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SYNDROME OF MEDIAN NERVE COMPRESSION IN THE CARPAL TUNNEL

Four cases treated surgically

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ANATOMICAL REMARKS

The sulcus carpi is bordered dorsally and on either side by the carpal bones. The firm, tight fibrous band, the ligamentum carpi transversum, extends from the radial to the ulnar eminence. Together they form the carpal tunnel (Fig. 1). Through this tunnel run the median nerve and the synovial sheaths with their flexor tendons of the fingers. The flexor carpi radialis does not pass through the tunnel proper, nor does the palmaris longus, which lies superficially to the ligament. The ulnar nerve also passes outside of the tunnel. The median nerve usually lies immediately beneath the ligament, either between the flexor carpi radialis and the palmaris longus or between the latter and the flexor digitorum superficialis. As a rule the ramus palmaris of the median nerve runs superficially to the ligament. The main trunk of the median nerve usually divides in the distal part of the tunnel, but sometimes it branches already at the upper border of the ligament. From the radial portion of the nerve extend branches for the motor innervation of the thenar. As a rule the median nerve supplies the abductor pollicis brevis, the opponens pollicis, and usually the superficial head of the flexor pollicis brevis. It also innervates the lumbricales I and II. The innervation pattern can vary in that the median nerve can innervate the entire thenar and the musculature in the first interstice. Another extreme variant is sometimes seen, namely when the ulnar nerve supplies the entire musculature of the thenar (*Seddon*, 1954).

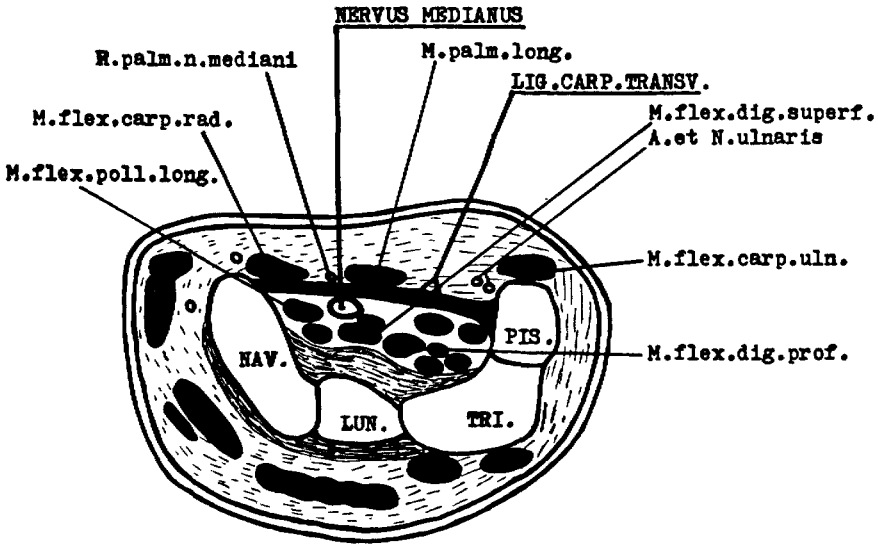

Fig. 1.
Schematic drawing of a cross section of the proximal part of the carpal tunnel.

HISTORY AND ETIOLOGY

In dislocation of the lunate in which the lunate bone is displaced forwardly and the median nerve, which cannot give way, is compressed, median paresis usually develops. As far back as 1865 Paget mentioned a case of median injury occuring late after a fracture of the wrist. Watson-Jones (1943) reported a case with acute traumatic hemorrhage into the hand with median paresis due to a hematoma in the carpal tunnel with compression of the nerve. In the Scandinavian literature Sisefsky (1950) gave a survey of earlier publications and reported a personal case of Colles' fracture with complicating median injury.

Median nerve lesions, however, seldom appear immediately after a local trauma, but usually later and sometimes not until after several years, and then it has been described as "tardy median palsy". Abbott & Saunders (1933) gave a survey of cases of median injury following fracture of the radius. On the basis of experiments in which they injected a dye into the perineurium, they claimed that on extreme flexion of the hand the nerve can be squeezed between the ligamentum carpi transversum and the edge of the distal end of the radius. Zachary (1945) described 2 cases, one with a defectively healed fracture of the radius, the other with an old navicular fracture, both with secondary arthrosis. Both cases were operated on (Seddon) with division of

ligamentum carpi transversum. In the carpal tunnel the nerve was found to be compressed, and the operative findings suggested that the arthrosis had encroached upon the tunnel with consequent compression of the nerve. Paresis can also be caused by diseases of the soft parts, e.g. periarticular fibrosis following distorsion of the wrist. Non-traumatic changes such as arthritis, especially of the proliferative type, and affections of the tendons or their sheaths can produce the same clinical picture.

As to the cause of unilateral or bilateral median paresis in the absence of any of the conditions referred to above, opinions have differed. Thus, according to the type of symptoms (motor symptoms, sensory symptoms or both) the paresis has been ascribed to some affection of the cells of the anterior horns of the cervical cord, to pressure against the cervical plexus, by cervical ribs or by the scalenus anterior, to compression of the neurovascular bundle in the inlet of the axilla owing to sagging of the shoulders, mostly in elderly women, or to pressure against the presumedly vulnerable and phylogenetically fairly young thenar musculature.

Hunt (1909) ascribed partial thenar atrophy to repeated occupational traumata against the motor branches of the median nerve distal to ligamentum carpi transversum. Some occupations (stokers, smiths, milkmaids, laundrywomen, ironers etc.) predispose to median paresis (Hunt 1909, Oppenheim 1913).

Marie & Foix (1913) described the postmortem findings in a patient with bilateral partial thenar atrophy. They found neuroma-like formations proximal to the ligament and changes in the tunnel suggesting strangulation or traumatization of the nerve. Apart from these findings autopsy revealed no signs of a pathologic condition. They conclude their paper by stating that if such a condition is diagnosed early enough, therapeutic division of the ligamentum carpi transversum might be able to prevent further impairment of the nerve.

Cannon & Love (1946) published 38 cases of tardy median palsy, of which 9 were submitted to operation. Of these 9 patients, one patient with symptoms from the right hand only, had typical acromegaly. One patient had a palpable tumour in the wrist. Operation revealed a median neuroma and neurolysis produced the desired effect. The results of operation were good and the authors mentioned particularly that the trophic disturbances in the form of lesions of digiti II and III in one of the patients disappeared after the operation. The authors did not discuss any possible etiologic factors. They conclude their comments

by saying: „It is possible by surgical means, however, to prevent further impairment of nerve function by decompression of the median nerve in an early tardy median palsy."

Brain, Wright & Wilkinson (1947) obtained for bilateral, spontaneous median paresis good surgical results in 6 patients, all housewives doing their own housework and all middle-aged or older. The nerve regularly showed the changes seen after compression. In an autopsy study in which they determined pressure changes by means of a balloon they found the increase in the pressure, implying decrease in space, in the carpal tunnel on extension of the wrist to be three times greater than that occuring on flexion.

Beck (1954) reported 10 cases. Five of them were working in a tobacco factory where they were rolling cigars. One of Beck's patients had an interesting history. Because of arthrosis of the hip he used a walking stick. Some years later median paresis developed in that hand. It gradually became necessary for him to use two walking sticks, and then median paresis appeared in the other hand, too. Autopsy revealed a pronounced neuroma-like swelling of the median nerve proximal to the ligamentum carpi transversum bilaterally. Histologic examination showed connective tissue proliferation with atrophy of the nerve. This case suggests that it is not the direct pressure against the nerve but the position of the hand (probably extension) that causes the compression of the carpal tunnel with consequent nerve injury. The carpal tunnel syndrome is much more common among women than among men and is frequently bilateral. It usually appears during or after the menopause. Dorndorf's (1931) 16 cases were seen in women in the climacteric, and in series reported since then women are predominant. In 3 cases Beck found pregnancy to exert an unfavourable effect on the disease.

Acroparesthesiae occur especially among middle aged women, and Kremer, Gilliatt, Golding & Wilson (1953) believe that it is often due to median compression. They claimed to have found neurologic signs of median affection of the hand in most of their 60 cases of acroparesthesiae. Forty were operated on with division of the ligamentum carpi transversum and in many of them the tunnel was found to be narrow. The results were said to be very good. According to these authors then the acroparesthesia syndrome is a variant of the carpal tunnel syndrome, an early partial median lesion with mainly symptoms of irritation. They also pointed out that the menopause and pregnancy might be factors of importance.

The carpal tunnel syndrome in association with acromegaly has been described by List (1932), by Woltman (1941), who was the first to perform therapeutic division of the ligament, and by Schiller & Kolb (1954), who gave a review of the literature and contributed with 3 cases of their own. In one of their patients the symptoms of median nerve involvement abated after the removal of a pituitary adenoma. The carpal tunnel syndrome has also been described in association with myxedema and with amyloidosis by Grokoest & Demartini (1954), for example. All of these groups were described as also having local edema and/or hypertrophy of the soft parts in the carpal tunnel. The findings on surgical decompression of the nerve(or at autopsy) and the effect of operation strongly suggest that here, too, it was injury to the median nerve in the carpal tunnel that was responsible.

The appearance of the nerve at operation is in good agreement with the experimental investigations of Denny—Brown & Brenner (1944) on the compression of peripheral nerves. Whether the nerve lesion is due to chronic traumatization by the wall of the narrowed carpal tunnel on movement of the wrist, or to a true compression with ischemia and edema of the nerve, or to both, is of minor importance.

AUTHORS' MATERIAL

Case 1. H.W. 245/54. The patient, aged 40, was a farm labourer doing fairly heavy work. He was righthanded. To his knowledge he had not sustained any blows against the hands. One year earlier, while cycling, he had noticed a feeling of numbness in the radial half of the palm and the 3 radial fingers. Soon afterwards he had increasing pain in these parts of the hand and later a sensation of tingling, pricking and burning occurred intermittently. The hand became weaker and weaker with poor thumb grip and decreased grip strength of the hand and successive reduction of the thenar musculature. For the last 6 months he had progressive symptoms of the same type in the left hand. He complained of a feeling of tightness of the fingers and severe pain, especially at night and often a slight swelling of the back of the hands in the morning, which abated when he lay on his back with his hands on the chest. The pain increased in association with use of the hands with the results that he had been unable to work for 7 months. He was referred from his local hospital to the Department of Neurology, Lund, with a presumptive diagnosis of multiple sclerosis.

On admission (May 1954).—Slight atrophy of the median portion of the thenar musculature bilaterally. Decreased functional strength of opposition and abduction of the thumb, and the finger-thumb grip was weak. In both hands there was slight but definite decrease in the sensibility to pain and temperature in the region corresponding to the median nerve. Slight tenderness to pressure over the ligamentum carpi transversum and increased pain in the fingers on passive dorsiflexion of the wrist. All of these changes were equally pronounced in both hands. The cuff test:

pathologically early paresthesia and numbness in the region of the median nerve on both sides. E.S.R. normal. Electromyography (E.M.G.): denervation and fasciculation activity in opponens and abductor pollicis brevis bilaterally. Roentgenography of the cervical spine and of the hand revealed no signs of a pathologic condition. Operation: division of the ligamentum carpi transversum of the left hand. The nerve was slightly edematous and discoloured (greyish) proximal to the ligament, and the tunnel was narrow.

Two to three weeks after operation the hand improved and the numbness and pain disappeared. At review in Sept. 1954 the left hand was much better, and now the right hand was also somewhat better. He had not worked because of joint and muscle pain of rheumatic type in the arms and legs since July 1954. Heavy work with the hands immediately produced pain and numbness in the right hand, but not in the left. The range of mobility of the left thumb was wider than that of the right. Sensory losses were no longer demonstrable in the left hand but the right hand was still hypaesthesic, though not to such a degree as before. When reviewed in Jan. 1955 the patient's condition was as before. It was decided to postpone operation on the right hand until the rheumatic trouble had disappeared.

Case 2.—K.E. 259/54. The patient, aged 58, was a lorry driver, whose occupation included heavy manual work. He was right-handed. For 8 years he had had a feeling of increasing numbness of the radial fingers of the right hand, first in the distal palmar region of dig. II and III and later in the thumb and up the palm of the hand. During roughly the same period he had noticed decreased mobility of the thumb with atrophy of the thenar musculature. For 5 years he had progressive symptoms of the same kind in the left hand. Occasionally he had radiating prickling in digiti II and III, especially on extreme movement of the wrist. The numbness increased on exertion such as after having driven his lorry for a long time. He was unable to work for 18 months because of these hand symptoms. He had been treated at his local hospital for assumed amyotrophic lateral sclerosis. In May 1954 he was referred to us for investigation.

On admission.—Pronounced partial atrophy of the thenar (Fig. 2), only minimal power of opposition of the thumb and weak thumb-finger grip. Severe loss of all forms of sensibility in the distal parts of digiti I–III and slight sensory loss in the rest of the median region. No trophic disturbances. All of the changes were more pronounced in the right hand than in the left. Slight pressure tenderness in the palmar area of the carpus. Extreme passive dorsiflexion of the wrist produced parasthesiae of digiti II and III. Cuff test: pathologically early paresthesiae in the right hand (within 1 minute) and in the left (within 2 minutes). No other neurologic signs were observed. The patient showed no evidence of cervical root involvement. Roentgenography showed slight cervical spondylosis and advanced arthrosis of the hand between os naviculare and multangulum, especially in the right hand. E.M.G.: denervation potentials in the median musculature distal to the carpus. Operation (2-stage): division of ligamentum carpi transversum bilaterally. In both hands, especially in the right, the nerve appeared markedly edematous proximal to the ligament and seemed to be definitely squeezed in the tunnel. The ligament was unusually thick and fibrous.

When last seen in Jan. 1955 the patient stated that he still felt no improvement since the operation, but for the first time he had noted no progression for 6 months. Now there were no paresthesiae. Objectively the opposition of the thumb was some-

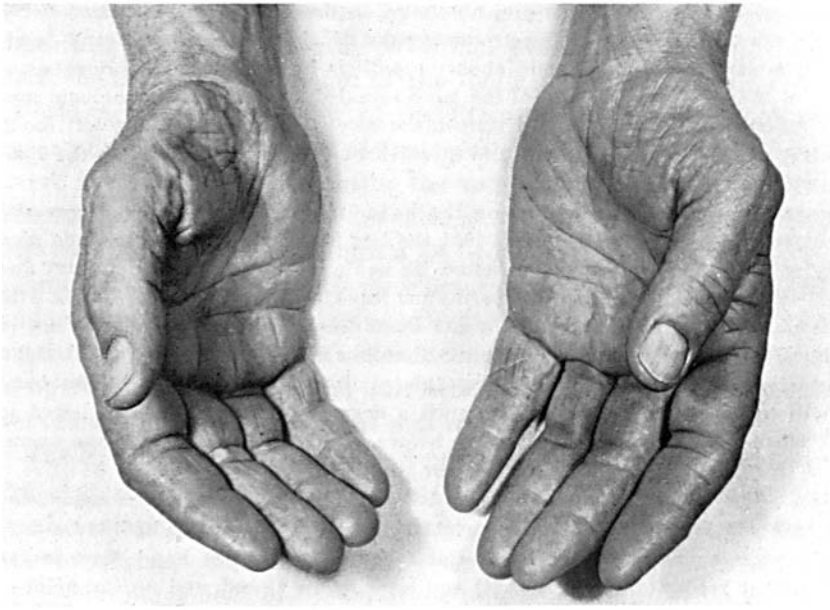

Fig. 2.
Case 2. Typical atrophy for a median nerve lesion, affecting the proximal, outer part of thenar.

what better than before and sensibility less impaired. Otherwise the state of affairs was same as before operation. He was still unable to work.

Case 3.—N.L. 317/54. The patient was an unmarried woman, aged 58. She was right-handed. For the last 40 years she had been doing office work with much typewriting. For 27 years she had paresthesiae first in the right hand and later in the left. The paresthesiae were localized to the palmar aspect of the radial fingers but even dorso-peripherally. The paresthesiae in these areas gradually became increasingly painful, usually at night and occurred in the form of attacks. Rotation or dangling of the hands usually gave some relief. Typewriting accentuated the pain, and, especially during the last few years, manual work caused severe painful hypersensibility to touch and cold in the affected area, which felt as if it was void of skin. For 7–8 years she had increasing thenar atrophy and weakness of the right hand and during the last few years motor symptoms also in the left hand. She had been unable to work for 1 year. Formerly her condition had been diagnosed as progressive spinal muscular atrophy.

On admission.—Pronounced atrophy of the proximal, radial part of the thenar bilaterally with poor function of opponens and abductor pollicis brevis. The thumb was adducted. Typical "ape hand" bilaterally. Corresponding to the region innervated by the median nerve the skin of both hands was dysaesthesic and severely hyperaesthesic with painful discomfort and coldness on touch but no impairment of sensibility. No trophic changes of the skin or nails. The symptoms were more pronounced on the right side than on the left. Pressure over the palmar aspect of

the carpus (Tinel's sign) or extreme dorsiflexion produced increasing pain and radiating paresthesiae. The cuff test was markedly pathologic bilaterally. E.M.G.: signs of denervation in opponens and abductor pollicis brevis. Roentgenography showed pronounced cervical spondylosis but no changes in the skeleton of the hand. Operation (2 stages): division of ligamentum carpi transversum bilaterally. The nerve was on the whole of normal appearance, possibly somewhat swollen proximally. The distal portion of the tunnel appeared to be unusually narrow.

The patient was followed up regularly and was last seen in Jan. 1955. The patient stated that she had experienced no benefit from the operation, and no signs of any improvement were demonstrable. The wounds healed without complication. Reoperation has been offered, but as yet refused.

Case 4.—S.M. 260/54. The patient, aged 29, was right-handed and had been working for 4 years as a tinsmith, an occupation in which the handling of the tools placed a heavy strain on the hands, especially on the right. In Dec. 1951 he had a fracture of os metacarpale II dx, which healed without complications. In Dec. 1952 he sustained subluxation of the os metacarpale I dx with a fracture of Bennett's type. He did not present himself until 2 months after the accident, by when the lesion could no longer responds to conservative treatment. He afterwards had dull pain and tenderness in the region of the metacarpo-carpal joints. In March 1952, thus before the last accident, he noticed a gradual decrease in the mobility of the right thumb, especially opposition of the thumb. The hand became increasingly helpless: he could not screw on a nut, or spread butter on bread etc. The thumb-finger grip was extremely weak. These changes were accompanied by successive atrophy of the right thenar musculature. He had only very slight pain, which was localised to the radial aspect of the palmar part of the thumb and occurred mainly at night. He had no paresthesiae or numbness of the fingers but a certain hypersensibility to cold in the radial half of the hand. The symptoms increased after the accident in Dec. 1952, but he could still carry on with his work. In July 1952 he was treated at his local hospital for assumed atrophy of the right thenar, for which neurologic examination at that time failed to reveal an explanation. In May 1954 he was referred to Lund for investigation.

On admission.—Moderate but definite atrophy of the right thenar musculature, which felt loose and flabby. Distinctly decreased opposition of the thumb, which could not be opposed to the digiti IV and V. The thumb grip was weak. No impairment of sensibility was demonstrable. There was no deformity but slight tenderness to palpation over the metacarpo-carpal joints with slightly decreased mobility. No tenderness of the thenar or in the palmar region of the carpus. Passive extension and flexion of the wrist revealed nothing of interest. The cuff test was negative. E.M.G.: uncertain denervation potentials in opponens and abductor pollicis brevis. The roentgenogram of the cervical spine was of normal appearance. Roentgenography of the hand showed: healed fracture of os metacarpale II; in os metacarpale I a Bennett fracture that had healed with slight dislocation; no arthrosis in the carpus. Operation: division of the ligamentum carpi transversum. The nerve appeared somewhat flattened and the carpal tunnel seemed to be narrow, but otherwise no pathologic changes were observed.

The postoperative course was uneventful. The patient returned to work 1 month later. At review in Aug. 1954 opposition of the thumb was much better and the thumb grip stronger. The atrophy was about the same as before. The patient was

very satisfied with the result of the operation. In Jan. 1955 the mobility and grip-strength of the thumb were practically normal, the wound had healed, the patient was symptomfree and had recovered pre-injury working capacity.

DISCUSSION

In 3 of our 4 cases the symptoms were bilateral and in all of them it was the dominant hand that was involved first. Case 4, with unilateral paresis, resembles those described by Kendall (1950) in which the occupational history included the handling of heavy tools for many years. In case 4 the patient had in addition sustained traumata with fractures of the right hand and probably distorsion of the wrist while playing handball, but to what extent these might have contributed to the condition is difficult to say; the Bennet fracture occurred after the onset of the symptoms. One might discuss whether the condition in this case were due to compression of the median nerve in the actual tunnel but the excellent result of operation argues strongly against any other diagnosis than that established. In the other cases the mechanical factor also seemed to play a certain rôle; farm work and driving a lorry are rather trying for the hands, and typewriting can probably also imply repeated traumatisation of the median nerve. Roentgen examination showed bilateral arthrosis in the carpus in case 2. It is possible that these changes were the underlying cause of the condition in this patient.

The patients' ages in our cases were fairly representative (40, 58, 58 and 29 years). The disease usually appears in middle aged people or older, but when, as in our case 4, the disease is due to some occupational factor (or trauma) and unilateral, the disease usually occurs earlier in life.

In injury of the median nerve the muscular atrophy is usually characteristically limited to the proximal, radial part of the thenar, so called partial thenar atrophy. It is above all opposition of the thumb that is disturbed with resultant so-called "ape hand". Decreased sensibility is most common on the palmar aspect of digiti II and III. Trophic and causalgia-like disturbances are not rare in partial injury of the nerve.

In the carpal tunnel syndrome the partial atrophy develops successively. The corresponding paresis often appears to be less pronounced than what might be expected. Grip-strength is poor, the hand is clumsy and the performance of work requiring precise movement with an

instrument held between the finger and thumb is poor. The thumb has a tendency to be adducted. All of our patients had typical atrophy.

In cases 1 and 3 the picture was initially dominated by paresthesiae in the region of the median nerve, which gradually developed into increasingly severe burning pain, which was most pronounced at night and accentuated by use of the hand. Several authors have described the paresthesiae as most severe at night. Kremer et al. believe the cause to be a swelling of the hands because of impaired venous drainage as a consequence of decreased muscle activity during the night. These authors described cases in which they themselves had observed such swelling, and the patient in our case 1 also reported nocturnal swelling. Characteristic of this swelling is that it disappears on rotating or dangling the hands. In the large compilation of Kremer et al. acroparesthesiae is described as a frequently early and dominating symptom. Numbness and hypaesthesia occur relatively late, by which time atrophy of the thenar musculature has usually made its appearance. However, the clinical picture varies from case to case. Sometimes sensory loss antedates and/or dominates the symptoms of irritation; sometimes the motor symptoms precede the sensory. This is also apparent from our cases. In case 2 and 4 the paresthesiae and the pain were slight.

In our cases except case 4 the sensibility disturbances observed were characteristic, localized strictly to the region of the median, most pronounced in digiti II and III and not grave. Unlike Kendell's cases, none of ours had trophic disorders, but our case 3 showed an almost causalgia-like hyperesthesia. Hypersensibility to cold is a common symptom and in our case 4 it was the only sensibility disturbance. It should be observed that none of our patients had any disturbance of sensibility in the region of the ramus palmaris. As a rule this branch does not pass through the carpal tunnel and escapes compression. The absence of sensory loss, as in case 4, does not argue against a carpal tunnel lesion. Cannon & Love described several cases of this type in which operation showed the nerve to be grossly changed, and even the operated cases described by Zachary as "thenar palsy" had only slight sensory symptoms. Zachary stressed that traumatization of a mixed nerve often causes a dissociated lesion with motor symptoms and pain before any decreased sensibility is demonstrable.

DIAGNOSIS

In typical, well developed cases the carpal tunnel syndrome offers no diagnostic difficulties. Often it requires careful neurologic and orthopedic investigation, however, because the differential diagnostic possibilities might be many. As is apparent from the cases described above, the condition is often falsely diagnosed. Cases with mainly motor symptoms are liable to be conceived as amyotrophic lateral sclerosis, which, however, is seldom confined to the proximal radial part of the thenar and which usually causes fasciculations and never sensibility disturbances. Brain et al. stress the cervical rib as a source of error, and even the scalenus syndrome and plexus neuritis are mentioned in the literature as conditions from which it can be difficult to differentiate the carpal tunnel syndrome. Herniation of a vertebral disk with pressure against the root of C_6 or C_7 can also be difficult to exclude. In none of the cervicobrachial syndromes do both the motor and sensibility disturbances occur exactly in that part of the hand supplied by the median nerve.

It is possible that the differentiation from the scalenus syndrome is overestimated owing to the fact that formerly many cases of carpal tunnel syndrome were misdiagnosed as scalenus syndrome. Studies of the brachial pulse will, however, usually decide the diagnosis, with more or less support from roentgen examination of the spine. In case 3 pronounced cervical spondylosis was demonstrated, but the clinical picture was not that of rhizopathy. Acroparesthesiae of the fingers are sometimes symptoms of unknown origin, sometimes they are co-symptoms of some systemic disease in which there is no reason to suspect median compression, but sometimes they are early symptoms of the carpal tunnel syndrome. Kremer et al. stress that they had several patients who first reported that they had parasthesiae of all of the fingers but later, when they returned, that the symptom was confined to the 3 or 4 radial fingers. Median nerve lesion proximal to the carpal ligament will, of course, also produce paresis. Here trauma (wounds, fractures of the upper or lower arm etc.) is the commonest cause, but the possibility of nerve tumours should also be borne in mind.

The establishment of a diagnosis of carpal tunnel syndrome requires that the symptoms are localized to the musculature innervated by the median nerve and to the skin distal to the carpus without involvement of the region supplied by the ramus palmaris. But 6 of Beck's cases also had symptoms in this region. In exceptional cases the pain might also

radiate up the lower and upper arm, (Newman 1948, Kremer et al.) and has been explained as referred pain. A few cases (Newman 1948, Phalen 1951) are on record with palpable ganglia-like swelling over the upper margin of the ligament owing to the neuroma-like swelling of the nerve, but this finding is surely rare.

Kendell stressed that in the investigation of the possible rôle of occupational factors in the cause of the condition, it is important to anlyse how the patient holds his tools and the position of the hand during the work.

According to Phalen, a characteristic of the carpal tunnel syndrome is that percussion over the palmar aspect of the carpus accentuates paresthesiae and pain. Like Kremer et al., we have found this sign to be of little value. Of greater diagnostic importance are the parenthesiae radiating into the fingers on extreme passive extension of the wrist. This is in line with Beck's observation and might be explained by the stretching of the lesioned nerve across the palmar edge of the distal end of the radius during such extension. Passive flexion of the wrist, during which the nerve might possibly be pressed against the distal margin of the ligament (Phalen), did not accentuate the pain in our cases. Gilliatt & Wilson (1953) described the "cuff test" as a good diagnostic adjuvant. In the presence of a nerve lesion the application of a pneumatic tourniquet round the upper arm will produce paraestesiae quicker than normally, as well as pain and anasthesia in the region of the nerve involved as a sign that the injured nerve is hypersensitive to ischemia. In 3 of our cases this test was positive. Kremer et al. used the test in their cases and found it useful.

TREATMENT

The treatment of choice of the carpal tunnel syndrome is surgical, i.e. division of the ligamentum carpi transversum with decompression of the median nerve. It is true that Kendell recommends conservative treatment with rest and immobilization of the wrist in unilateral cases due to severe occupational traumata, but the risk of recurrence after such treatment is surely great (Kremer et al.). Estrogen therapy has been suggested by earlier authors. In long-standing cases and in cases with pronounced motor disturbances as in our case 4, surgical treatment should probably be preferred. All bilateral cases should be treated surgically. Treatment requires only a minor operation that can surely be performed by any general surgeon.

Formerly (Cannon & Love, and others) one approached the field by a longitudinal incision over the nerve, but since then it has been more usual to use a transverse incision. We used the surgical method described by Kremer et al. (1953).

In all of our cases plexus anasthesia was used with good effect. A pneumatic tourniquet was applied to the upper arm and the limb exsanguinated. A transverse 3 cm long incision was made in the distal wrist crease. The palmaris longus was isolated and retracted to the ulnar side. The ligament was incised and with the underlying median nerve protected by a small spatula the ligament was divided (Fig. 1). Care should be taken to carry the division also through the very distal end. In order to avoid the risk of injuring the motor nerve branches to the thenar musculature, the incision should not be made too close to this region. The ramus palmaris is usually seen above the ligament and should be spared. The actual median nerve should not be touched: one should only check that decompression has been adequate. The skin incision is sutured and a pressure bandage is applied. No splint is necessary. Any subsequent hematoma in the operative field will jeopardize the results of operation. Should the result be unsatisfactory and re-operation necessary (see below) the incision should be longitudinal because it can then be extended out into the palm of the hand and thereby permit better exposure of the entire section of the nerve. The stitches are removed after about 10 days. The patient is then allowed to move the hand, but he should not return to work until after about 1 month.

Cannon & Love also carried out a so-called inner neurolysis with razor blade incisions in the epineurium. Brain et al. expressed the view that the nerve should be lifted up from its groove in order to free it from any adhesions. Now, however, it is agreed that the injured and thereby extremely vulnerable nerve should not be exposed to the possibility of operative traumatization. The risk of postoperative synechiae and pain is then small.

According to the literature, at operation the nerve proximal to the ligament usually shows edema, a neuroma-like swelling and discolouration, while that part in the tunnel appears flattened and compressed. On exploration with a sound the tunnel usually feels narrow. We made such observations in 2 of our cases, while no gross changes of the nerve were seen in the others despite the fact that the tunnel felt narrow. Both Phalen and Kremer et al. described cases in which the nerve as seen at operation was of normal appearance, and the for-

mer also stated that he often found no relationship between the motor symptoms and the swelling of the nerve at operation.

In some cases the ligament may be thickened, as in our case 2. Histologic examination of a biopsy specimen from the ligament or of the surrounding tendon sheath (Phalen) usually shows no striking changes. In advanced cases, the nerve changes consist histologically of connective tissue proliferation and nerve atrophy.

After operation the prognosis is good. The pain and paresthesiae usually soon disappear, then the sensory loss and afterwards the motor symptoms. In longstanding cases—several years—with marked thenar atrophy, however, the prognosis is poor. This has also been found by earlier authors. Paresthesiae and pain always indicate operation which always prevents further impairment of nervous function. In our cases 1 and 2 the paresthesiae disappeared after operation, while in the patient who had had symptoms for 27 years the pain did not disappear. This case was so typical that the diagnosis could hardly be doubted; it is possible that the condition had become irreversible also with respect to the pain. However, we suggested reexploration with a longitudinal incision. We contemplated a longitudinal incision because it is sometimes difficult to obtain complete decompression of the distal part of the nerve by the technique used in the first operation. Kremer et al. described 2 cases and mentioned 2 others in which re-operation (with a longitudinal incision) revealed that the division of the ligament at first operation (with transverse incision) had been insufficient. In these 2 cases re-operation produced good results. They also obtained good results in the rest of their series: of 40 operated on, improvement was achieved in 37 without reoperation. Most of their patients could return to their usual work. The majority were fairly early cases with a history of only 1–2 years. In our case 4, in which the patient also had only slight partial nerve lesion, good improvement was also recorded. It often happens (Phalen, Gardner & La Londe 1950) that operation on one hand is also followed by improvement of the other, probably because it can be spared more during work. The results of operation cannot be judged properly until the patient has been followed up for at least 1 year.

The operation is practically free of risks if it is carried out by the non-touch technique and by a surgeon well acquainted with the anatomy of the hand and wrist. In our cases the postoperative course was uneventful: none of the patients complained of postoperative symptoms from the hand and in none was the ramus palmaris lesioned.

There is probably no risk of prolapse of the tendons because the hand is usually slightly dorsiflexed when being used. Since treatment requires only a minor though important operation, it might also be indicated in possibly less certain cases, especially as postponement of an adequate operation involves the risk of an irreversible nerve lesion.

SUMMARY

The carpal tunnel syndrome is frequently bilateral. It is most often seen in middle-aged women doing housework. The etiology of the condition is not yet properly understood. The possibility of the condition should be considered in the investigation of paresthesiae and pain in the hands as well as in cases of hand symptoms with signs of median paresis. Unless the condition is diagnosed in time, the changes may become disabling and irreversible. Division of the ligamentum carpi transversum can often give relief. Four personal cases are described and a survey of the literature is given.

RESUME

Le syndrome du tunnel carpien est fréquemment bilatéral. Il apparaît le plus fréquemment chez les femmes d'un certain âge s'occupant des travaux du ménage. Son étiologie n'est pas encore parfaitement comprise. Il faut la prendre en considération dans l'examen des paresthésies et des douleurs de la main, aussi bien que dans les cas de symptomes de la main avec signes de parésie médiane. Si la maladie n'est pas diagnostiquée à temps, elle peut conduire à un état d'infirmité et devenir irréparable. La scission du ligament carpien transversal peut souvent soulager. Quatre cas personnels sont décrits, en même temps qu'il est donné un aperçu de la littérature.

ZUSAMMENFASSUNG

Das carpale Tunnelsyndrom tritt häufig beiderseitig auf. Es wird zumeist bei Frauen im mittleren Lebensalter, die Hausarbeit ausführen, beobachtet. Die Ursache des Leidens ist noch nicht vollständig aufgeklärt. Man sollte an die Möglichkeit dieser Erkrankung denken, wenn Parästhesien und Schmerzen in der Hand, aber auch wenn Zeichen von Medianusparese vorhanden sind. Wenn das Leiden nicht rechtzeitig erkannt wird, können die Veränderungen zu Invaliditet

führen und irreversibel werden. Durchschneidung des ligamentum carpi transversum erleichtert den Zustand oft. Vier eigene Fälle werden beschrieben und eine Übersicht der Litteratur wird gegeben.

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