approximate agreement between the respective age groups. It should be remembered that some of these disorders in the Services are in troops who are engaged in driving convoy lorries and who in civil life are bus drivers and lorry drivers, in whom gastric disorders are known to occur so very often.

From this study it is clear that Army life causes recurrent symptoms to a great extent in the soldier with a previous history of gastric disease, but it remains to be seen to what extent Army life actually will cause the onset of these diseases in the future. There is need for a large-scale investigation of this problem. It is probable that defects in diet, which would be a difficult problem to remedy, long periods between meals, oral sepsis, excessive smoking, mental strain, and a familial tendency are in the main the responsible factors.

There have been a number of cases with pylorospasm without evidence of ulcer, in which the pathology is chronic gastritis with spasm combined with inflammatory changes in the gastric mucous membrane. These cases closely resemble clinically cases of peptic ulcer, and the exact diagnosis can be obtained with confidence only by the use of the gastroscope. It is doubtful whether the spasm is caused by mental strain alone, though the pain threshold may be lower in these subjects than in others. I believe these cases are distinct from the group of pure nervous dyspepsias.

Summary

A study is made of the disorders of the stomach and duodenum in the fighting Services, with special reference to a comparison of the incidence (a) in civil life before the war, (b) in the war of 1914-18.

These disorders outclass in incidence rate all other medical diseases in cases sent back from the front to two sector hospitals since the onset of the war. The reason for such a state of affairs is inquired into: it is found that Army life causes an aggravation of the diseases in patients who had previously suffered from them, but there is no evidence yet to show that the diseases will originate in soldiers healthy on joining up.

A brief study of pylorospasm without peptic ulcer is made, with a short discussion on the pathology. Three case records are appended.

My thanks are due to Professor G. W. Pickering for his criticism of this paper, and to Dr. W. D. W. Brooks and the medical superintendent of the sector hospital for allowing me to investigate cases under their charge.

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R. L. Nelson (*J. Pediat.*, 1939, 14, 39), who records two personal cases of pertussis encephalitis with a review of the literature, states that the probable causes for neurological complications in whooping-cough are (1) encephalitis, haemorrhagic or non-haemorrhagic; (2) functional disturbances of the cerebral blood vessels; (3) spasmophilia, and (4) intracranial haemorrhage.

TREATMENT OF SEPSIS AND TRAUMA BY 3 TO 6 METRE SHORT- WAVE CURRENTS

BY

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Short-wave currents were first introduced into medicine on purely empirical grounds, and it was therefore unfortunate that early enthusiastic reports on the method led to its widespread clinical trial before several fundamental questions had been investigated. In consequence further progress became impeded by two serious defects in its practice. In the first place no method of measuring the dose was adopted—and this alone will account for many conflicting clinical reports; and, secondly, its mode of action was studied in physical rather than physiological terms. Thus, in addition to lacking a system of dosage, indications for treatment were ill defined and had no rational basis. With such drawbacks it is scarcely surprising that short-wave therapy failed to find favour among many of the more critical members of the profession.

My personal experience of short-wave therapy relates primarily to the treatment of acute and chronic infections of the nasal, buccal, and pharyngeal mucous membranes. In attempting, however, to elucidate the physiological mechanism of its action I undertook the treatment of a large number of acute localized pyogenic infections, such as carbuncles, furuncles, whitlows, etc., and a series of chronic infective lesions such as pyorrhoea, chronic osteomyelitis, and infected minor injuries. These cases have been carefully controlled, and I am satisfied that from the clinical standpoint the method has most valuable therapeutic properties in the treatment of localized inflammatory lesions.

During the course of the experimental work the dose of each treatment has been measured by means of a specially constructed electrode (Burch and Stock, 1939), and it is now possible to formulate some general principles governing the response of inflammatory lesions to varied intensities of short-wave currents. In extension of this clinical study I have carried out some experimental work in an attempt to determine the physiological changes taking place when short-wave currents are applied to the body. It is interesting to consider the clinical phenomena first and subsequently to see how far these may be correlated with the experimental findings.

Treatment of Acute Inflammatory Lesions

The application of short-wave currents to acute localized pyogenic infections or to lesions resulting from trauma is followed as a general rule by two main therapeutic results. These are: (1) relief of pain; (2) accelerated resolution.

1. Relief of Pain

The application of short-wave currents produces symptomatic relief in the majority of painful conditions. This analgesic effect is of variable duration and is analogous to that produced by other forms of heat. In acute inflammatory conditions the reduction of oedema and the regression of the lesion which frequently follow short-wave treatment may result in the initial relief from pain remaining permanent.

2. Accelerated Resolution

The accelerated resolution of acute inflammatory lesions is well illustrated by a description of the changes which follow in isolated furuncles subjected to short-wave currents. This description is based on a series of isolated furuncles treated in the course of this investigation and compared with untreated controls.

Two possible courses may follow the application of short-wave currents to a boil: either regression of the inflammatory process takes place and clinically the boil may be said to have aborted, or else the stages of necrosis, liquefaction, and separation of the slough follow rapidly during the ensuing twenty-four to forty-eight hours. Two principal factors appear to determine which of these courses is followed. The first of these is the stage reached by the pathological process at the time of the treatment; the second is the duration and, above all, the intensity of the treatment.

When the short-wave currents are given within twenty-four hours of the onset of the boil regression without suppuration is the course most generally followed, provided that the dosage is optimal. On the other hand, where central necrosis has already taken place the more usual event is rapid liquefaction of the slough. This is not, however, invariable, for occasionally even at this stage regression may take place and the necrosed area, provided it is small, undergoes absorption instead of liquefaction.

When any acute localized infection is treated within three or four days of its onset it is found that the outcome is profoundly modified by the duration and intensity of the treatment. In the case of a single furuncle the short-wave current in these experiments has been applied by means of a metal "air-spaced" electrode with an area of 14.2 sq. cm. A second electrode, as a rule larger, was placed at some convenient site on the opposite side of the body. The current which is leaving the front face of the first electrode is measured at the electrode itself, and the optimum range of intensity for securing regression of the furuncle has been found to be 0.15 to 0.2 ampere applied for ten to fifteen minutes. Where current intensities of 0.25 up to 0.6 ampere are employed retrogression is unlikely; with currents of this order of intensity the result which commonly follows is first a characteristic bluish discoloration of the furuncle, often with increase in both pain and swelling, and then rapid necrosis of its centre and subsequent liquefaction and separation of the slough. Such a result, if it occurs within twenty-four to forty-eight hours, may well represent a shortening of the natural course when compared with the time of untreated controls, but it is obviously less satisfactory than regression.

With still higher current intensities, from 0.6 to 0.85 ampere, the result in two cases was extension of the area of induration and bluish discoloration of the overlying skin, followed by fairly extensive sloughing and delay in healing up to ten days, or even more. Experience with overdosage of other inflammatory lesions confirms the opinion that increase in the size and duration of the lesion is the common result.

There is a striking difference in the character of the discharge from a furuncle which has been treated by short-wave therapy and that from one not so treated. The purulent material retains the same colour, but is thin, abundant, and of watery consistency, in contrast to the glutinous clotted discharge which usually obtains. This change is apparent within the first twenty-four hours. When the lymphatic glands draining the affected region are enlarged and tender it is usual for these to diminish in size actually during the first application of the current, although they may be some distance away and well outside the path of the current.

This description of the changes which take place in furuncles subjected to short-wave currents is applicable generally to any localized pyogenic infection similarly treated, and the following principles may be summarized for acute conditions: (1) in the pre-suppurative stage currents of relatively low intensity usually secure retro-

gression and disappearance of the lesion; (2) application of currents with intensity greater than this is more likely to lead to precipitation of necrosis or, worse, to spread of the condition; (3) if suppuration or necrosis has already supervened before treatment is started the usual course is acceleration of resolution through the stages of liquefaction and separation of the necrosed tissue. Any regression of the inflammatory process is heralded or accompanied by a rapid reduction of the inflammatory oedema. This reduction of oedema appears to be of fundamental importance, and the effect may be conveniently studied in the oedema of simple trauma.

Treatment of Simple Trauma (Trauma without Infection)

The majority of minor injuries are followed by exudation of fluid into the tissues. This reaction is well marked in injuries of the face and in the supporting tissues of joints. In either situation discomfort, pain, stiffness, and swelling occur. When an application of short waves is made within twelve to twenty-four hours of the injury (employing the milder range of current intensities) there is immediate reduction of pain, swelling, and stiffness in the course of a fifteen-minute treatment. This reduction of swelling is always considerable and may be complete; subsequent recurrence is rare.

Treatment of Chronic Infection and of Infected Wounds

In general, the longer the interval that has elapsed between the onset of an inflammatory lesion and the time when it is first subjected to short-wave currents the less marked is the variation of response to variation of current intensity. In chronic infective lesions, broadly speaking, the difference in response to low or high dosage is one of degree only and not one of kind. The clinical changes which follow when chronic infections are treated by short-wave currents may be summarized as: (1) increased redness at the margin of the lesion; (2) reduction of any oedematous swelling; (3) reduction of discharge; and (4), coincident with (2) and (3), healing, usually by granulation.

My experience of the treatment of infected wounds has been confined for the most part to infected abrasions of the skin. Red indurated areas of skin with deep linear excoriations that are causing pain and limitation of movement have regularly been found to subside completely within twelve hours of being treated. A few superficial incised wounds in which sepsis had supervened have been treated with similar results; but the number is small, and I have not had the opportunity of controlling these against untreated cases.

Mode of Action of Short-wave Currents: Experimental Observations

The therapeutic properties of short-wave currents do not appear to depend on any bactericidal action. Earlier claims in this direction have not been substantiated, and clearly no such mechanism is involved in the case of simple trauma. We may therefore conclude that short-wave currents produce their effects through some physiological mechanism evoked by their passage through the tissues. The statement is widely made that dilatation of capillaries is the principal mechanism involved. The evidence on which this statement rests is based on experimental observations made on the web of a frog's foot. I have carried out some experiments in order to determine if human capillaries react to therapeutic short-wave doses in a similar manner. This work has been

mainly carried out with a special 16-mm. objective modified by the addition of an oversized oil-immersion front component. The source of illumination is a half-watt lamp the filament of which is imaged on to the skin by means of a corrected condensing system. The illumination is fed in through the margin of the oversized lens. This front component carries two advantages: in the first place the oil does not tend to run away and does not therefore require constant replenishing; and in the second place the N.A. of the objective is increased from 0.28 to 0.42. The objective itself has been used as the electrode (insulated from the rest of the microscope). It is surrounded by a guard electrode with which it is in electrical contact only via the centre pole of a lamp socket. The current is fed into the guard electrode and reaches the objective through the filament of a low-voltage lamp. By matching the luminosity of this lamp with that of a comparison lamp fed with D.C. through a milliammeter, the current which is actually leaving the objective for the skin can be measured with a high degree of accuracy.

Experimental Observations on Human Capillaries

Direct observations were made of the capillaries at the bed of the nail where the loops run parallel to the skin surface. The movement of the individual red cells was watched before, after, and even during the application of short-wave currents. The following changes have been observed:

1. *Alterations in Calibre.*—There is no marked alteration in the calibre of capillaries which were already patent before the current was switched on. Neighbouring capillaries which had previously been closed were almost invariably found to open up.

2. *Alterations in Speed of Red Cell Flow.*—Acceleration of the circulation rate through the capillaries, as judged by the rate of flow of the red blood corpuscles, is the most constant finding both during and after exposure to short-wave currents. The slower the initial rate of flow the more readily can this change be demonstrated. It is common for the final speed to be too great for the individual red cells to be distinguishable and for an increased circulation rate to be discernible in the treated finger, compared with any other finger, for upwards of an hour. This is presumably the result of arteriolar dilatation—not visible to the microscopical examination.

Variations in the intensity of the current employed in these experiments produce corresponding variations in the degree of the effect observed. No evidence has been found of any difference in the *kind* of response of normal capillaries to different short-wave doses.

Discussion

Stasis of capillary flow is a characteristic feature of the circulation in the later stages of inflammatory lesions. Provided that the accelerated flow which is observed in these experiments on normal capillaries still obtains under conditions of inflammation, it will satisfactorily account for the changes which follow clinically when short-wave currents are applied to localized infection or trauma—that is, the rapid subsidence of oedema with regression or accelerated resolution. In chronic inflammatory conditions, in addition to reduction of oedema, flushing of the affected region with blood is probably equally important. A similar acceleration of flow in the capillaries of the skin may be produced by heat or even by simple massage. But since short-wave currents flow more or less evenly through tissue (and do not confine themselves to the body surface) we may

expect that they produce a more or less uniform acceleration of capillary flow throughout the part under treatment.

In the experiments described the only difference observed in the capillary response to variation of current intensity is one of degree, and it must be admitted that this seems insufficient to account for the very great difference in the clinical course of acute inflammation which may result from variations of dosage. These differences are, however, peculiar to *acute* inflammatory lesions and are not seen in more chronic conditions; they are not, therefore, likely to correlate with corresponding differences discernible in experiments on normal capillaries. Clinical observations suggest the possibility that in acute lesions the higher current intensities actually lead to further dilatation and stagnation in the capillary circulation rather than to an acceleration of the flow.

Short-wave Currents in Treatment of Gunshot Wounds

The foregoing clinical and experimental observations indicate that the employment of short-wave currents can be regarded as a beneficial non-specific form of treatment for localized inflammatory lesions of infective or traumatic origin and justify the claim that there is a rational basis for the extension of their use in other fields of tissue injury. Although there is at present no available evidence concerning the action of short-wave currents in the treatment of gunshot wounds and other war injuries, clinical analogy suggests that, provided the injuries are localized, similar beneficial results would be obtained as have been shown to ensue from this form of treatment in the "peacetime" infections and injuries. In particular there appears to be good reason to believe that relief of pain, subsidence of inflammatory swelling and discharge, and accelerated recovery could be expected, and from my experience I believe these effects would be sufficiently striking to justify the general use of short-wave currents in the management of wound sepsis. From the practical standpoint this form of treatment would present very little difficulty, as the work could be very largely carried out by relatively low-powered portable sets, while the standardization of technique and the reproduction of the correct dosage are simple matters easily achieved under instruction by anyone familiar with any of the modern forms of electrotherapeutic apparatus.

My sincere thanks are due to C. R. Burch, Ph.D., for both suggesting and constructing the oil-immersion system employed in this work and for his continued technical advice and assistance throughout; also to Professor T. B. Davie for many valuable suggestions and criticisms.

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T. Cohen, M. Weichsel, and J. H. Lapin (*J. Pediat.*, 1940, 16, 30) record their observations on 432 whooping-cough patients treated with various therapeutic agents. Vaccine treatment, which consisted of Krueger's vaccine, Sauer's vaccine, toxin vaccine, or Bordet vaccine, did not improve the symptoms, but was even associated with attacks which were more severe than those of the eighty controls. The results obtained with nasal topagen (soluble protein of *Haem. pertussis* in normal saline) and topagen hypodermically did not differ from those of the controls. Patients treated with convalescent serum and hyperimmune serum had fewer coughing spells, a shorter period of illness, and greater freedom from complications, but only when the serum was injected before the paroxysmal stage.