Trench "frost-bite" : some observations on cases admitted to the Duchess of Westminster's War Hospital / by C. Gordon Watson and Charles S. Myers.

TRENCH "FROST-BITE."

Some Observations on Cases Admitted to the Duchess of Westminster's War Hospital.

BY

C. GORDON WATSON, F.R.C.S.,

MAJOR R.A.M.C., COMMANDANT,

AND

CHARLES S. MYERS, M.D.,

CAPTAIN R.A.M.C., REGISTRAR.

Reprinted from the BRITISH MEDICAL JOURNAL, *March 6th, 1915.*

LONDON:
PRINTED AT THE OFFICE OF THE BRITISH MEDICAL ASSOCIATION,
429, STRAND, W.C.

1915.

TRENCH "FROST-BITE."

EARLY in December last a number of men suffering from "frost-bitten" feet were admitted into the Duchess of Westminster's Hospital at Le Touquet, usually after a few days in a clearing hospital, and other cases have been admitted since. The following observations, taken from an analysis of these cases, seem to us worthy of record.

History of Onset.

Such a case as this may be regarded as typical:

CASE I.

Sergeant W. N. marched eight miles to the trenches, which he entered with wet feet. The trenches were very muddy; rain fell at first, frost occurred on the second, and snow fell on the third day. He woke on the third morning in the trenches to find his feet "stone cold" and numb. His feet continued numb although he walked about. He felt pain in them for the first time two days later, on marching to his billet six miles away, which he reached with great difficulty. There he took off his boots, changed his socks, and rubbed his feet, but did not wash them. He slept that night without pain, but the next morning his feet were so swollen that he could not get his boots on. He "reported sick." The feet began to be again painful after he had been in hospital for two days.

"Exposure to cold and wet" would be a more suitable name to apply to these cases than "frost-bite," for in some instances the feet were affected in the absence of actual frost. There were a few instances, too, in which the feet only began to show signs of being affected some days after the patient had left the trenches.

In the slighter cases, especially when the patient left the trenches after only two or three days' exposure, no swelling of the feet occurred, but only numbness followed by pain. In one of the severer cases, on the other hand, the swelling was said to have burst the bootlaces. In several instances the patient managed to remain on duty by wearing larger-sized boots.

The pain before admission was variously described as "burning," "throbbing," "like pins and needles," "like electricity." In two cases it was attributed to the "boots getting tight" and compared to "a tight string running up between the laces and across the ankle." Generally, the pains increased as the swelling diminished, when the shooting pains, described below, usually began. In a few

cases, however, the pains in the toes were preceded by "cramps" in the legs and pains in the knees.

At this stage, when the boots were removed before or at the onset of swelling, the feet were found to be not only cold but often discoloured—that is, "dark blue," "black."

Sometimes the swelling and pain were not preceded by any noticeable numbness. When present the numbness was usually confined to the feet, but occasionally extended up the legs.

The percentage frequencies of the occurrence of numbness, swelling, and pain were 34, 68, 82 respectively. In by far the majority of cases this was also the time-order of their appearance.

Some of the patients had been instructed by their officers to warm their numbed feet at the fire or to wash them with warm water; others had been warned to avoid warmth, or had been told to rub their feet with oil or grease. Such initial treatment did not seem appreciably to affect the subsequent severity or course of the symptoms.

Condition on Admission.

Many of the patients were suffering from the effects of general fatigue and insomnia.

At the time of their admission the swelling in their feet of which the patients had complained had in most cases disappeared. But this was not always so; and in one case not only were both feet swollen and tender on admission, but the swelling extended up to the middle of the calf. The feet were at this period generally normal as regards temperature; they were often flushed, especially at the toes and still more often sweating freely.

In a few cases, especially where the feet were still cold, discoloration was still present, the toes most frequently being cyanosed. In one case both feet showed a purple mottling, which extended up to the knees. In a small number of cases (4 per cent.) haemorrhage had occurred, usually beneath the nail of the hallux. In a few instances the toes presented a polished appearance. Desquamation was common.

In the great majority (89 per cent.) of cases the skin surface was unbroken; these constitute what we shall term the "first degree" group. In the remainder (11 per cent.) blisters had appeared on the skin, which had usually (in 82 per cent. of these cases) broken before admission, and in some instances had given rise to a definite ulcer. The cases (9 per cent of the whole) in which the surface of the epidermis was thus interrupted we shall term the "second degree" group. Still rarer (2 per cent.) is the "third degree" group, in which the deeper dermal tissues were involved; these cases showed all the appearance of dry gangrene. In one of them the necrosed part of the hallux was bounded by a swollen red area and by a bleb containing pus, from which *Staphylococcus albus* was cultivated. (For a more detailed description of these severer cases see Cases x to xv at the end.)

Mobility.—Often the toes, and sometimes the ankles, were stiff, and their mobility was much diminished or absent. The toes were occasionally in a condition of hyperextension. Even in the slighter cases movements of the foot could often only be carried out with pain and difficulty. Walking had become so painful that in many cases this had been the cause of the patient "reporting sick."

Reflexes.—The knee-jerk, when examined, was found to be normal, save in one case, in which the legs were held very stiffly in the position of talipes equino-varus; in this instance an unusually brisk reflex was observed.

Sensibility.—In the majority of the cases there was either definite anaesthesia (65 per cent.), or numbness accompanied (15 per cent.) or unaccompanied (11 per cent.) by some diminution in sensibility. Thus only in 9 per cent. was there an absence of numbness or lessened sensibility. Hyperaesthesia was recorded in 15 per cent. of all the cases, very rarely without anaesthesia elsewhere. In one case the hyperaesthesia disappeared with increasing pressure of the fingers on the foot.

The plantar surface of the hallux was the seat of the most extensive and severe disturbance of sensibility. Less commonly its dorsal surface was also involved, and still less commonly the plantar and dorsal surfaces of the other toes. In a few cases the whole foot was anaesthetic, and in two cases the anaesthesia extended up the leg.

There seemed to be no constant relation between the disturbances of sensibility and the other symptoms observed. In one case both feet showed areas of hyperaesthesia, but the right foot was hotter, and showed a severer anaesthesia. In another case both feet were equally anaesthetic, but the right foot sweated more and was more painful than the left. In two cases the warmer foot alone showed hyperaesthesia. In one case only the toes were swollen, numb, and cold, but were not definitely anaesthetic. In two of the three cases of the "third degree" no anaesthesia was found outside the gangrenous patch; in a case of the "first degree" it was most marked over the areas of discoloration.

Sensibility ("epicritic") to light touch (cotton-wool), and the discrimination of double touches (compass points) and of differences of temperature (warm and cool tubes), appeared to be lost or diminished together. Sensibility ("protopathic") to painful (needle prick) stimuli—no investigations were systematically carried out with very hot and cold stimuli—was usually the last to be lost, and the first to return during recovery. On its return pain was found to be badly localized, having a radiating character; by one patient a prick was described at this stage as "ticklish," by another as "scratchy," "shooting," "as if you were rubbing it with your nail." Frequently before a prick could be recognized as such, it produced in the patient the illusion that he was being touched by the finger or a pencil.

The area of anaesthesia was rarely (the exceptions, 6 per cent., being all, save one, slight cases) confined to one

foot, though one foot often suffered more than the other. Thus in one case the condition was as follows:

Right Hallux.	*Left Hallux.*
Prick at first lost, later described as "ticklish."	Prick at first lost, later present as pain.
Light touch at first lost, later present save at tip and over plantar surface of terminal phalanx.	Light touch at first lost, later regained entirely.
Right Foot.	*Left Foot.*
Discrimination of temperature differences absent.	Discrimination of temperature differences later present.
Spatial threshold (compass test) more than 30 mm. over middle toe.	Spatial threshold (compass test) 15 mm. over middle toe.

As a rule sensibility returned first over the proximal and later over the distal phalanges of the toes.

Several patients complained of alternating temperature (subjective) of their feet—for example, "they feel hot and cold alternately," "they feel cold by day and hot at night," "they shoot in the day, but are cold at night."

As a rule, the pain was greatest or occurred only at night; very often it prevented the patient from sleeping. In the severer cases the early throbbing or burning pain gave place to pains of a shooting character, and no longer remained localized, as before and as in the slighter cases, in the hallux or toes or balls of the feet; it now "ran up the legs" to the knees or even (in 2 per cent. of the cases) to the hips. One patient referred the pain produced by squeezing the toes of his foot to his knee.

Body Temperature.—Only in the severer cases—especially in those in which the foot was blistered, flushed, or sweating, and the mobility of the toes was lost or much diminished — the temperature rose slightly (to about 99° F.) at night.

Treatment and Progress.

Most of the patients remained in this hospital only for a week or ten days, before being sent to England or the base; consequently little can be said under this head. The pain and insomnia were generally relieved by acetylsalicylic acid. Cases of the "first degree" were treated by gentle massage, or by belladonna or camphor liniment, or (to relieve the hyperaesthesia) by 1 in 40 carbolic acid compresses. Some underwent no local treatment. In cases of the "second degree" fomentations were applied, followed later by gauze dressing. Picric acid in solution was employed in two cases of the "third degree."

It is hence impossible to compare the efficiency of these different modes of treatment. All that can be said is that every case—even the gangrenous cases—made remarkably good progress. The patients left this hospital, walking better than when they entered it; though a few were still unable to walk on their discharge. In several cases a return of the swelling of the feet was noticeable when first the patients began to walk, and at this stage there was a general complaint of pain, mainly, or only, when they began to put their weight on their feet. The pain

was usually over the balls of the toes; such patients consequently hobbled on their heels. Sometimes the pain in walking was felt in the ankles and legs.

Only the very slight cases recovered sensibility here completely. Even in cases of only moderate severity progress was in this respect surprisingly slow, considerable areas of anaesthesia remaining after a fortnight's rest. A characteristic feature of the anaesthesia was its variation from day to day, sometimes diminishing, sometimes increasing in extent and severity.

Unusual Cases.

The following instances of complications and of deviations from the normal course hitherto described may conceivably help to elucidate the nature of the affection.

Attention has already been drawn to one case which showed a purple mottling of the feet extending to the knees. Another case presented the following history and condition:

CASE II.

Captain R. C. C. On December 5th (six days before admission here), after several cold, wet days in the trenches, he found his legs numb, cold, and useless. Presently they became painful up to the hips, especially at the knees. There was some stiffness across the loins and tingling in the feet. On admission both legs were stiff and tender, especially in the region of the knees and above them. Over the inner aspects of both knees, but rather below the level of the joint, were large areas of yellow bruising, not traceable to any definite injury, unless to kneeling in cold water for three hours during a four hours' spell. The soles of his feet felt "like lumps of raw beef." There was much tenderness along their outer margins, and also over the dorsum of both feet. The left foot was the more tender. Drawing a sock over the left toes evoked a yell of discomfort. Light touch could be felt on the plantar surfaces of the feet; but he imagined a plantar prick, distal to the centres of the metatarsals, to be the touch of a finger. On both halluces a prick was recognized over the dorsal surface of the distal phalanx, but over that of the proximal phalanx it was called a scratch. On the dorsal surface of the terminal phalanges of the second and third left toes a prick was not felt at all, in the case of the fourth left toe it was called a touch, and on the fifth left toe "certainly not a prick."

In the following cases, also, other regions were affected in addition to the feet:

CASE III.

Private S. M. On November 20th (fourteen days before admission here), after having been three days in the trenches, the patient felt his feet to be "dead." On walking back to rest, his ankles ached and his right knee also. His ankles swelled, but were not red. The next day his toes became slightly discoloured, but after two days the discoloration disappeared.

CASE IV.

Private H. B. On November 24th (ten days before admission here), he noticed on coming out of the trenches that his toes were discoloured. For a week previously he had had aching pains in both knees and ankles. On November 27th he had pain in and swelling of the right elbow. On admission he complained of pain over the tubercle of the right tibia and internal condyle of the right femur, and a slight swelling, without redness, was here noticeable. Over the olecranon of the right elbow there

was slight pain, but no swelling. On both feet (which were of normal appearance and temperature) anaesthesia was present over the first three toes and the ball of the hallux, and hyperaesthesia over the fourth and fifth toes and instep.

CASE V.

Private F. W. was admitted to clearing hospital on November 30th, and to this hospital on December 4th. On December 7th, in addition to extensive anaesthesia of both feet, the two terminal phalanges of the middle, ring, and little fingers were found to be "numbed."

CASE VI.

Private J. E., on November 25th (nine days before admission here), while in the trenches found his feet were swollen. He remained three more days in the trenches and when he came out he was unable to walk. He first noticed that his fingers were tingling on his journey in the train to this hospital. On admission he complained of his fingers "feeling twice as large as usual"; no anaesthesia, swelling or other abnormal appearance could be detected.

The difficulty of movement of the toes and occasionally at the ankle-joints in many cases has been already mentioned. In the following two patients, admitted at the same time, difficulty of movement without "frost-bite" was also present.

CASE VII.

Private E. W., fourteen days after admission here began to have pains in his ankles, later in his knees and back. On admission his heart and temperature were found normal. The movements of the legs were carried out with great caution and with great rigidity. He complained two days later of shooting pains in the legs.

CASE VIII.

Private A. G., nine days before admission here began to complain of cramping pains in the back and legs. On admission his heart and temperature were found normal. There was much stiffness of the back and lower limbs, the pains being vague, widely spread, and apparently muscular.

The cultivation of *Staphylococcus albus* from a bleb at the margin of the area of necrosis in a case of the "third degree" has been already mentioned. Beside this case may be placed the following:

CASE IX.

Private J. N. In the trenches between November 12th and 19th, 22nd and 25th, and November 28th to December 1st. Boots not removed between November 22nd and December 1st. Feet continually wet. No swelling of the feet. Since November 26th numbness and coldness of both feet. On November 29th, when "stamping" feet in order to get warm, his legs gave way at the knees, and he fell to the ground. On December 1st he walked to hospital, a distance of 1,000 yards, in one hour and three-quarters. He had never warmed his feet. On admission here, December 4th, his feet were found to be cool and of normal colour. He complained of a "numbish ache" over the metatarso-phalangeal joints of both feet. Voluntary movement of the toes was much diminished. Sensibility to light touch was lost on the dorsal and plantar surfaces of both halluces and on the two next toes of the left foot. Sensibility to prick was lost on both surfaces of the left hallux. The loss extended in each case to the metatarso-phalangeal joint. The remaining toes showed diminished sensibility to light touch

and prick. He complained of giddiness and falling when getting on his legs during the first three days after admission. Heart and temperature normal; some flatulence.

December 13th. Patient much improved; now getting up. This morning he noticed a sore on the right shin. At its centre was found a pustule, ¼ in. in diameter, surrounded by a dusky blue and a wider oedematous area. It resembled so closely the pustule of anthrax that a bacteriological examination was immediately made. There was no glandular tenderness, and there were no constitutional symptoms. The patient had not received a kick, nor had he been exposed to any obvious source of contagion. The inflammation disappeared in the course of a few days. A film of the exudate from the pustule showed no pus cells, no organisms, only a few large mononuclear leucocytes and epithelial cells. A culture of the exudate on agar-agar grew a white staphylococcus.

Pathology.

Frost-bite attacks especially those parts of the body which are most exposed to the air; it occurs in extremely cold, "arctic," weather. But in the cases here considered the patients had not been exposed to cold of very great severity; and the regions chiefly affected are those which had been most exposed, not to cold only, but to continual wet and cold.

As in ordinary frost-bite, so in these cases the lesion is no doubt primarily vascular, but it is less severe, more "chronic," in character. Accordingly, actual gangrene is extremely rare, but the nervous, and perhaps the circulatory, disturbances are of longer duration.

It may be supposed that when an area of the body is exposed for some days to wet and cold the numbness which is felt is due to constriction of the arterioles of the region. At this stage a complete and rapid recovery ensues when the part is removed from its previous environment, especially if it be subjected to gentle massage.

Further exposure to wet and cold must upset the normal equilibrium between the capillary walls and the blood. Extravasation and mottling or discoloration, with some oedema of the skin, will occur, and at this stage a definite neuritis begins, owing to malnutrition and the action of toxic substances.

Thereupon the patient usually manages to improve his environment. He takes off his boots and perhaps rubs his feet. Owing to the removal of the pressure of his boots, or owing to the restoration of the blood circulation, lymph pours out into the surrounding tissues and the feet swell.

In the severer cases, when the swelling, if occurring, has subsided, the feet often remain flushed and secrete sweat abundantly, the result, probably, of disturbance in the function of the nerves supplying the blood vessels and sweat glands. At this stage there is well-marked anaesthesia or hyperaesthesia and some loss of movement.

Bearing in mind that none of the three cases of the "third degree" showed hyperaesthesia, and that in only one of them did the anaesthesia spread beyond the area of gangrene, we suggest that in continued bloodlessness of a part of the foot the neuritis is much less pronounced than in a temporary interference which later passes away and

allows of a freer diffusion of toxic products into the tissues.

Certain cases already described establish a close relation, if not a transition, between the neuritis thus arising and that due to so-called "rheumatism." In this connexion the possible invasion of ultramicroscopic organisms may be worth consideration. A susceptibility certainly appears to be shown to the attacks of micro-organisms, in particular to *Staphylococcus albus*.

On the other hand, in some cases the disturbances of sensibility were complicated by the general mental condition of the patient. Nevertheless, that they are to be regarded as primarily the result of a local "organic" neuritis rather than of a central "functional" dissociation, we have not the slightest doubt.

Of the 152 men admitted, belonging to twenty-two different regiments, more than a third (37.5 per cent.) came from two regiments, both of which had just returned from India. Of the remainder more than a third (41 per cent.) came from three other regiments, of which two are known to have been sent to the seat of war from Egypt and Malta. It is therefore probable that want of recent adaptation to cold and wet may be a predisposing influence.

That the hallux should be the part of the foot which suffers most severely recalls its proneness to attacks of gout. Perhaps the blood circulation is more liable to obstruction in the hallux than in the other toes.

The notes of the cases have been taken by Captains S. R. Scott, F.R.C.S., W. P. S. Branson, F.R.C.P., Harold Pritchard, M.R.C.P., C. S. Myers, M.D., T. M. Body, M.R.C.S., Lieutenant J. S. Burn, B.C., Messrs. L. T. Giles, F.R.C.S., J. P. Hedley, F.R.C.S., H. R. Robinson, and H. S. Crichton Starkey, M.B. The Registrar's work was facilitated through an initial analysis by the last named. The photograph of the last case was taken by Lieutenant Dudley Stone, M.R.C.S., radiographer to the hospital.

Severe Cases.

The following are the notes of the severe cases to which reference is made earlier:

Case x.—*Necrosis of Skin.*

Private R. F., admitted November 16th, 1914, had sustained a perforating bullet wound of lung and haemothorax. He was severely ill with the condition of lung and pleura. About three days after admission, when his feet "began to get warm," he noticed "pins and needles" and pains in both feet worse in the right. It was then noticed that there was an area of skin on the sole of the right foot which appeared to be bruised and which was anaesthetic. The skin on this area gradually necrosed, and eventually sloughed off. Treated by fomentations. There was no anaesthesia in the toes.

The history of his frost-bite was as follows. While in the trench he was able to walk up and down, and so his feet never got numb. After being hit he lay in the trench twelve hours, until bearers came and took him to the dressing station. Exposed in the open trench that night to hail and cold, he felt his feet becoming numb, and finally he lost all feeling in them.

At the dressing station his stretcher happened to be in front of the fire, and consequently his boots and stockings steamed (he could not feel the heat of the fire). When his boots were seen to be steaming they were taken off, and a hot-water bottle was placed on his feet, but he could not feel it. He left the dressing station in the evening for the train journey to this hospital. He says that he could not feel his feet properly until fourteen days after admission.

CASE XI.—*Necrosis of Skin.*

Private R. C. was admitted on December 3rd, 1914. About ten days earlier he noticed that both his feet felt very hot. He left the trenches that night, and took off his boots when he got to his billet. Next morning he noticed that both his feet were much swollen, and he had much trouble in getting his boots on, and only succeeded by slitting them down either side of the tongue. He then did another three days' duty in the trenches, and again returned to his billet for a night's rest. He went back for another four days in the trenches, but suffered severe pain in his feet. On his return from the trenches he did not take his boots off, as he had to appear in a review before the King. That night he was on sentry duty for three hours, and on the next day he did a day's digging. He was then told to march two miles to draw rations, which he was unable to do; he reported himself sick. He found a large swelling under the big toe of his right foot. At the hospital, while the surgeon was examining the ball of this big toe, the swelling burst, and the skin was then cut away. The patient thinks the skin cut away was "white with some blue about it."

On admission the right foot was anaesthetic from the tips of the toes to about midway between toes and heel. The toes of the left foot were numb, but not completely anaesthetic. There was hyperaesthesia on pressing the toes in both feet. On the plantar aspect of the right foot there was a patch of gangrene involving the entire thickness of the skin. The margin was red and inflamed.

One week later the gangrenous area was sharply defined and the island of skin black and dry; sensation over the remainder of the foot had returned. Hyperaesthesia on pressure was still present, the left foot was practically normal. The right foot was painted with a solution of picric acid and spirit and covered with sterile gauze. It healed well.

CASE XII.—*Ulceration.*

Private A. D., when admitted on December 3rd, 1914, had an ulcer on the great toe of the right foot. The toe was completely anaesthetic, but the remainder of the foot normal. Prior to the appearance of the ulcer the toe had been greatly swollen for several days while in the trenches.

CASE XIII.—*Local Asphyxia of Skin.*

Private C. A. S., two days prior to admission on December 11th, 1914, took off his boots and was unable to get them on again owing to swelling of the feet. On admission both feet were red and swollen up to the ankles, the right being worse than the left. Over the head of the fifth metatarsal of the right foot there was a patch of dark blue skin, and below the external malleolus there was a patch of bright red skin. Both feet were extremely sensitive and hyperaesthetic.

CASE XIV.—*Necrosis of Skin.*

Private W. B. was admitted on December 3rd, 1914. Five days previously he noticed that his right foot felt cold and sore. There was not much pain in nor did it swell much. On admission the skin over the terminal phalanx of the right hallux was found to be gangrenous; a clear line of demarcation surrounded the gangrenous area. The skin over the dorsal sur-

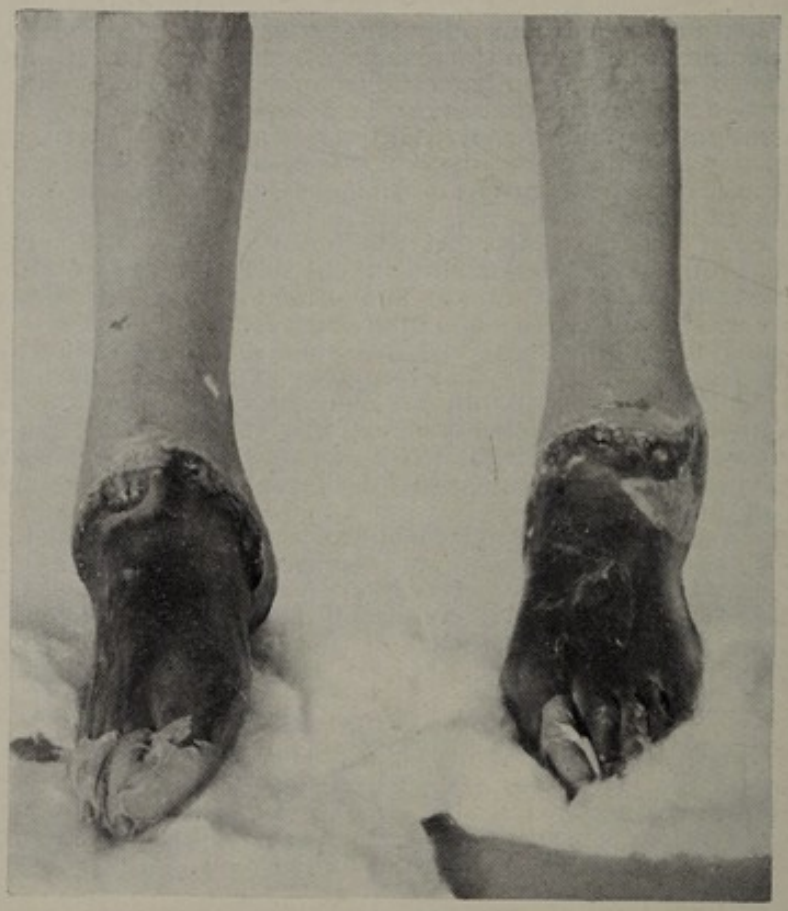
face of the first phalanx of the hallux was red and swollen. At the root of the nail was a small collection of pus from which *Staphylococcus albus* was cultivated. The swelling and redness gradually disappeared after treatment by fomentations.

The patient never experienced any pain or hyperaesthesia. There was an area of tactile anaesthesia, which involved the right hallux; there was no anaesthesia elsewhere, and no hyperaesthesia.

CASE XV.—*Gangrene of Feet following Exposure in a German Soldier.*

Private A. D. (German prisoner of war) was admitted on November 17th, 1914.

This case, although not arising through exposure in the trenches, is here added as an extreme example of frost-bite.



Case XV.—Gangrene of feet following exposure (German soldier.)

On November 3rd he was hit in the buttock and in the middle toe of the left foot, probably by German fire during an attack on British trenches. He fell and remained in a wood for four or five days with very little food and exposed to much rain and cold (not frost). He cut off his boots on the second day, as he found that his feet were swollen and that he had no feeling in them. Unable to walk, he gave himself up to British troops, whose attention he managed to attract. On admission both feet were swollen, bluish-black, oedematous, cold, and insensitive. There were many large blisters on them containing serous fluid. The oedema extended to the junction of the upper and middle third of each leg; temperature 102.4°, pulse 100. His general condition, usually frail, was now very weak.

November 28th. A line of demarcation had formed on each foot at the level of the ankle joint. The feet were very foul-smelling. Both feet were amputated at the junction of the upper and middle thirds of the tibiae; anterior and posterior flaps were made and the wounds closed by suture, except a small part posteriorly.

The note on December 10th was that he had made uninterrupted progress and that the wounds were clean and healthy, healing by first intention.

On December 31st the wounds were completely healed.