

remain unsuspected in such a case is thus perfectly understandable and reflects no discredit on the clinical acumen of any physician. But we do feel that it was a pity that, in the absence of any attempt at bacteriological confirmation, Case 12 was written off as "streptococcal tonsillitis." This diagnosis made—as, in our experience, it not infrequently is—with the unaided senses is not merely a delusion of muddled minds, it is a dangerous snare which by the mesmeric influence of a jargonistic label closes the mind to the possibility of reappraisal. "Tonsillitis" is a perfectly valid clinical diagnosis; only the laboratory can ascribe to it a specific aetiology.

We do not wish to embark here on the perennial controversy concerning the indications for antibiotics or chemotherapeutic agents in the treatment of acute sore throats, but it is pertinent to plead that if the physician in charge has made up his mind to administer one of these drugs he should at least take a throat swab—he need not await the result of the culture—before starting his course of treatment.

### Summary

A localized epidemic of diphtheria involving 12 cases (one fatal), the brunt of which fell on one infants' school class, is described. Virulent *C. diphtheriae* gravis was isolated from nine of these cases and 14 other carriers. The relatively low immunity status of the school community (less than 50% of the children having been immunized) was thought to be an important factor in the development of the epidemic.

The treatment of carriers is considered, the obstacles (notably the widespread use of antibiotics) to bacteriological diagnosis are recounted, and the difficulties in tracing the original source of infection is discussed.

Our thanks are due to Dr. A. J. H. Tomlinson and the staff of the Public Health Laboratory, London County Hall, for accepting our strains for confirmation and virulence tests, and for accepting direct the enormous number of swabs taken when the mass swabbing had to be extended. It is a pleasure to acknowledge our debt to the medical, nursing, and administrative staffs of the Barking Public Health Department and to local family doctors for their ready help and full co-operation throughout the epidemic.

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The *British and Overseas Pharmacist's Year Book 1960* has now been issued by the publishers, the British and Colonial Druggist Ltd., organizers of the National Pharmacy Exhibition and the London Medical Exhibition. Though primarily for the pharmacist, the *Year Book* contains much information that would be of interest to the general practitioner, including sections on the Pharmacy and Poisons Act, the Dangerous Drugs Act, and on the National Health Service (112+xvii pp.; price 5s.).

## TREATMENT OF THE CARPAL-TUNNEL SYNDROME\*

BY

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The carpal-tunnel syndrome consists of paroxysmal paraesthesiae, pain, and subjective numbness in one or both hands, often accompanied by some objective impairment of sensation in the digits supplied by the median nerve, and by muscular weakness and wasting in the thenar eminence. It affects women predominantly, and untreated it usually pursues a variable course, with exacerbations and remissions, for years. Paroxysms occur most commonly in the night and are often of such frequency and severity that the sufferer can get little sleep for weeks on end. By day, symptoms may be induced by use of the hands, and many patients have to give up much of their ordinary domestic occupations. Thus this syndrome can be a source of great distress and disability to those affected by it.

It is a common condition. Brain *et al.* (1947) described six cases of the fully developed syndrome. By their work the carpal-tunnel syndrome was established as a definite entity, caused by compression of the median nerve within the carpal tunnel, and capable of being relieved by division of the flexor retinaculum. In the ensuing years there have been a number of reports of much larger series (Kremer *et al.*, 1953; Garland *et al.*, 1957; Heathfield, 1957) which reveal that the diagnosis is being made with increasing frequency and the diagnostic criteria are becoming less rigid. It has been shown that patients with "acroparaesthesiae," who even after years of persistent symptoms may have no objective physical signs, are suffering from the carpal-tunnel syndrome and can be relieved by this simple surgical procedure. A diagnosis of the carpal-tunnel syndrome is now a commonplace in general medical, neurological, and orthopaedic practice.

The main standby of treatment is operative decompression of the median nerve in the carpal tunnel by division of the flexor retinaculum. Before the work of Brain *et al.* (1947) the successful use of this operation was reported by Woltman (1941), Zachary (1945), and Cannon and Love (1946). Its effectiveness has been well attested in a number of large series since then. Brain and Strauss (1955) and Garland *et al.* (1957) regard it as being the only effective treatment.

Immobilization of the wrist has, however, been shown to be effective in relieving symptoms. It was first recommended by Roaf (1947) as both a diagnostic and a therapeutic measure. Phalen and Kendrick (1957) found it successful in mild cases of short duration. Heathfield (1957), who also used immobilization as a diagnostic measure, reported symptomatic relief in 48 out of 51 cases. He immobilized the wrist in the neutral position by means of a splint which was worn at night and in some cases also by day. Relief of symptoms occurred rapidly, and after wearing the splint regularly for from six weeks to three months 34 of the 51 cases remained free from recurrences during a follow-up period of from 6 to 30 months.

Another method of treatment that has been reported to be successful is injection of hydrocortisone into the

\*This communication is based partly on an investigation which was the subject of a thesis for the degree of M.D., Aberdeen.

carpal tunnel. Phalen and Kendrick (1957) treated 20 cases in this way, and claimed remission of symptoms in 16, only one injection being required in some. Kopell (1958), Richmond (1958), and van der Bracht (1958) have also reported similar successful results, the latter combining a relatively large volume of local anaesthetic with the hydrocortisone injected. Meanock (1958), too, found this method of value in cases of recent onset.

The object of this communication is to report on the use of these three methods of treatment.

### Material

The present series consists of 81 cases of the carpal-tunnel syndrome (72 female and 9 male). 50% of these patients were between the ages of 40 and 59 when the diagnosis was made, but when the age of onset is considered the incidence in each decade from the third to the eighth is respectively 13, 17, 17, 18, 13, and 3. The duration of symptoms before diagnosis varied from a few weeks to 44 years, being less than one year in 27 and over 10 years in 13. Symptoms were bilateral in 51 and unilateral in 30.

The syndrome was associated with carpal osteoarthritis in four patients, with rheumatoid arthritis in seven, with primary generalized osteoarthritis in 12, and with acromegaly in two. In 16 patients the onset occurred during pregnancy or early in the puerperium. The onset was clearly related to a specific incident or a period of strenuous use of the hands, or to occupational factors, in 23 patients, and there was a less definite but probable relation to work in another 12.

Before the correct diagnosis was made a great variety of oral and parenteral drugs had been given to these patients, often over long periods, with invariable lack of success. Local therapy to the hands in the form of ointments, massage, heat, wax baths, and electrotherapy had proved ineffective. Six patients had received physiotherapy to their neck and shoulders, and several had had their cervical spine manipulated, all without definite benefit.

A few patients had at some time obeyed their doctors' instructions to have a complete rest from work and had been temporarily relieved. One who was made to wear the affected arm in a sling for two months had a complete remission lasting 12 years.

All of the patients have been followed up for at least one year after completion of treatment, apart from a few of those treated surgically who were kept under observation for only a few months after operation.

For purposes of description they can be divided into four groups: those who received no specific treatment, those treated initially by immobilization, those treated with local hydrocortisone, and those treated surgically, either initially or after failure of other methods.

### No Treatment

Nineteen patients received no active treatment. Two refused treatment and were still suffering from symptoms of varying severity two or more years later. Three patients whose symptoms were not severe were satisfied when reassured of their benign nature. One acromegalic received radiotherapy to the pituitary gland, which brought about improvement in his acromegalic state and was followed by remission of the syndrome.

In 13 patients symptoms remitted spontaneously and did not recur, except for brief episodes of mild paraes-

thesiae in a few, during a follow-up period of one to five years. This remission followed the conclusion of pregnancy in three and a reduction in manual work in four, while in four others it occurred, after as long as six years, for no discoverable reason. In two patients the syndrome was of sudden onset after a specific incident of manual work, and spontaneous recovery occurred after some months.

In several of these patients the marked sensory loss and wasting that were present at the time of diagnosis recovered completely. This was most striking in the last two referred to.

### Immobilization

Immobilization was achieved by means of a close-fitting anterior splint, made of plaster-of-Paris, which extended from the upper part of the forearm to the metacarpophalangeal joints. This was worn by the patient at night, being kept in position by light bandaging, and held the wrist immobilized in a *neutral* position. Thirty-six patients were treated in this way, of whom 18 received splints to both wrists. The duration of their symptoms varied from a few weeks to 19 years, and all degrees of severity of symptoms and of motor and sensory loss were represented.

Nineteen of these patients received immediate relief of nocturnal symptoms, and this was followed by a slower subsidence of diurnal symptoms. One of these, however, had a severe relapse after six weeks, though she continued to wear the splints regularly. In another eight patients benefit was not apparent for one or two weeks, and complete freedom from nocturnal paroxysms did not occur in some for several months. In a few of this group the wearing of splints seemed at first to exacerbate the condition, but after a few nights benefit was felt and thereafter nocturnal symptoms subsided completely. Nine patients were not benefited in any way, and a few of these claimed that the splints so increased their symptoms that they were unable to continue wearing them.

The patients who improved with this treatment wore their splints regularly at night for periods varying from three weeks to six months. Many who discarded them after a few weeks suffered an immediate relapse and had to continue using splints for a longer period. All of them were able to discard the splints eventually without an immediate return of symptoms, but several had later recurrences which did not always respond to resumption of the splints.

Only five can be said to have been "cured," and the longest period of follow-up observation in these is two years. One of these developed the syndrome in pregnancy and wore the splint regularly until after delivery. Another was an acromegalic whose acromegaly appeared stationary and who remained symptom-free after wearing the splint for six months. Ten others are very satisfied with the results of treatment, but still suffer from mild recurrences, usually precipitated by work, which necessitates their resuming the use of splints for a few successive nights. Of these, two had carpal osteoarthritis and one had rheumatoid arthritis.

Neither the duration of symptoms before treatment nor the presence or absence of signs of neuropathy seemed to have any bearing on the response to splinting. A close analysis of the data of these cases fails to reveal any common factor by which the response of any individual case might be predicted. In some cases with

bilateral symptoms, one side would respond well, while the other would not. The results in such cases are classed according to the more unfavourable response.

In 21 patients treatment by immobilization can be regarded as having failed: three continue to have troublesome symptoms which are only partially relieved by intermittent use of splints; 13 were subsequently treated with local hydrocortisone; and five received surgical treatment.

#### Local Hydrocortisone

Twenty-two patients, including 13 in whom immobilization had failed, were treated by injection of hydrocortisone into the carpal tunnel. The technique of injection was as follows. The wrist is first examined to identify, if possible, the median nerve and also to ensure that neither of the main arteries runs an abnormal course across the flexor aspect. Then, with the wrist and fingers in flexion against resistance, the tendons of flexor carpi radialis and of palmaris longus (if present) are identified. After preparation of the skin and the production of local anaesthesia, with the wrist relaxed in a position of about 45 degrees extension, the needle is inserted at the proximal skin crease at the wrist immediately on the ulnar side of the tendon of flexor carpi radialis, making an angle of about 60 degrees with the forearm. It is then advanced deep into the carpal tunnel between the tendons of the finger flexors. In some cases the structures within the tunnel appear to be tightly compressed, but, by gently moving the point of the needle from side to side as it is advanced, a path between the tendons is readily found. The injection is performed during withdrawal of the needle, which is moved up and down and from side to side between the tendons so as to distribute the hydrocortisone fairly uniformly throughout the tunnel.

In some of the early cases treated in this way, 4 ml. of local anaesthetic was injected into the tunnel before or along with the hydrocortisone, but this appeared to cause a painful sensation of swelling and stiffness of the wrist and fingers which persisted for as long as 48 hours. In later cases no local anaesthetic (apart from an initial small subcutaneous injection) was used, and the procedure seemed to cause less pain at the time and less discomfort afterwards. Usually 50 mg. of hydrocortisone acetate was injected, but in many cases 37.5 or 25 mg. only was given, and the results did not appear to be any less satisfactory.

In these 22 patients 31 hands were treated, and the results in 28 were dramatic. After an initial period of 24 to 48 hours of discomfort or pain and stiffness, patients found that their symptoms had abated to a great extent or had entirely gone. In 10 instances the injection was repeated after one or two weeks, as the relief, though immediate, had not been complete, and in each case this completed the "cure." All patients were encouraged to continue working with their hands in the normal way, and even to try doing things that before treatment would have been sure to give them trouble. They were all surprised and delighted to find that they could now do their gardening or spring-cleaning, or knit or sew, without provoking symptoms.

One patient who had bilateral symptoms of 20 months' duration received only partial relief. No improvement whatever occurred in another patient with unilateral symptoms of 11 years' duration. The latter had previously failed to respond to splinting of her wrist, but was later completely relieved by operation.

The ages of those who responded, of whom two were male, varied from 29 to 70 years, and the duration of symptoms from two weeks to 19 years. None of these patients was suffering from rheumatoid arthritis. One had carpal osteoarthritis, and one was treated two weeks after the onset in the fourth month of pregnancy. Symptoms were severe in all of these patients, and physical signs of neuropathy were present in all but one whose symptoms were of only six weeks' duration.

The later results of local hydrocortisone therapy, however, did not bear out its initial promise. Symptoms recurred in 16 of the 20 "successes" within one to eight months. Nine were then given a second course of injections consisting of two or three weekly injections of 25 to 50 mg. Seven of these again had a complete cessation of symptoms only to relapse within four months. One failed to improve a second time, though given three injections of 50 mg. One was partially relieved, and had no recurrence of severe symptoms in the year she remained under supervision. Two patients received a third course of injections with complete success but relapsed respectively three and six months later.

In only two cases can this form of therapy be regarded as completely successful, but the result was satisfactory in a third. One was the patient already referred to whose symptoms began in the fourth month of pregnancy. She was completely relieved by one injection and had no recurrence during a 14-month follow-up. The second was a 75-year-old woman with bilateral carpal osteoarthritis and bilateral symptoms. Immobilization had been completely successful in one hand, but failed in the other. After two injections in the latter she had no further symptoms during a 14-month follow-up. The third, whose symptoms were of only six weeks' duration, suffered from occasional minor paraesthesiae throughout the ensuing year. One other patient who had responded fully to injection received surgical treatment as she chose not to risk the possibility of relapse.

Of these 16 failures, eight later received surgical treatment, which was successful in all, and one is awaiting operation. The remaining seven patients still have symptoms of varying severity, though some express themselves as pleased with the result of treatment. Several have reverted to the use of splints.

In this series of 65 injections, infection was introduced into the flexor tendon sheaths on one occasion. This occurred early in the series and was due to faulty technique. When a reasonable standard of asepsis was observed (the aim being to take the same precautions as are usually observed in the performance of a lumbar puncture) there were no complications. The patient who developed synovial infection was treated early with tetracycline, followed by physiotherapy, and made a complete recovery with no residual disability.

#### Surgical Treatment

Thirty-one patients had surgical treatment, of whom seven had previously been treated with hydrocortisone or immobilization, and seven had received both. Nine of these had operations on both sides, and two had two operations on the same side. These 42 operations were performed by several different surgeons and the method of operation was not the same in all cases, but the essential object in each case was the complete division

of the flexor retinaculum. In some cases a transverse incision at the wrist was used and the retinaculum divided "blindly." In others it was displayed through a longitudinal incision extending into the palm and divided under direct vision.

Of the 40 median nerves exposed at operation, only 11 showed any abnormality. In these there was obvious constriction of the nerve within the tunnel and swelling of the nerve immediately proximal to it. In some cases there was a distinct transverse groove on the nerve at the level of the proximal edge of the flexor retinaculum. The finding of such obvious changes bore no relation to the duration or severity of the symptoms or signs. In two cases (one of which had had local hydrocortisone) fine adhesions were found surrounding the nerve. In some cases the cut edges of the retinaculum separated widely immediately after division, demonstrating the presence of increased tension within the tunnel. In one case the retinaculum was thought to be abnormally dense and in another the flexor synovial sheaths were thickened and oedematous.

The results of 35 operations were excellent. Patients almost invariably experienced immediate relief from severe symptoms and most of them within a few weeks were free from all symptoms. In a few, minor episodes of paraesthesiae continued to occur intermittently but were never severe enough to cause any inconvenience. Objective sensory impairment and muscular wasting improved slowly after operation in most cases and in a few made a full return to normal, but where they were severe before operation, even if of short duration, complete recovery never occurred. However, all of these patients expressed themselves entirely satisfied with the results of operation, and even those who had residual gross wasting and very definite sensory impairment were aware of little or no disability. In four patients with bilateral symptoms successful operation on the more severely affected side was followed by rapid subsidence of symptoms in the other hand.

The results of operation in three patients were not so immediately satisfactory. In one patient, who had a considerable post-operative haemorrhage into the carpal tunnel, symptoms persisted, though with greatly diminished frequency and severity, and they were still present two and a half years later. The second patient, who had both flexor retinacula divided in pregnancy, and in whom one nerve was observed to be constricted, improved, but her symptoms did not cease completely until after delivery. The third patient, who had very severe symptoms before operation, was entirely relieved of pain but continued to have troublesome paraesthesiae. The period of post-operative observation in this case was, however, only two months.

Two patients each had two operations on the same wrist. One, whose symptoms were completely relieved after operation, had a recurrence one month later. Permanent relief followed the second operation, at which it was found that the distal part of the retinaculum had not been divided. A second operation was performed in the other case for the same reason. Symptoms were relieved, but the median nerve at the wrist was damaged and permanent sensory impairment resulted.

Post-operative complications developed in two patients. The first suffered a relapse after two months and developed a "trigger wrist" associated with a cystic swelling arising from the flexor sheaths at the wrist. A

similar sequel to operation has been described by Kremer *et al.* (1953), and their patient was relieved once more by the removal of such a cyst. This patient's symptoms subsided almost completely without operation. In the second patient the wound burst when the stitches were removed and she suffered a severe recurrence of symptoms, which, however, subsided spontaneously.

### Discussion

Methods of treatment other than those described here have been advocated. Kendall (1950), who regarded external pressure on the palm as an important aetiological factor in younger patients with unilateral symptoms, was able to relieve several patients whose occupations involved such pressure by providing them with a pad to protect the palm. It is difficult to reconcile this result with current views on the aetiology of the syndrome; in any case, such treatment would be applicable to very few sufferers indeed.

The administration of oestrogens has been reported to be effective by a number of authors. Young (1950), Schiller and Kolb (1954), and Reid (1956) claimed relief of symptoms, sometimes permanent, in menopausal patients after intermittent or continuous administration for several months. In the large doses used, a number of their patients had abnormal uterine bleeding or toxic symptoms. Layton (1958) used stilboestrol (in doses of 150 mg. daily) in pregnant sufferers with success. On the other hand, Kremer *et al.* (1953) found oestrogens to be entirely ineffective. When the difficulties and troublesome effects of continued administration of oestrogens are taken into account the reported success of such treatment is not consistent enough to recommend its routine use.

Diuretics, with or without fluid and salt restriction, have been used with success in a few isolated cases, especially in pregnancy (Jones, 1953; Guly, 1959; McCallum, 1959; Wood, 1959). The danger of electrolyte depletion makes long-term therapy of this nature undesirable, but it merits further investigation.

Exercises and other forms of physiotherapy aimed at elevating the shoulder girdles have in the past been said to relieve the symptoms of the carpal-tunnel syndrome, and this belief is still expressed (*British Medical Journal*, 1959). No evidence of lasting relief has been published. Walshe (1945) found such treatment of no value unless preceded and accompanied by a long period of complete rest from manual work. Turner *et al.* (1958) found it helpful sometimes but of limited value. Six patients in the present series had had prolonged courses of physiotherapy to their shoulders and none had received any definite benefit. In two of these cases the hospital notes of the time were available, and in them symptomatic improvement was recorded after weeks of treatment, but the patients later denied having received any memorable or lasting relief.

As in other disorders that are subject to spontaneous remissions, the results of any form of therapy for this syndrome must be viewed critically, and success can be claimed only after an adequate period of follow-up supervision. Seventy cases in the present series were the subject of a detailed investigation, and it was found that 59% of them had experienced complete spontaneous remission of symptoms for periods varying from a few weeks to a few years. Such remissions were initiated in some cases by a period of complete rest, or a change of

occupation, or a reduction in manual work, or a spell of warm weather, but in others they occurred for no discoverable reason. Prolonged remissions occurred without any treatment after symptoms had been continuously present for as long as six years.

This investigation also revealed that many of these patients, when their complaint was diagnosed and some explanation of their symptoms given, would for the first time, and quite spontaneously, take steps to reduce their manual work. (It was for this reason that all patients in this series receiving hydrocortisone were specifically instructed to carry on with their full normal occupations.) In some cases this alone may initiate remission, and the credit may be given to whatever therapy has been applied. This consideration does not apply to cases treated by operation or local hydrocortisone, nor to most of those treated by immobilization, for in all of these improvement is almost immediately apparent. It does apply, however, to those in this series who received delayed benefit from splints, and it certainly also applies to the claims that have been made for shoulder-girdle therapy.

### Conclusions

Both immobilization of the wrist (Roaf, 1947; Heathfield, 1957) and local hydrocortisone (Crisp, 1959) have been recommended as diagnostic procedures for cases where the diagnosis is in doubt. In this respect local hydrocortisone is greatly to be preferred. It is far more reliable, since only 1 out of 22 patients failed to receive definite benefit from one injection, whereas immobilization had no effect in 9 out of 36 patients. Furthermore, it is easier and quicker to apply and the results are apparent within one or two days.

The choice of the method of treatment in any particular case must be influenced by many factors. The age, occupation, and state of general health of the patient, the circumstances of the onset, the severity of the symptoms, the severity and rate of progression of wasting and sensory loss, the presence of associated diseases such as rheumatoid arthritis, acromegaly, or myxoedema, and, of course, the patient's preference, have all to be taken into account. It is impossible to make any definite recommendation that will be applicable to all cases, but from the present study some conclusions can be drawn.

Injection of hydrocortisone into the carpal tunnel will in almost all cases bring about a striking remission of symptoms. It is therefore worth using to bring immediate relief in severe cases, whatever other treatment is proposed. In patients who develop the syndrome in pregnancy or after a specific incident or period of manual work—that is, in those most likely to recover spontaneously—it can be expected to give lasting relief. In patients with carpal or generalized osteoarthritis, in whom compression in the carpal tunnel may arise from a secondary tenosynovitis, it may have a lasting effect. It is worth a trial in patients who can change a harmful occupation or reduce their manual work. A trial is justified, too, in patients with rheumatoid arthritis. In most cases, however, local hydrocortisone, as used here, causes only a temporary, though sometimes lengthy, remission.

Immobilization of the wrist at night induces a fairly rapid remission in about 75% of patients, but the long-term results are likely to be satisfactory in only about

half of these. Though some authors (Lang, 1954; Phalen and Kendrick, 1957) have recommended immobilization only in cases of recent onset, the experience in this series indicates that cases of even very long duration are just as likely to benefit. It seems to be worth a trial in any case where a lengthy period of use of night splints is acceptable to the patient.

Where for economic or any other reasons a sure cure is called for, with the least risk of relapse and no necessity for prolonged treatment or supervision, operation is indicated. Operation is, of course, still available if other methods of treatment fail. In all but a very few patients the results of surgery are excellent, and even these few relative failures can probably be eliminated by careful technique and post-operative care.

### Summary

The results of treatment are described in a series of 81 cases of carpal-tunnel syndrome which were kept under prolonged observation. The methods used were immobilization of the wrist at night, local injection of hydrocortisone, and division of the flexor retinaculum. Other recommended forms of therapy are briefly discussed.

Local hydrocortisone is advocated as a diagnostic measure, as a means of rapid alleviation of severe symptoms, and as therapy in a limited number of cases, notably where the syndrome is associated with pregnancy and where it develops acutely after excessive use of the hands. Immobilization yields a satisfactory result in about 40% of cases, whatever their severity or duration. Surgical treatment offers almost certain and permanent relief.

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