressed concerns about the soldiers' diet. For example, Surgeon-General C. E. Nichol, DMS Fifth Army, attended a conference in December 1916 where he spoke on the poor nutritional status of his men and the lack of availability of fresh meat, bread, and vegetables.[30] He emphasized that good food was required to both energize the men and protect them from disease.

The environmental/circulatory causation for trench foot strongly conformed to accepted ideas about lower limb physiology and temperature regulation.[28] Because of this, infective theories did not gain many supporters. However, 2 French officers, Médicin Majors V. Raymond and J. Parisot, were involved in circulating a memorandum to the Allied Forces in 1916, asserting that trench foot was caused by a specific infection.[31] They also claimed to have isolated the agent, the mold *Scopulariopsis koningii*, from trench mud. A culture of this organism, when inoculated into animals, produced all the symptoms and signs of trench foot, conforming to the postulates of Koch. Raymond and Parisot hypothesized that their microbe gained entry to the feet at the grooves on the side of the nails or through scratches on the skin. In addition, cold facilitated entry of the fungus and was therefore of secondary importance.[32] This was an influential theory, which was debated in the British camp. In January 1917, Sir William Leishman, Pathological Advisor to the BEF, was telephoned by Major Black at GHQ, who had recently met with Colonel Dopter, his French counterpart.[33] Black had been informed by Dopter of the importance that the French attached to Raymond and Parisot's research, which pointed to the condition being largely of microbial causation.[33] After reviewing papers on the subject, Leishman expressed the view that the French conclusions were doubtful.[33] It is not really surprising that the British, who had firmly taken the position that exposure was the primary cause of the condition, did not accept this theory, and Leishman was not the only British officer to disagree with the findings. For example, Major P. Turner wrote to *The Lancet*: ''I do not think that many will agree with Majors Parisot and Raymond that cold and wet are only of minor importance.''[34] Subsequently, the British were proven correct in their skepticism: at a meeting of the Interallied Congress of Hygiene in 1919, Dr E. Roux, Director of the Pasteur Institute, proclaimed that the conclusions of Raymond and Parisot had been soundly discredited.[35] Writing in the official history of the US Army Medical Department, Lieutenant-Colonel F. W. Weed agreed that the Frenchmen's theories had ''not [been] confirmed by other investigators among whom there was a unanimity of opinion that trench foot is not an infectious disease.''[36]

There were those who took a multifactorial perspective on the causation of trench foot, considering a combination of environmental, dietary, and infective factors. Major C. G. Watson and Captain C. S. Myers, for example, argued that exposure to wet and cold in the harsh environment of the trenches upset the normal equilibri-

um between the capillary walls and the blood.[37] When a man removed his boots, the circulation was restored, causing lymph to swell the surrounding tissues. Of the 152 men from 22 regiments admitted to their ward with the condition, two thirds had come from units that had just returned from India, Egypt, or Malta. Watson and Myers added: ''It is therefore probable that want of recent adaptation to cold and wet may be a predisposing influence.''[37] Nevertheless, they also stated that clinicians should consider the invasion of ultramicroscopic organisms in trench foot.[37] They believed that cases showed a susceptibility to the attack of certain microbes, especially *Staphylococcus albans*. Writing in the *Journal of the Royal Army Medical Corps* in 1916, the consultant Soltau also gave microbes a role in the etiology, reporting that cultures from cases of trench foot had revealed a streptococcus in both superficial blebs and deeper structures.[20] However, in the same article, he provided support for the environmental/circulatory theory, stating that he was particularly impressed by the number of hours that the men spent almost motionless in the trenches. In this situation, the help muscle contraction afforded to the circulation was lost. He presented his ideas at a meeting of the Second Army Medical Society at the Northumbrian Combat Casualty Station (CCS), Hazebrouck, which ''brought forth much discussion.''[38] Another MO, Captain B. Hughes, considered nutritional, environmental, and infective factors in the disease's causation.[39] From October until the end of December 1915, he was attached to a regiment that was holding a section of line where trench foot was widespread. He set about proving a role for diet in the etiology of the condition. Hot soup, made from bones, meat extract, and vegetables, was given to the men daily. With this extra nutritional input, the health of the men improved significantly, and the number of cases of trench foot also declined. Hughes noted: ''This suggested that by an improvement in the general health of the men, by giving stimulating hot drinks at night with a rum issue at stand-to in the morning . . . we might hope to get rid of the condition entirely.''[39] However, despite these measures, it did not disappear as he had first hoped. Subsequently, he described an incident that he believed might be connected with the etiology:

> *I was doing my round of the trenches . . . and incidentally stopped to rest on the fire-step with my legs hanging down. I was surprised to find that at the end of the three minutes my feet had 'gone to sleep', there was the sensation of pins and needles, and the feet felt numbed. Thinking this might be a coincidence; I tried it on two successive occasions, only to find that the same thing happened each time. After the third time my feet in the morning were tender, and decidedly swollen, so that I could not get my boots on.*[39]

Hughes, therefore, concluded that another aspect of the trench environment, the trench's structural design, might be connected with cases of the disease. Insisting that his men lie with their feet up on the fire-step when resting, he later noted with satisfaction: ''Since taking this precaution we have had no cases of trench feet over a period of twelve days in the trenches. This is not a coincidence, I think.''[39] Importantly, Hughes also considered an infective cause for the condition.[39] All of his cases had been on active duty in a ''wet sap.'' On examining their boots, socks, and feet, he found that their footwear was letting in mud. This implied that the origin for the disease could lie in the ''soupy'' mud of the trenches, which was full of decomposing organic matter. In fact, he discovered that those men who had succumbed to trench foot had socks that emitted a fecal odor, a smell similar to wounds contaminated with gas bacillus. He believed that this could be due to the multiplication of organisms derived from the liquid mud. However, opposing this theory was the fact that the socks of healthy men, including his own, reeked in an almost identical fashion. Furthermore, when he issued rubber boots, preventing the men's feet from becoming muddy, trench foot continued to plague his battalion. Both these pieces of evidence seemed to disprove a microbial cause. Hughes concluded, therefore, that there were 2 causative factors. The first was a predisposing factor, namely fatigue. The second was an exciting factor, namely venous stagnation, with exudation of fluid into the tissues of the foot. This work was influential and was referred to in the *Official History of the War—Medical Services,* which noted that the provision of hot food was a factor that had led to a decline in the incidence of the disease.[40]

There were 4 major investigations of the etiology of trench foot. Working in Edinburgh, Professors J. L. Smith and J. Ritchie and Dr J. Dawson reproduced animal models of trench foot and provided evidence that trench foot was caused by cold and its direct effect on the blood vessels of the foot and not to bacterial invasion.[41] They were supported by the Medical Research Committee, making their findings influential. Research done by Professor Sheridan Delépine[42,43] and Dr N. C. Lake[44] in England, and the Americans Majors J. E. Sweet, G. W. Norris, and Lieutenant H. B. Wilmer,[45] working at a general hospital in France, supported an alternative explanation that the essential pathological mechanism was a vasomotor reaction. However, although they gave different explanations, all these studies supported the exposure/circulatory theory—trench foot was a physiological condition, predisposed to by cold,

wet, and pressure—conditions prevalent in the trenches; infective theories were largely rebuffed. *The Official History of the War—Medical Services* proclaimed: ''Trench foot is generally considered to be caused by cold, wet, and the effects of pressure. Bacterial invasion . . . has been regarded as a secondary infection resulting from the lowered resistance of the tissues.''[46]

## Labeling

An article in the February 1915 edition of the *British Medical Journal* reported that the term ''water-bite'' had been widely used to describe the condition.[18] An editorial, published in *The Lancet* in April of the same year, listed the various names that had been used, including ''trench foot,'' ''chilled foot,'' ''trench frost-bite,'' and ''boot-bite.''[12] However, the author was in favor of the term ''trench foot'':

> *It is better to employ a non-connotative name, and on the whole the term trench foot appears to be the most suitable for a condition which has practically only been met with in those who have had to remain for long periods in the trenches.*[12]

At a meeting of the Third Corps Medical Society in December 1915, Colonel W. W. Pike stated that GHQ had decided that the disease was to be known as ''chilled-feet.''[14] Furthermore, he complained that the term ''trench feet'' was a ''wash out'' and added: ''from the mere fact of calling them 'trench feet', the soldier expects to get them in the trenches.''[14] However, the expression ''chilled-feet'' seems to have been used only rarely in the medical literature, and official sanction for the expression ''trench foot'' came at the beginning of 1916. On 4 February, Sloggett received a copy of an Army Council instruction, dated 31 January, which stated that to ''ensure uniformity in statistical returns,'' the condition would in future be referred in all admission-and-discharge books and in medical returns as ''trench foot.''[47] Appended to these instructions, were extracts on the condition from the latest *Memorandum on the Treatment of Injuries in War.*[48] Sloggett forwarded copies of this publication to all those in authority. After this time, the term trench foot seems to have been used on an official basis[49] and was the name attached to the disease in the *Official History of the War—Medical Services.*[46]

## Threat

Trench foot constituted a grave problem in the British army. No. 6 CCS first encountered the condition in October 1914.[50] In December, its Commanding Officer (CO) noted that a large number of cases with inflamed and swollen feet had been admitted.[50] In the same month, W. M. Floyd, an orderly in the St John's Ambulance Brigade, wrote that cases of trench foot were very prevalent.[51] A stretcher-bearer, G. Swindell, also mentioned it as one of the most frequent conditions that he had encountered in the trenches.[52] In October 1915, Captain H. W. Kaye wrote in his diary: ''We have cases of 'trench foot' every day now—quite a dozen yesterday . . . It is a serious problem as once a man gets it I understand he is useless for this war again throughout the winter.''[53] In an article entitled ''Flanders Foot,'' J. C. McWalter stated that the condition had ''thrown hundreds, if not thousands, of men out of action.''[54] These reports document the evolution of the epidemic from a bothersome one to a plague that incapacitated thousands. However, lessening the threat from trench foot was the fact that it followed a seasonal variation, with a peak in the winter months.[55] The total number of admissions during the war was calculated as 74 711 with 41 deaths, giving an average admission rate of 14.45 per 1000 men.[55] The American army, who only experienced 1 winter fighting in France, reported 1987 cases of trench foot with only 5 deaths and an admission rate of 0.54 per 1000 men.[56]

With proper treatment, most men would regain full functioning of their lower limbs, unless they had developed gangrene that necessitated amputation. Furthermore, a number of soldiers were pensioned off with trench foot, imposing an economic burden on the state.

## Treatment

Therapy for trench foot involved a number of conventional, tried-and-tested methods, including deep cleansing, the application of ointments, fomentations, exercise, massage, galvanic baths, and electrotherapeutics. This approach was based on the general belief that the condition was caused by circulatory changes in the foot caused by cold, wet, and pressure, and not by an infectious agent, which meant that treatment was largely localized to the lower limbs, physical, symptomatic, and not aimed at killing microbes. In addition, more innovative techniques were attempted, such as the subcutaneous injection of oxygen.[57] In cases of severe gangrene, surgeons still had to resort to amputation, though they agreed that this should be only a last resort.[9]

## Prevention

Because it took many men a long time to recover from trench foot, leading to manpower shortages, preventative measures were emphasized. For example, a circular

drafted by the surgeon Sir Arthur Bowlby, sent to all COs in February 1915, stressed that wastage from trench foot should be regarded in the same light as wastage from wounding, and every precaution taken to avoid it.[58] The importance of keeping the feet warm, dry, and unconstricted by tight boots or puttees was soon realized. Consequently, 3 major preventative methods were adopted—general measures to improve the trench environment; modification of the footwear worn by the men; and the provision of greases to protect them from moisture. Close surveillance of the condition also proved important, as did discipline and teamwork.

## Conclusion

Trench foot first appeared in the winter of 1914 and became a serious threat to men in the trenches. The opinion emerged that trench foot was caused by circulatory changes in the foot due to cold, wet, and pressure. Predisposing factors included dietary inadequacy and fatigue. All these features were very much associated with trench warfare—the men were fighting in a cold and wet environment, were tired and hungry, and were wearing puttees and footwear that afforded insufficient protection against these conditions. The environmental/circulatory theory was so strong because it conformed to accepted ideas about lower limb physiology and temperature regulation. The medical reaction to this condition seems to have been relatively effective. The causation was identified, and prophylactic measures were introduced to fit this model; these seem to have been successful in reducing the admission rate from the condition by 1917–18.[59] However, this period also coincided with the ending of trench warfare.

## Epilogue

Although trench foot was accepted as a new disease during World War I, subsequent historical analysis has recognized that this condition has occurred in many military campaigns throughout history, including the Balkan Wars of 1912, the Crimean War, and Napoleon's campaign into Russia, among others.[60]

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