OBSERVATIONS ON SOME NORMAL AND INJURIOUS EFFECTS OF COLD UPON THE SKIN AND UNDERLYING TISSUES

II. CHILBLAINS AND ALLIED CONDITIONS*

BY

SIR THOMAS LEWIS, M.D., F.R.C.P., F.R.S.

Physician to University College Hospital

The reactions of the skin to cold described in Lecture I (p. 795) are acute reactions in that they appear in quick response to the stimulus and are relatively transient effects. The main response is vascular, consisting of vasodilatation and increased permeability, displayed in the traditional signs—redness, heat, and swelling. We are about to examine reactions that are neither transient nor so simple, and yet are recognized as associated with exposure to cold. And we are to discuss the responsibility of cold for these lesions and the manner in which they are produced. I refer to chilblain, to "erythrocyanosis" of the skin, and to so-called "trench foot."

Principal Features of the Lesions

First it may be well briefly to outline the salient features of these lesions and the circumstances in which they arise.

Chilblain.—The chilblain is most familiar to us as it occurs on the fingers, its most frequent site. It affects particularly the dorsal surface of the phalanges, especially between rather than over the joints. The thumbs are relatively exempt, though there is no part of the dorsal surface of the hand, or for that matter of the foot, which may not be affected. The chilblain appears as a red swelling, usually warm or hot and itching. There is obvious vasodilatation, and there is oedema—phenomena which, like itching, are common reactions to cutaneous injuries of any kind. The further course of the chilblain is inconstant. It may disappear in a few days. Usually it continues for periods of days, weeks, or months, but the original state of vasodilatation subsides. Redness gives place to a deep purple or reddish-purple colour, itching to soreness and pain; the swelling remains and may increase; the tissues may become tender; the skin often blisters or even ulcerates; but whichever happens the inflammation tends to indolence and slow healing.

That chilblains have come to be regarded as provoked by cold, and not by frost, is implicit in a term that has for so long met with popular approval in this country. But in other lands cold as the essential provocation has not been so clearly recognized. Thus it happened that Unna (1894) obtained credit for asserting, as late as that time, that these lesions, popularly termed "Frostbeulen" in German-speaking countries, are not due to freezing, as he stated they were generally regarded to be. The chilblain is common in our own land, where, though damp cold is frequent, frost-bite is a rarity. It appears with winter and generally departs only with the coming of warmer days. It is not the rule for subjects to account for the lesions presented by a single and unusual exposure to cold, though from time to time such histories are given. It is quite definitely the rule that sufferers from chilblains of the hands are people, young rather than old, whose hands in winter, and quite often in summer too, are habitually colder than those of their companions. It often happens that the hands as a whole are deeply coloured.

* The third, and last, of these lectures, on "Frost-bite," will appear in our next issue.

Erythrocyanosis of the Leg.—This lesion appears as a vascular discoloration of the lower part of the leg; the front of the leg immediately above the ankle is perhaps the favourite site. The skin becomes diffusely purple, or purple and red; the region of the follicles is often particularly marked by this congestion. The skin is usually over-tense, and therefore sometimes shiny; the oedema may be great, and in time the skin may blister or thickening may appear and break down to form ulcers. The lesions become chronic and indolent, and breaches of the skin surface heal slowly. The relation of the lesion to cold is similar to that of chilblain. It comes in winter and stays till the warmer days return. As in the case of chilblain of the hands, with which it is often associated, this lesion appears in those whose limbs tend to persistent coldness.

Trench Foot.—This condition sometimes begins with pain and tenderness without notable abnormality in appearance. Usually the foot is cold, red or blue, and swollen. Out of the cold trench the foot may be hot. In the more severe cases blisters and ulcers form and areas of the skin become necrotic; toes or even large parts of the foot become gangrenous. The condition was recognized and clearly described by Larrey (1812) in his account of Napoleon's Russian campaign. Larrey's description is memorable: he pointed out that the malady could not be ascribed to frost-bite. He says that in the exceedingly cold days which preceded and succeeded the Battle of Eylau—the temperature being 10° to 15° (Réaumur) below zero (9.5° to -1.75° F.)—not a soldier complained of frost-bite, although the days and many of the nights were passed in the snow with hard frosts. Then the temperature rose abruptly to 3° and 5° R. above freezing-point (39° and 43° F.); a thaw had set in and it rained. From this time a large number of soldiers complained of severe pain in the feet, and of itching, redness, and swelling, which progressed in some to insensibility and gangrene. In the Crimean War the most serious foot troubles appeared in cold wet weather. In the war of 1914-18 "trench foot," as it was called in France, appeared among men who stood or worked for days in the cold water or mud of the trenches, and was responsible in the first winter for thousands of casualties (Grattan, 1922, 1923). Similar foot trouble was reported among Turkish soldiers exposed in wet cold trenches (Wieting, 1913). By general consent long exposure to wet and cold was responsible, though tight footwear was regarded as contributory, and infection, which occurred readily in the conditions experienced, might be added to complicate the lesion.

Relationship of the Lesions

Here, then, are three conditions—chilblain, erythrocyanosis of the leg, trench foot—separately described, but increasingly regarded as different manifestations of essentially the same process and as resulting from prolonged action of cold. They have a very great deal in common: in the early stages itching or tender, presenting coldness and high vascular coloration, they may proceed to swelling, blistering, and ulceration in all three instances. That necrosis belongs more to trench foot finds a natural explanation.

ation in the severity of damage and in a neglect enforced by conditions of service. Indolence of the lesions and slowness of healing are common to all three.

Their chief distinctions lie in their locations, and these are clearly fixed by manner of exposure. Chilblains come on exposed hands and on just those parts that cool most profoundly; when they affect the foot they will often display the areas of chief exposure, appearing in women on the dorsum and sharply defining the parts of the foot unshod. Erythrocyanosis is particularly a woman's malady, and as a frequent lesion is recent: its prevalence dates from the shortening of skirts and the use of thin stockings. In "trench foot" it is the foot only that has long been wet and cold.

A comparison of the microscopical lesions of chilblain and erythrocyanotic skin confirms the view of their close relationship. The lesions are those of subacute or chronic inflammation: widened vessels, oedema, and perivascular infiltration form the essence of the picture, until destructive lesions, also of common pattern, are added (Gans, 1925; Grattan, 1922, 1923; Hodara, 1906; Juster and Delàter, 1926; Pautrier and Ullmo, 1928). Haxthausen (1930) has rightly insisted on their general resemblances. Of the histology of trench foot we know little or nothing directly. But we do know that trench foot not infrequently presents macroscopically a picture identical with that of large chilblain (Grattan, 1922, 1923). It is a mistake to regard the lesions as we see them as specifically distinct: they present a common, fundamental, and hardly unexpected picture.

If it is accepted that chilblain, erythrocyanosis, and trench foot are in their origins essentially similar, further discussion may be concentrated upon one of these.

Pathogenesis of Chilblain

Our interest in the pathogenesis of chilblain cannot be satisfied by referring to H-substance release. Such release would of course account for the itch, the redness, and the swelling. Chilblain, however, is more than a simple vascular response; it is supplemented by other processes—namely, diapedesis of red and white cells, infiltration by various types of inflammatory cell, hyperplasia of epidermal and connective-tissue cells, etc. These are all phenomena common to subacute inflammatory processes occurring in response to diverse injuries, such as repeated friction or long-continued action of heat. They are the natural and inherent reactions of the skin to injury in general. The interest of the problem is no longer in the lesions themselves but in the manner in which injury arises, and inquiry may take one of several directions

In Chilblain Subjects, are the Immediate Reactions of the Skin to Cold Normal?

The reactions of a finger to crushed ice may be taken first. If the subject is sitting ordinarily clad in rooms at temperatures of from 19° to 21° C. (66° to 70° F.), it is the rule for the finger to react well, its temperature rising 4° to 8° C. (7° to 14° F.) within 10 to 20 minutes of its cooling. At lower room temperatures—namely, 17° to 19° C. (63° to 66° F.)—the reaction is usually smaller and delayed or fails. A chilblain subject sitting very warmly clad out of doors, the temperature being 6° C. (43° F.), showed a large reaction of the finger (8° C.) after cooling. Tenderness following such exposure to cold is no greater than that displayed by normals. Thus the normal mechanism of defence against injurious cooling is present in these cases. It is limited in them in one sense only. The reaction of the finger of normal subjects is neither so free nor so prompt if the forearm is unusually cold, because this coldness tends to close down the vessels of the forearm through which blood passes on to the region

that is called upon to react. The forearm of the chilblain subject is in general colder than that of the normal, and thus the defensive mechanism, though intact, is less effective.

The immediate reaction of the chilblain subject's skin to histamine pricked in, or to simple injuries of any kind, is normal, provided that the skin is naturally warm when so tested. The reactions of skin, whether belonging to the normal or the chilblain subject, are less intense but more prolonged if the skin is cold. Thus the chilblain subject's skin reacts normally when tested under standard conditions, but the coldness of the chilblain skin modifies the reaction.

If the hand of a chilblain subject is immersed in cold water (3° to 5° C.; 37° to 41° F.) for a period of two hours its appearance at the end does not differ from that of the similarly treated normal hand. There are the same signs, described in the first lecture, of vascular dilatation and oedema—signs that subside within a few hours. As stated in the same lecture, there are rare instances in which cold damages skin very unusually, producing acute whealing. These subjects are not prone to chilblain; neither do chilblain subjects present this phenomenon.

However the skin of the chilblain subject has been tested in its immediate reaction to injury it does not depart from the normal.

Production of Chilblain by Prolonged Cooling

In the chilblain subject it is very unusual for a finger that has a normal appearance to develop chilblain after immersion in ice-cold water for half an hour. In no instance out of many such tests have I seen such an after-effect. But I have known chilblain follow more prolonged cooling. Thus an exposure of the hands out of doors for two hours at 9° C. (48° F.) followed by an hour in a cold room and warming of the fingers before a stove produced in a predisposed subject the first chilblain of the season. A patient usually suffering from chilblains on both hands was asked to immerse the left or less susceptible hand for five minutes in cold water (5° to 10° C.) ten times a day. She continued to do so for a month, and then developed chilblains on several fingers of this hand, the right remaining without them. These observations bear out the statements of many patients and emphasize the importance of prolonged or repeated cooling. There is, however, a very real difficulty in arriving at true values for the duration of cooling required. A patient suffered regularly in the winter from chilblains; during the autumn, before any chilblain had appeared, her hand was immersed in water for a period of two hours at 7° (45° F.). The hand had resumed its usual appearance within two hours, but at five hours a typical chilblain had begun to form on the little finger; it blistered the same evening and healed in a few days. Now, it is to be observed that such an exposure does not cause chilblains in a normal subject and that all five fingers of the patient's hand were similarly exposed but one only developed chilblain. The reason may be found in the fact that the chilblain appeared on the dorsum of a proximal phalanx where seven months previously a chilblain had occurred, and which still presented a persistent reddening and a little thickening of the skin. The observations, at all events, definitely support the idea that an area that has suffered once is one specially prone to suffer again. Here attention may be drawn to the fact that skin which has previously been damaged is in general prone to react. Thus scars left in the skin from small infected wounds sometimes, and temporarily, become red and swollen, and itch, from time to time without obvious reason. A man who has had trench foot is stated to be more prone to have it a second time. But, recognizing that there is this proneness in the case of chilblain, it is impossible accurately to

determine by observation the amount of cooling needed to produce a lesion in a chilblain subject; for in no experiment can we be sure of the extent of preliminary damage that is present: the final or provocative cooling may be regarded as adding its quota of damage, the sum of which leads to an obvious reaction.

We are brought to ask if there is evidence that cooling can produce chronic inflammatory lesions in skin that has previously displayed no chilblain or predisposition, and, if so, how much cooling is required in these. Smith, Ritchie, and Dawson (1915-16) were prompted by observations upon trench foot, during the last war, to expose the shaved feet of rabbits to damp cold. The rabbits stood on cold or half-frozen mud. Swelling of the feet was visible in forty-eight hours, and subsequently increased; microscopically they found oedema, perivascular infiltration, and other evidences of vascular damage, including fibrin in the tissue spaces. They thus proved that, in the rabbit, simple prolonged exposure to cold can produce a subacute inflammation of the skin and subcutaneous tissues of the feet. And the time required was about two days. The data we possess indicate that "trench foot" usually requires longer exposure or repeated exposures.

It is noteworthy that patients displaying trench foot for the first time give no previous history of trouble with feet or of chilblains (Smith, Ritchie, and Dawson, 1915-16). Though susceptibility no doubt varies, the lesions may be regarded as occurring in normal people. Chilblains appear on the foot and leg of children paralysed by anterior poliomyelitis, but only when disuse has brought the limb to a state of almost persistent coldness for a long period; here intermittent exposure of weeks or months is responsible.

The Predisposing Cause of Chilblain

It has been suggested that chilblains are associated with an altered blood-coagulation time (Wright, 1897); but such change is not found with constancy. The only predisposing cause which can be cited because constant, in the case both of chilblain and of erythrocyanosis of the leg, is an almost habitually defective circulation in the limbs; so that the temperature of the skin often falls close to that of the surrounding air, in circumstances in which a normal limb circulation would preserve a natural warmth. The limbs are cold not only in cold but also in cool surroundings. There are many distinct conditions in which the blood supply to a limb is defective, and in all these chilblains often occur. Thus they are frequent in the limbs in syringomyelia, anterior poliomyelitis, and conditions of coldness from disuse; they are found in acrocyanosis, in Raynaud's malady, and in thrombo-angiitis, where blood-flow deficiency results variously in spasm of vessel wall or thrombotic obliteration of the vessels (Lewis and Pickering, 1936).

As the examples of trench foot, and of chilblain in anterior poliomyelitis, illustrate, there is reason to believe that adequate and sufficiently prolonged cooling will produce inflammatory states of the skin originally quite normal. It is to be expected that given exposures will produce chilblain more readily in subjects in whom the skin temperature falls most readily. It is to the high vascular tone of the limb vessels, to the readiness with which the temperature of fingers or other part falls to that of its surroundings, and to the long delay in the release of this spastic condition of the vessels after general vasodilatation sets in, that the chilblain subject seems to owe his predisposition to these lesions.

Smith, Ritchie, and Dawson found in their rabbits that strapping the legs intensified the injury due to exposure; it is recognized that tight footgear increases the frequency of

trench foot; and in a chilblain subject I have seen chilblains appear only on a strapped foot when both feet had been equally exposed to cold for some hours in a deliberate test. In all these instances the explanation lies in hindrance to blood supply causing greater cooling on exposure.

The indolence of chilblain and of erythrocyanosis, once such lesions are established, is also clearly explicable on this basis of deficient circulation; and nothing leads more quickly to recovery than the re-establishment of a flow of blood to the affected parts adequate to bring their temperature to and maintain it at normal levels. The essence of treatment lies in establishing natural warmth. The affected parts are to be directly protected from exposure to cold and from mechanical injury; and relaxation of the limb vessels is to be induced by warming the trunk with extra clothing, by warmer rooms, and, when necessary, by confinement to bed.

REFERENCES

- Gans, O. (1925). *Histologie der Hautkrankheiten*, 1, 175, Berlin.
Grattan, H. W. (1922). In *History of Great War: Med. Serv., Surgery of the War*, 1, 169.
— (1923). *Ibid.*, *Hygiene of the War*, 2, 295.
Haxthausen, H. (1930). *Cold in Relation to Skin Diseases*, Copenhagen.
Hodara, M. (1906). *Monatshfte prakt. Derm.*, 42, 449.
Juster, E., and Delàter, G. (1926). *Bull. Soc. franç. Derm. Syph.*, 33, 618.
Larrey, D. J. (1812). *Mémoires de Chirurgie Militaire et Campagnes*, 3, 61, Paris.
Lewis, T., and Pickering, G. W. (1936). *Clin. Sci.*, 2, 149.
Pautrier, L. M., and Ulmo, A. (1928). *Bull. Soc. franç. Derm. Syph.*, 35, 80.
Smith, J. L., Ritchie, J., and Dawson, J. (1915-16). *J. Path. Bact.*, 20, 159.
Unna, P. G. (1894). *Die Histopathologie der Hautkrankheiten*, p. 20, Berlin.
Wieting (1913). *Zbl. Chir.*, 40, 593.
Wright, A. E. (1897). *Lancet*, 1, 303.

SOME EFFECTS OF VITAMINS B AND C ON SENILE PATIENTS

BY

W. STEPHENSON, Ph.D.

C. PENTON, B.M.

AND

V. KORENCHEVSKY, M.D.

(From the Littlemore Hospital, Oxford, and the Institute of
Experimental Psychology, Oxford University)

The literature on the effects of vitamins B and C on the aged is not great.

Vitamin C in Old Age

Yavorsky, Almaden, and King (1934) investigated the amount of ascorbic acid in human organs at different ages. They found that with ageing the organs become poorer in this vitamin. For example, the following amounts of ascorbic acid in milligrammes per gramme of organs were recorded:

	Age: 1 to 30 days	11 to 45 years	46 to 77 years
Adrenals	0.581	0.393	0.230
Brain	0.460	—	0.110
Liver	0.149	0.135	0.064
Kidney	0.153	0.098	0.047
Lung	0.126	0.065	0.045
Heart	0.076	0.042	0.021

A similar decrease with ageing occurred in pancreas, spleen, and thymus. Marinesco, Alexianu-Buttu, and Olteanu (1936) estimated the amount of ascorbic acid in the cerebrospinal fluid (in mg. per 100 c.cm. of fluid), and found in children up to 10 years old 2.8 to 2.2 mg., in persons aged 20 to 30 years 1.4 to 1.1 mg., in those aged 50 to 60 years 0.6 to 0.4 mg., and in those over 70 years old 0.3 to 0.2 mg. A low level of vitamin C in the blood, cerebrospinal fluid, or urine of aged people was also recorded by Plaut and Bülow (1935, 1936), Gander and Niederberger (1936), Altmann and Goldhammer (1937), Monauni (1937), Remp, Rosen, Ziegler, and Cameron (1940). The last-named authors, and also Plaut and Bülow, and Gander and Niederberger, were able to increase this low level by oral administration of ascorbic acid, which appears to exclude the possibility that this condition can be caused by decreased