Prophylaxis

About the prevention of streptococcal implantation little can be said which is not common knowledge. The prevention of scarlet fever by isolation of the sufferers is the most magnificent failure of preventive medicine, but the isolation of the non-infected has been an equally magnificent success, for this is nothing but Listerian surgery carried to its logical conclusion. The surgeon sometimes fails, not through his fault or that of his dressers or nurses, but from the peculiar character of his enemy, which can lie dormant in places immune to its action, but from which places it wanders to new sites which are damaged and cannot resist its attentions.

The removal of septic foci seems a logical remedy for this danger, but doubts have arisen of its soundness and there are probably better ways to be discovered of overcoming this persistent menace to all of us. That we shall ever prevent pathogenic streptococcus from living parasitically upon us is, I think, unlikely, but that we shall

discover means of rendering this biological union harmless can be looked for with some confidence. The key to it will probably be found in the study of scarlet fever.

Before I close, I would make two remarks to stimulate the bacteriologists present to take part in the discussion. The question of the type of the streptococcus is of profound importance, but there seems to be much difficulty in its determination. Formerly, when desiring the opinion of a bacteriologist upon types of streptococcus, I sent cultures on similar media taken at the same time, in similar conditions, to four bacteriologists of unimpeachable veracity. No two reports were ever in complete agreement.

I mentioned a belief that the passage of a streptococcus through a host exalted its virulence for similar hosts. I instanced the progress of epidemic puerperal fever. The fact—for I have been told that it is a fact—that these streptococci alleged to be exalted in virulence for puerperal women do not show exaltation of virulence for male guinea-pigs has nothing to do with the case.

TRAUMATIC OEDEMA

A PITFALL IN PHYSICAL MEDICINE

BY

L. C. HILL, M.D., M.R.C.P.

HONORARY PHYSICIAN TO THE DEVONSHIRE ROYAL HOSPITAL, BUXTON

Physiotherapy, largely on account of its unique flexibility of application, has at last received tardy recognition, and now takes its place as an important branch of medical treatment. There are, however, certain disease processes which at first sight would appear of the type likely to benefit from such methods but which fail to respond as expected. I have recently encountered in hospital and private practice such a group, and after floundering in a state of considerable uncertainty for some time I arrived at certain conclusions regarding their appropriate treatment as a result of the experience thus obtained.

To those whose work brings them into regular contact with industrial compensation cases the development of oedema after injury to an extremity offers great difficulty, and it is important that the peculiar problems of true traumatic oedema in regard to its treatment, expected course, and prognosis should be fully understood. My main object has been to discuss the various methods of treatment and their influence upon the development and prognosis of the disease. A summary of present knowledge of the aetiology and pathology has also been included, and an attempt has been made to review the various theories of causation in the light of such knowledge. The following cases will serve as illustrations.

Case I

A quarryman, aged 32, on April 16th, 1934, sustained a severe crushing injury to the left foot from a fall of stone. There was moderate shock, bruising of the lumbo-sacral region, pulping of the great toe with protrusion of bone, and there were two fractures of the terminal phalanx.

For seven weeks before admission the foot was immobilized in splints, but the patient was allowed to sit up for short periods daily after the third day. The oedema diminished but did not disappear. After a further fifteen weeks on crutches the oedema gradually increased and pain became severe.

He was seen in the out-patient department of this hospital on October 3rd, five months after the original injury. The limb was grossly oedematous almost to the knee, and the skin was cyanosed, glossy, and tender to pressure; he was unable to put his foot to the ground.

X-ray findings: "Patchy areas of osteoporosis contrast with intense sclerosis, particularly in the metatarsal heads."

TREATMENT

He was treated for one month with local whirlpool baths, alone and with massage, contrast baths, and underwater douches. The pain was intensified after each treatment, especially after massage, and the oedema increased until the patient was unwilling to submit to further treatment along these lines. On November 3rd the limb was immobilized in plaster-of-Paris from toe to knee for one month. The patient was advised to rest with the limb elevated.

On November 30th, when the plaster was removed, the oedema had diminished considerably and there was no pain. The x-ray report was: "Decalcification proceeding; areas of porosis now predominating; sclerosis disappearing." Massage was instituted and was followed by the immediate return of pain and oedema. After three days plaster was reapplied for three weeks. On December 22nd the plaster was removed again, the oedema and pain being greatly improved; elastoplast was substituted and rest and elevation advised, but the patient was permitted to move about the house. The x-ray report was: "Decalcification now excessive; mottled appearance still evident."

Very slow progress was maintained for the next twelve months. With the object of speeding up recovery he was referred for operation, but the surgeon considered progress satisfactory under the conservative treatment and operation therefore unjustifiable. All attempts to hasten progress by physiotherapy invariably ended in failure and temporary relapse, the patient finally refusing further experiments in this direction.

The foot is now shrunken, mobility is reduced at all joints, and there is severe pain on attempting to increase forcibly the range of movement. The skin is still cyanosed and cold. He complains, too, that the pain is worse in cold weather. Several efforts to find him a light job have ended in failure. Deterioration in his morale is now obvious, the unfortunate result of prolonged absence from regular work and the limitations imposed by living in a small village.

The report on an x-ray taken in October, 1935, is: "General decalcification, mottled appearance disappearing; some increase of density in the shadow cast by peri-articular soft structures."

Case II

The lady superintendent of a rest home, aged 58, on July 29th, 1934, sustained a Colles fracture of the left wrist from a fall while climbing; there was little shock but much deformity. The wrist was immediately immersed in cold water for half an hour. It was then reduced without anaesthesia, and splints were applied. The position was modified the next day under gas. X-ray showed the fragments in satisfactory alignment after the second reduction. Thereafter she resumed her normal duties with the wrist in splints and a sling. After a week daily passive movements were started with massage. The swelling, after diminishing during the first week, rapidly increased and the pain became worse.

Treatment along these lines continued for two months at a large hospital centre.

When she was first seen at this hospital, on October 1st, the hand and forearm were grossly swollen, brawny, and tender, especially over the lower end of the radius and at the phalangeal joints. The skin was cold, cyanosed, and glossy, and symptoms of aching pain, numbness, and uselessness were complained of. The *x*-ray report was: "Fracture united. Patchy decalcification in tarsal and metatarsal bones with, apparently, areas of sclerosis." Later, on October 29th, after one month's physiotherapy: "Mottled appearance more evident. Loss of definition in joint."

TREATMENT

Physiotherapy was tried for one month, local whirlpool baths, massage, underwater douches, contrast baths, and hot paraffin baths being given; the oedema and pain increased. On November 30th the wrist was immobilized in plaster from fingers to elbow, with elevation for one month. It was then removed, and pain, swelling, and tenderness were diminished. Passive movements and massage for one week produced immediate relapse. A plaster allowing movements of the fingers was then reapplied for three weeks. The next *x*-ray report was on December 9th: "Decalcification predominating; sclerosis disappearing."

On December 22nd her condition was generally improved. A light plaster cock-up splint, suitable for removal daily for short periods, was then applied.

Further progress has been slow. The fingers at the end of two months were semi-flexed and stiff, with phalangeal joints enlarged. Pain followed efforts to straighten them forcibly. An increase in swelling followed moderate use and the application of heat, while the pain was aggravated by cold.

Case III

A shop assistant, aged 18, sustained a severe sprain of the right wrist from a fall on to the back of his hand on October 8th, 1934.

The discomfort and slight swelling gradually increased. The wrist was up in splints and a sling at the end of one week. When seen in the out-patient department of this hospital on October 29th the hand and wrist showed the typical appearance of traumatic oedema. *X*-ray showed commencing loss of calcium from metatarsal heads.

TREATMENT

Physiotherapy, instituted for one month, caused an exacerbation of symptoms and a spread of oedema into the forearm. On November 28th the arm, from fingers to elbow, was immobilized in plaster for three weeks; but he was given no precise instructions as to elevation. *X*-ray of the hand then showed decalcification extreme in patches, contrasting with areas of sclerosis—typical mottled appearance; and of the neck, supernumerary cervical rib on right side. On removal of the plaster the pain was less, but the oedema was only slightly diminished. The plaster was then reapplied for four weeks, with elevation; at the end of this time there was no pain, and the oedema had greatly diminished. He was discharged on December 22nd with a cock-up splint and a sling. The *x*-ray report on January 22nd was "Decalcification predominates." At the end of one year the hand was said to become puffy after a day's non-laborious work, while movements were weak and sluggish. Pain was present only after prolonged use. An interesting feature in this case is the presence of the cervical rib on the affected side, and its possible effect upon the control exercised by the higher sympathetic centres, particularly in view of the relative slightness of the original trauma.

Case IV

A stone filler, aged 43, sustained a fracture of the tibia and fibula from a fall of stone on May 20th, 1935. There was a moderate degree of shock, with extensive bruising over the back of the thigh. The limb was immobilized in plaster for six weeks. On removal, union was satisfactory and there was only a trace of swelling present. He was then treated by physiotherapy, with active and passive movements, for seven weeks. There was a progressive increase in oedema

and pain. On August 22nd, when I first saw him, typical traumatic oedema was present, and an *x*-ray showed: "Healed longitudinal fractures of tibia and fibula four to six inches above ankle; fragments in good position. Bones of foot show typical mottled moth-eaten appearance. The osteoporosis predominates."

Immobilization was advised but not carried out; rest with the leg elevated and firm bandaging was tried, off and on, for the next two months; afterwards he was allowed to walk.

Recent progress has been slow. The leg is still swollen, particularly at the end of the day or after walking. The skin is slightly cyanosed and cold. He has been unable to resume work yet, but is clearly improving. The two most recent *x*-ray reports were: January 28th, 1936—"Generalized osteoporosis of bones of foot and lower end of the tibia and fibula; no mottling, but 'lines of force' prominent"; and on March 29th—"Moderate recalcification has occurred in last two months, 'lines of force' not so clear."

There are three main theories with regard to the production of traumatic oedema according as the condition is thought to result from changes in the circulatory, lymphatic, or sympathetic nervous systems. Whatever the cause of the retention of fluid in the tissues the distension produced may ultimately lead to a proliferative reaction in the connective tissues and result in diffuse fibrosis, which shows itself mainly as a permanent peri-articular thickening with a consequent hampering effect on movement.

The Circulatory Theory

Venous stasis, which is an accepted cause of oedema, may result from the blocking of a vein, as in phlebitis, vaso-dilation, or vaso-constriction. By means of local thermometry, Braeucker showed that the circulatory disturbance is localized in the region of the arteriolo-capillary network, manifesting itself by wide and frequent alterations in the skin temperature. Unfortunately, pathological examinations have not assisted in establishing the culpability of the circulatory system, since organic changes in the vascular walls have only been found in a fraction of the cases investigated. There is much evidence to show that traumatic oedema cannot be due to circulatory effects alone, and it may be summarized as follows:

1. Leriche showed in a case of oedema that section of a venous cord blocked by phlebitis, which could not therefore influence the circulation, caused disappearance of the oedema. (The effect of this operation is that of a true sympathectomy.)

2. Methods aimed at improving the circulation by direct action upon the vessels are useless.

3. Ranvier tied the inferior vena cava of a dog below the level of the right ventricle and then cut the sciatic nerve. As a result gross oedema developed on the affected side. When the sciatic nerve was cut below the point where its fibres enter the vessel wall there was no oedema.

4. Leriche, in ten instances, tied three veins in a rabbit's ear without producing oedema. If, however, a cervical sympathectomy were done at the same time, oedema resulted.

The Lymphatic Theory

The theory that lymphostasis is to blame in traumatic oedema is supported by Basset, Hagenau, and Gemthrou, who came to this conclusion after failing to obtain satisfactory results by operative measures. These operative measures included:

1. Exposure of the iliac vessels for the purpose of confirming or not the presence of the thickened bands which had been discovered by Leriche. In no case were any such bands discovered.

2. Peri-iliac sympathectomy: at this operation fragments of adipose subcutaneous tissue were removed, and while on histological examination they were found to be rich in arteries and nerves the only marked abnormality was the presence of abnormally dilated lymphatic canals.

The writers suggest that under the name of traumatic oedema are grouped several different conditions, some nervous in origin (meningeal thickening, spina bifida of Leri), some venous, some perivenous (Leriche), and some undoubtedly lymphatic in origin. Various explanations have been put forward in regard to the lymphatic theory. Some workers consider that it may be due to changes in the nerve supply of the lymphatics and others to an obliterating lesion analogous to filarial elephantiasis. As for the site of the lesion, the lymphatic dilatation points to the probability of an obstruction above that area in the pelvis which was explored at the time of the operation.

According to Adami, mere obstruction of main lymphatic channels does not lead to a complete stagnation of lymph, as there is a continuous interchange with the capillaries. Nevertheless continuous and prolonged distension of the parts with lymph may lead to a fibrosis, diffuse in type, although it is only obvious around the joints. Evidence of this is shown at an early stage by the appearance of connective tissue changes of a sub-inflammatory nature. Clinically, a dependent limb has increased arterio-capillary pressure, whereas the same limb distended with oedema has relatively a smaller amount of blood in it. The connective tissue changes may be due to a combination of indirect tissue reactions (from increased normal or abnormal lymph) and chronic venous congestion.

The Sympathetic Nervous Theory

Leriche may be truly described as the greatest exponent of this theory, and his published figures are very striking; Telford and Stopford in this country and others have also worked on this problem. Brandao describes a series of operations on the upper limb which produced exactly similar results. He began with a sympathectomy, the immediate result of which was disappearance of oedema and pain, but at the end of ten days the condition reasserted itself. The next step was the removal of the stellate ganglion. Again the relief was immediate, this time lasting for three months, after which the swelling returned, but to a diminished extent, and it did not extend above the wrist. Lastly, he removed the whole of the cervical sympathetic system, with the result that the oedema once again disappeared and had not returned in any of his patients at the time of publication of the article, a period varying between one and a half and two and a half years after the operation.

Leriche, on the other hand, carries out the operation in exactly the reverse order, taking out the ganglion first and afterwards carrying out the sympathectomy, with equally good results in the cases described. The apparently segmentary control of the sympathetic nervous system was shown by the fact that after a sympathectomy the oedema returned to the same extent as before operation, whereas after the stellate ganglion had been removed it only returned to a diminished extent. It would thus appear that ultimate control depends upon the preservation of the whole cervical chain. It is curious that when Leriche and Jury removed the superficial stellate ganglion in a rabbit oedema appeared, while in the case of a rabbit with oedema from other causes the removal of the same ganglion caused the oedema to disappear.

Calvé maintains that oedema is always an accentuation of a physiological state; in other words, it is probably

due to a disturbance of the mechanism regulating normal physiological balance. The operative measures described above act by suppressing the long reflex. The control of fluid interchange in the extremities depends upon the activity of local peripheral centres operating through short reflexes. These are sufficient to maintain equilibrium in the absence of abnormal stimulation via the long reflexes from the higher sympathetic centres. Thus it has been shown experimentally by Leriche and Fontaine that local oedema due to phlebitis can be cured by sympathectomy or removal of the appropriate sympathetic ganglion, thus indicating the capacity of the local centre to restore fluid balance after the removal of an abnormal higher influence.

The condition appears to be relatively unknown in children, and the several theories advanced to explain this include the following: the increased vascularity of the growing child; the extreme rapidity with which their lymph circulation is re-established; and the relative unimportance of the long reflexes in the control of local fluid interchange in the extremities.

Symptoms and Signs

This aspect of traumatic oedema has been sufficiently covered in the description of the cases, so that a short summary will suffice.

The initial trauma is usually severe, but not necessarily. Three of the present series were associated with fractures and gross injury; the fourth followed after a sprain of the wrist. Pain is always present. It diminishes in severity in proportion as the tissues recover from the effects of the original injury. It reappears when immobilization ceases, and is intensified by the application of any form of physical treatment. It is variously described as being of a jarring, aching character, and deep-seated. Tenderness to deep pressure is a constant feature. In the later stages the pain becomes intermittent, but it always accompanies movement. It is probably due to changes in the spatial relationships of the sensory nerve endings, which are pressed upon by the increasing fluid bulk, especially in the extremes of movement.

The primary swelling is soft, pits on pressure, and tends to diminish rapidly with the preliminary measures of rest, especially in plaster. The skin shows little abnormal change; it varies in colour but is usually pale; it may be moist and its temperature is normal. Trophic changes are not present in the nails. The secondary swelling or true traumatic oedema appears at the end of two or three weeks, and is hard and brawny in character. The skin is now usually cyanosed, cold to the touch, and possesses the glossy appearance associated with trophic changes. The nails become grooved and brittle. Other sensory variations occur with hypo-aesthesia or more often hyperaesthesia. The persistent and unchanging character of the oedema soon becomes apparent, and is characteristic. In the hand the appearance of the swollen, tapering fingers with prominent joints is typical. Connective tissue changes begin soon after the establishment of the secondary oedema, and in some cases ultimately progress to a generalized diffuse fibrosis which is obvious only when the oedema has subsided. It then appears mainly as an enlargement of the joints, and is responsible for the deformity and loss of function. It is said to occur more particularly in joints distal to the site of the trauma.

Some loss of function is always present. Each joint possesses a greatly reduced range of painless movement, beyond which pain occurs. The loss of movement is not due to joint changes or to tendon fixation, but to the hampering effect of tender peri-articular thickening.

X-Ray Changes

Progressive decalcification with, in the late stages, increased density of the peri-articular soft structures constitutes the main change. The decalcification is more intense than that which follows simple disuse. The loss of calcium is uneven, and the bones show a curiously mottled, moth-eaten appearance. This mottling is particularly evident where physiotherapy has been persistently employed or where mobilization has been prematurely allowed. In such cases areas of dense sclerosis appear side by side with the more typical porosis. It is interesting to reflect that such changes do not follow the oedema of general anasarca, nor that due to the ligation of veins or the severance of nerves in a limb, excluding trophic disturbances. The slight increase in the density and thickness of the peri-articular shadows is only seen in the late stages of neglected cases.

Physiotherapy and Mobilization

With regard to the value of physiotherapy in the treatment of traumatic oedema the opinions of other workers are in close accord with my own experience. Generally speaking, at all stages of the disease it is likely to do more harm than good. Occasionally in the later stages, when the morale of the patient has been undermined by the prolonged period of incapacity, physiotherapy may act as a stimulant and so have a useful psychological value. In particular, massage, passive movements, douches, and baths are dangerous, and if persisted in will bring about an increase not only in the oedema but also in the subjective discomfort of the unfortunate patient. A certain amount of active movement of fingers or toes may be permitted even in the early stages (this is quite consistent with immobilization in plaster), and in the later stages, when not associated with pain, active movements may lead up to the provision of suitable light work. Early mobilization of fractures and severe sprains is responsible for the development of traumatic oedema in the majority of patients.

Immobilization

This is the method of choice, and it must be early, complete, and accompanied by elevation of the limb. It is not within the province of this article to deal at length with the treatment of fractures by immobilization in plaster with provision, consistent with complete immobilization at the site of the fracture, for finger or toe movements, and permission even for gentle use of the limb; such treatment would prevent many cases of traumatic oedema. When, in spite of these precautions, oedema appears or fails to disappear, then complete immobilization of the whole limb with elevation is essential for at least one month. At the end of this time the plaster may be "bi-valved" and, if the oedema is diminishing and the pain has disappeared, removed for a few minutes daily for gentle active movements. These may be carried out with great advantage in a bath at about 99° F. At least a fortnight should elapse before greater activity is permitted. Afterwards the length of time for which the plaster is removed may be progressively increased.

Operative Measures

Should the oedema return quickly then two courses are open: either a repetition of the immobilization or recourse to operation. The choice of operation lies between peri-articular sympathectomy and the removal or suppression of the appropriate sympathetic ganglia. Having had no experience of these methods I am not in a position to discuss the relative merits of each or of their combination. The advantages of early recourse to surgery are the very material shortening in the period

of recovery and the prevention of the ultimate loss of mobility and the peri-articular fibrosis which inevitably occurs in proportion to the length of time during which the oedema has been present and its extent.

Discussion

Sufficient space has already been accorded to a consideration of the relative parts played by the circulatory, lymphatic, and sympathetic nervous systems in the production of traumatic oedema. All are involved, the breakdown of the normal mechanism of fluid interchange being, whatever the cause, maintained by abnormal impulses from the higher sympathetic centres via the long reflexes; and these in their turn depend on irritating afferent stimuli from the damaged tissues, now distended with lymph. The intense bony atrophy may be due to a state of chronic venous congestion, the obstruction to the venous return following extreme distension of the part with lymph. The operation of sympathectomy, which by dilating the vessels might be expected to aggravate the situation, actually produces its beneficial effect by suppressing the long reflexes from the higher sympathetic centres.

It is a little difficult to reconcile the good results from two such vastly different procedures as immobilization and sympathectomy. It is probable that immobilization combined with elevation, by relieving tension and promoting complete muscular and ligamentary relaxation, may modify the afferent impulses to the sympathetic ganglia. Thus a gradual toning down of the abnormal efferent influences responsible for the maintenance of the oedema takes place. The successful performance of a sympathectomy probably effects its cure by a similar action.

Conclusions

1. Traumatic oedema is a specific affection of an extremity coming on several days after trauma, which is usually, but not always, of a severe character. It consists of a distension of the part with lymph following a dislocation of the normal fluid interchange in the tissues. Experimental evidence and a consensus of opinion suggests that changes in the lymphatic rather than the circulatory systems are responsible. Its persistence is due to the development of abnormal influences from the higher sympathetic centres which prevent the re-establishment locally of the normal equilibrium.
2. The majority of cases can be prevented by the correct treatment of fractures as described elsewhere, and by the avoidance of early mobilization.
3. In an established case early immobilization with elevation and complete rest will not only greatly curtail the period of incapacity but will prevent the resultant fibrosis.
4. The application of physiotherapy at any period other than in the very late stages is unjustifiable.
5. Operation in certain hands offers great advantages when the condition is established, since it not only cuts short an otherwise protracted course, but if carried out at an early stage prevents the development of fibrosis. It would appear that both peri-articular sympathectomy and removal of the corresponding portion of the higher sympathetic system is required for a permanent cure.
6. Uneven osteoporosis is the characteristic x-ray appearance with, in the later stages, peri-articular thickening.

BIBLIOGRAPHY

- Braeucker, W.: *Zeit. f. Kreislaufforsch.*, 1932, xxiv, 601.
 Idem: *Monats. f. Unfallheilk.*, 1931, xxxviii, 241.
 Basset, A., Hagenau, N. Y., and Gemthrou, Mlle: *Revue Neurol.*, 1930, p. 258.
 Brandao, F.: *Lyon Chir.*, xxix, 401.
 Leriche's and Fortaine's work reviewed in above.
 Villaret, M., and Desville, H.: *Les Oedèmes Atypiques des Extrémités*.
 Link, K. H.: *Med. Klin.*, 1930, xxvi, 897.