Wassermann reactions will be found to have become weak or negative if the case is one of cerebral syphilis, whereas in general paralysis they will remain almost unaltered.

The cases of acute syphilitic meningitis which come on during the first two years after infection are easily mistaken for other forms of meningitis or encephalitis unless the Wassermann reaction is examined. Finally, it must be remembered that tumours of the brain and other non-syphilitic diseases may afflict a patient who has a positive Wassermann reaction in the blood. In such cases the Wassermann reaction is usually negative in the fluid.

Paraplegia

Lumbar puncture may give valuable aid in the diagnosis of the cause of paraplegic symptoms, and is rarely contraindicated in such cases. Attention is here directed, first, to the possibility of compression of the spinal cord or of blockage of the spinal subarachnoid space, and, secondly, to the presence of inflammatory changes in the fluid. Careful manometric examination, using Queckenstedt's test, is therefore essential in such cases. A complete spinal block is shown when there is no change in the manometric reading on deep bilateral jugular compression or on the inhalation of amyl nitrite, though coughing or abdominal compression may bring about a temporary rise of pressure. Lesser degrees of spinal block are more clearly indicated by failure or delay in the return of the pressure to normal when jugular compression is stopped than by a delay in the initial rise, seeing that the latter may be due to an obstruction, as by a nerve root, at the point of the needle. Associated with spinal block there is always an excess of protein in the fluid, but this of itself is insufficient evidence of spinal compression, as it may appear in other conditions. Spinal block usually indicates the presence of a tumour or granuloma within the spinal canal, although it may more rarely be caused by adhesive meningitis of an acute or more chronic type.

Accurate diagnosis at as early a date as possible is essential in such cases, and although lumbar puncture of itself will rarely indicate the cause of the spinal compression, it may, when combined with radiological examination, clinch the diagnosis. In addition to the primary tumours of the meninges, and benign and malignant tumours of the bones, the possibility of invasion of the spinal canal by granulomatous masses (tuberculous, staphylococcal, or lymphadenomatous) must be borne in mind, especially in the more acute cases.

Poliomyelitis is characterized in its early stages by a high cell count, in which polymorphonuclears are often abundant, along with a comparatively slight excess of protein, usually below 0.1 per cent. This may serve to distinguish it from Landry's paralysis and polyneuritis, in which the fluid either is normal or contains a considerable increase of protein with a low cell count. In rare cases of polyneuritis a higher cell count may be found in the fluid, along with a great excess of protein and often a yellow colour.

In the acute inflammatory or demyelinating diseases of the spinal cord (acute disseminated myelitis, disseminated sclerosis, and diffuse myelitis) the cell count is rarely above 20 per c.mm., and the protein excess is also moderate. Acute syphilitic myelitis is usually associated with a high cell count in the fluid and with a positive Wassermann reaction in the fluid and blood. In this condition, and in disseminated sclerosis, the Lange reaction is often strong, and, especially in the latter disease, may be of the "paretic" type. Thrombotic lesions of the spinal cord are not usually associated with any increase in the cells or with any great excess of protein.

In more chronic types of paraplegia the chief value of lumbar puncture is to eliminate the possibility of spinal tumour or compression. The diagnosis of disseminated sclerosis may sometimes be indicated by a moderate increase in the cells along with a strong Lange reaction, but, except in these conditions and in syphilitic myelitis, no characteristic changes in the fluid are to be expected.

Pain in the Distribution of the Spinal Nerves

When the chief, or the only, symptom is pain along the distribution of one or more of the spinal nerves, lumbar puncture is often of great help in diagnosis. Many such cases are due to a small tumour on a nerve root or to compression of a nerve root by disease of the vertebrae, and it is important to eliminate these possibilities by testing for spinal block. Inflammatory disease of the lumbo-sacral roots or of the sciatic nerves may be associated with a considerable excess of protein and occasionally with a rise in the cell count in the lumbar fluid; but in these cases no spinal block will be present. A similar excess of protein without spinal block may be found when a spinal tumour lies in the lumbo-sacral canal below the level of puncture. Radiological investigation with or without the help of lipiodol is often useful in cases of the latter type.

Finally, in cases of neuralgic pain the possibility of tabes should be borne in mind. It is true that a considerable proportion of the cases of tabes in which pain is the chief symptom have a perfectly normal spinal fluid, but some excess of lymphocytes, a positive Lange reaction of the "luetetic" type, and a positive Wassermann reaction, are usually found.

OBSERVATIONS ON FIJIAN FIRE-WALKING

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On Thursday, August 29th, 1935, the ceremony of fire-walking was performed at Suva by native Fijians from a neighbouring island (Mbengha) for the benefit of members of the British Medical Association who were visiting the island of Fiji on their way to Australia.

We were invited to make an examination of the fire-walkers that we desired, in order to learn, if possible, how a performance which might be expected to cause severe pain is carried out without obvious painful reactions. It is not necessary to describe here the full details of the performance, which have been recounted by other observers, beyond stating that the one that we witnessed conformed fully to the traditional routine.

On arrival we found that, in preparation for the ceremony, a pit, some twelve to fifteen feet in diameter, had been scooped out in the ground to a depth of several (four or five) feet. The floor of this hollow had been covered with stones of irregular shape, each about the size of a football. On them a fire of logs had been burning for nine or ten hours. The stones were of a whitish-grey colour, possibly owing to the action of the fire, mostly rounded or water-worn, and of a granular surface. They had been specially brought from Mbengha by the performers. When we arrived, the logs, still glowing, had been mostly burnt up or reduced to charcoal. Before the ceremony began, a few unburnt logs on the surface were carefully removed by native assistants by means of loops of twisted green bark attached to long poles. Some stones were turned over by these men and roughly arranged so as to afford a fairly steady and secure foothold.

Examination of Fire-walkers

The native chief, on behalf of the performers, agreed to submit them to a full examination both before the ceremony began and after its completion.

We selected two men whom we considered we could identify again after the performance. Both of them were of superb muscular development. The brown skin of their body and limbs had been oiled. They were arrayed in multi-coloured skirts of foliage and flowers, and they wore chaplets of leaves of various colours around their heads, with a small tuft of white umbelliferous flowers implanted in the thick, wiry hair of the scalp.

Our preliminary examination yielded the following results: The feet were normal in form and texture. The skin of the soles was soft and pliable, neither unduly dry nor unduly moist, and showed no sign of any previous local application of oil or other substance. There was no undue or unusual degree of cornification, but there was a slight thickening of the skin over the whole sole, not more than would be expected in a man who had walked barefoot all his life. The area of contact with the ground included a considerable portion of the centre and outer part of the sole, together with the heel and the balls of the toes. The skin of the feet in both men was sensitive to pain, as shown by wincing of the face in response to pin-pricks. As might be expected, the thinner skin of the dorsum was more sensitive than that of the sole. The response to heat was tested by the somewhat drastic method of applying the glowing end of a lighted cigarette. In one man contact of this burning end with the skin of the sole caused him immediately to wince; in the other, more prolonged contact, for a second or longer, was endured with apparent apathy, the end of the burning cigarette being eventually crushed against the skin near the centre of the sole without inducing a grimace, although he indicated that it was unpleasant. The reflexes in the lower limbs were normal, including brisk ankle-jerks and plantar responses of the normal flexor type.

The Ceremony

After this examination the two men, with some seven or eight of their comrades, retired into a small hut of palm leaves to prepare themselves for the "fire-walking." We did not enter the hut, but one of us was told by the chief that the ceremony consisted in prayers to a "small devil," who was invisible. During this part of the ritual, which lasted several minutes, the hot stones were being carefully examined by the others to verify their steadiness. Several scraps of paper were thrown into crevices between the central stones, where the heat was sufficient to cause the paper to burst into flames almost immediately. The native assistants round the pit then began to chant songs and cries, which became progressively louder and louder. The performers now made their appearance, running from the prayer-hut over the damp grass to the pit. They walked across it in single file, stepping on the heated stones. The duration of contact of their feet with the stones was that of an average footstep—about a second—and their walk was not appreciably hurried. Each man appeared to step exactly on the same stones as his predecessor. After they had crossed the diameter of the pit and had walked a few steps just within its circumference, bundles of leaves and rushes, previously collected, were undone by the assistants and performers and quickly scattered over the stones, completely covering the central part of the pit.

The performers, by this time standing at the edge of the pit, then returned into it and sat down carefully on the vegetation, huddled around the leader in the centre and facing him. Smoke began to rise in wisps from the leaves charred by the stones. The gluteal regions and feet of the men were now separated from the hot stones by an intervening layer of vegetable material. After a short interval the performers rose and walked out of the pit. Our two selected ones came and sat down on the grass beside us for re-examination. Both of them, immediately after the fire-walking, were clearly somewhat excited. The pulse rate in one was 96. Their hands were slightly tremulous. There was no undue dilatation or contraction of the pupils. The soles were covered with a thin layer of dust and ash; on brushing this off, there

was no sign of injury to the skin, neither blistering, charring, nor recognizable erythema. In one man the plantar skin was not unduly hot, while in the other it was warm. The prick of a pin to the sole induced a grimace of pain in both men as before.

One of the larger stones, still very hot, was extracted from the pit and rolled along the ground towards us, a distance of three or four yards. The men and ourselves all sat down beside it. We asked them to put their hands on the stone, but they, like ourselves, could not give it more than a momentary touch. When asked to put their feet on it they did so, but only for a second or so. The chief himself, however, who was supervising us, placed the sole of his foot on the hot stone and held it there with placidity for several seconds. Some amusement was caused by the two performers, who slyly turned the stone over so as to induce us to touch a portion of its surface which had been fractured and which was apparently rougher and hotter than the smooth surface on which they had walked. We found that this surface was so hot that we could touch it only momentarily with our finger-tips. The soles of our own feet also could only touch it for a very short time, perhaps a second, when the pain caused prompt retraction of the foot, followed by erythema but no blistering.

We were told that if either of us felt any pain one of their old men could remove or cure it. One observer's foot was decidedly hot and painful from contact with the stone, and the venerable physician was accordingly invited to treat it. This he did in a professional manner, sitting down, taking the foot in his hands, and asking which was the most painful spot. This he massaged gently and firmly with his thumbs with a deep stroking movement, which was quite pleasant and certainly seemed to relieve the pain. The other observer suffered no discomfort beyond a transient tingling and erythema, which passed off in a few minutes.

Comments

Assuming the foregoing observations to be accurate, and, in particular, accepting it as a fact that these Fijian performers actually walked with bare feet upon stones heated to a temperature sufficiently high to ignite ordinary paper, various explanations for the phenomena have been offered, among which may be mentioned the following.

1. That the texture of the tissues on the plantar surface of the feet is abnormally tough, hard, or thick, so as to act as a non-conductor. Our observations contradict such a theory. The skin of the performers' feet was neither thicker nor tougher than that of any other individual accustomed all his life to walk bare-footed.

2. That some analgesic substance (commonly rumoured to be oil from a particular variety of palm) is applied to the soles prior to setting foot on the hot stones, or that some opiate drug is administered internally to produce diminution of sensibility to pain. If this were so examination of the feet immediately after the ordeal should have shown them to be still insensitive to pain. No such analgesia was present, nor was there any trace of oil or any other locally applied substance. There was no clinical evidence of opiate administration: the performers were mentally alert; their pupils were normal in size.

3. That these Fijian natives possess a natural generalized blunting or abolition of sensibility to heat and pain. Careful testing showed no evidence of abnormal blunting of sensation. We noted, however, that both of the individuals whom we examined exhibited a degree of stoicism or indifference such as may be found in certain coloured races less highly strung than our own. Nevertheless, they reacted briskly and normally when painful stimuli were applied to the soles or elsewhere, both immediately before and immediately after their ordeal.

4. That some organic lesion was present, implicating the plantar nerves, the corresponding nerve trunks or posterior nerve roots (L 5 and S 1), or the spinal cord itself. The absence of any sensory, motor, reflex, or trophic abnormalities excludes this possibility.

5. That by training and practice and by the repeated exposure of the soles to heat the performers are able to endure, without severe pain, a temperature which to an untrained person is intolerable. Several considerations

have induced one of us (D. W.) to accept this view and to consider it unnecessary to seek any further explanation.

6. That the phenomena of transient therm-anaesthesia of the soles are due mainly to suggestion, either auto-suggestion by the performers themselves or hetero-suggestion by their native chief or priest or some other authority. This, in the opinion of the other observer (J. P.-S.), is the correct and adequate explanation.

The grounds of one of us (D. W.) for accepting hypothesis No. 5 may be stated as follows. It is a matter of common knowledge that, in some parts at least, repeated application of a painful stimulus to the skin in time ceases to cause pain; in other words, the threshold to pain is raised. The soles of the feet constitute one of these regions. Thus, for example, children who discard shoes and stockings after being accustomed to wear them cannot at first bear to walk over sharp gravel owing to the pain which it causes, but after a few days' practice they can do so with impunity. This may be ascribed to a thickening and toughening of the tissues of the soles, but examination shows no definite thickening or added keratinization, and it would appear that there is a blunting of sensibility, or, more precisely, that the threshold to pain has been raised.

It is also known that repeated exposure to high temperature raises the threshold to pain to a remarkable degree. A person accustomed to immerse the hands in very hot liquids comes in time to be able to plunge them, without experiencing severe pain or incurring any ill effects, into fluids of a temperature intolerable to others, and also to handle unusually hot objects. By habituation hot liquids can be taken into the mouth and there come in contact with its sensitive mucosa as well as with that of the tongue without causing severe pain or local damage, although liquids of the same high temperature could not be endured on the skin surface and would produce on it a marked erythema and even a blister.

It was clear from our observations of the feet before the ceremony or any preparation for it that the soles were not readily affected by a thermal stimulus. In our preliminary examination both of the performers endured, without retraction of their feet, the experience almost intolerable to an untrained European, of having the skin of the sole blackened by application of the glowing end of a cigarette. One of the men seemed to experience only slight discomfort, while the other indicated that it was merely unpleasant. The comparison after the ceremony of the reactions obtained on the soles of our own untrained and sensitive feet and those obtained on the soles of the "fire-walkers" showed the difference between us and them, for while we could only momentarily touch the hot stone, they, on the other hand, were able to apply their feet to it for a second or longer.

The temperature of the stones was doubtless sufficiently high to injure any organic matter long in contact with them, and prolonged contact would have burned the soles of the feet. But the momentary contact of stepping over the stones did not cause even the least degree of burning or produce any erythema and still less any blistering or destruction of tissue. Since it was insufficient to produce any of these results, it cannot have caused any severe pain. It must be remembered that keratinized epithelium is very resistant to heat, and their soles before the ceremony stood the application of a glowing cigarette end. After the ceremony the chief showed us that he could put his foot on a hot stone and keep it there for some seconds, withdrawing it only when, after that interval, he began to feel pain. Doubtless, were one of the performers to slip while walking over the hot stones and fall on them, so causing the hands, arms, or any portion of the skin of the trunk to be in contact with the stones, a severe burn might be caused, but it seems to be unnecessary to bring in any other factor to explain the performance.

In the opinion of the other observer (J. P.-S.) explanation No. 6 is supported by the temporary duration of the

indifference to intense heat, as evidenced by the normal responses to pin-pricks and to thermal stimuli immediately before and also immediately after the ordeal. It is also corroborated by the strict localization of the sensory diminution to the soles of the feet, since the performers, while able to stand or walk on the hot stones, were unable to sit on them with their gluteal regions in direct contact, nor did they touch the stones with their hands. Moreover, the highly significant preliminary religious ritual in the prayer-tent, whereby a degree of hypnotic suggestion is readily attainable, is closely analogous, and probably identical, with similar varieties of religious or hypnotic ecstasy which I have witnessed in certain Hindu fakirs and also in groups of emotional dervishes in Algeria, Tunisia, and other Mohammedan countries.

My friend Professor K. W. Bouman, the distinguished neurologist of Amsterdam, who was also present at this fire-walking performance, and who examined independently another of the performers, informs me that he corroborates the occurrence of well-marked pain reactions in response to a burning cigarette and to pin-pricks applied to the soles both before and after the fire-walking. Professor Bouman allows me to state that he is in agreement with my view—namely, that the religious ritual within the prayer-hut is a preparatory ceremony for the purpose of "purifying" the devotees prior to the fire-walking, and that this ceremony is of fundamental importance to the performers. Professor Bouman has witnessed similar performances of walking in hot ashes in Java, where the religious part of the ceremony is of the highest importance and is an indispensable preliminary for the fire-walking.

The absence of blistering or apparent tissue necrosis on the exposed surfaces of the soles has naturally been urged against this theory of suggestion or pithiatism. I would, however, recall the fact that similar marked abnormalities of vascular reactions in the skin and deeper tissues subjected to painful stimuli have repeatedly been verified in patients under the influence of hypnotic suggestion. One of us has personally witnessed at close quarters completely bloodless, and apparently painless, transfixion of both cheeks, also the whole thickness of the forearm, by skewers, as well as transfixion of the skin and subcutaneous tissues of the front of the neck by a bayonet, without a drop of blood appearing. Similar observations of bloodless transfixion of the deep tissues have been photographed and recorded by cinematograph, where a skewer entering at one side of the neck behind the carotid sheath traverses the prevertebral plane and emerges bloodlessly on the opposite side behind the great vessels of the neck.

Incidentally it may be recalled that during deep hypnosis of suitable individuals not only have negative reactions—such as absence of blistering, erythema, or bleeding—been observed, but abnormal reactions of a positive character sometimes occur—for example, temporary spontaneous erythema and blistering subjacent to a fictitious fly-blister, such as an ordinary postage-stamp, devoid of cantharides or other cutaneous irritant.

Finally, I would call attention to the religious element in the ritual, indicating that this was not an habitual or trivial or daily performance but an infrequent and specially prepared celebration. Religious ecstasy (as in the long procession of saints and martyrs of various creeds, from the days of Shadrach, Meshach, and Abednego in Nebuchadnezzar's fiery furnace down to St. Joan of Arc, burnt at the stake at Rouen in 1431, and many other instances, all probably the result of auto-suggestion) is capable of temporarily suppressing sensations of pain. Such interruption or suppression of sensibility is a cortical affair, whereby the individual for the time succeeds in inhibiting and ignoring painful stimuli arising at the periphery.

We are indebted to Sir Murchison Fletcher, K.C.M.G., Governor of the Fiji Islands, and to the Hon. C. H. Monckton, Minister for Native Affairs, for the opportunity of making the above observations.