

atism); Guy's Hospital; Hammersmith Hospital and Postgraduate Medical School of London; London Hospital; Radcliffe Infirmary, Oxford; Royal Infirmary, Edinburgh, and the hospitals served by the Edinburgh University Department of Pathology; Royal Infirmary, Manchester; St. Mary's Hospital; St. Thomas's Hospital. The following hospitals co-operated in a limited extension of the survey to include more cases proved by biopsy: Middlesex Hospital; Royal Victoria Infirmary, Newcastle upon Tyne; St. Bartholomew's Hospital; University College Hospital; Westminster Hospital.

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NEUROPSYCHIATRIC SEQUELAE OF LIGHTNING STROKE

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On July 14, 1955, lightning struck the racecourse at Ascot, killing two people and injuring a number of others. 51 were taken to various casualty centres in the vicinity, the majority suffering apparently from a minor degree of shock only; 31 were not detained. Twelve persons were rendered unconscious for more than a few moments, and two of these died from head injuries. The immediate effects, apart from shock, were in the nature of burns, temporary paralyses of the limbs, paraesthesiae, tremors, transient deafness and dysphasia, numbness, and headache (Arden *et al.*, 1956).

Injury or death from lightning is not a rarity in this country. It causes about five to ten deaths annually in England and Wales according to Hughes (1956), the victims usually being the unfortunate individual, or small group, trying in vain to shelter from the storm. Luckily, incidents on the scale of the one at Ascot occur very rarely. There was the well-known Koenigsberg disaster in 1925, which was fully reported by Panse (1925). Much more recently a lightning incident occurred at Aldershot.

Much of the relevant medical literature is concerned with the immediate effects of lightning injury. Neuropsychiatric sequelae are occasionally mentioned, but it is difficult to get a clear idea of their incidence. Psychiatric effects are recorded by Critchley (1932), the

principal ones being paranoid states and chronic psychoneurotic illnesses. Arden *et al.* reported that a few of the patients struck at Ascot had residual emotional disturbances, but no details were given. Hysterical manifestations after injury by lightning were also noted by Critchley (1932), particularly functional blindness, deafness, and loss of speech, and Langworthy (1936) mentioned hysterical aphonia as an occasional late sequel of injury by electricity. Hysterical symptoms were found by Critchley (1934) to be more common in lightning than in electrical injury. He also described a heterogeneous group of neuropsychiatric sequelae, which included transient pains, vasomotor disturbances, and spasms occurring in the limbs. A case of arterial spasm in the right arm and leg with transient paralysis has been reported by Currens (1945).

In the frequent references in the literature to paraesthesiae and loss of power in the limbs as the result of lightning stroke, opinions differ concerning the aetiology, although most authors emphasize a possible organic cause (Critchley, 1932; Cambier, 1953). Bach (1950) claimed to have demonstrated the organic nature of so-called neurotic symptoms following trauma by lightning. In one of his cases a demonstrable left-sided internal hydrocephalus was regarded as responsible for a fairly typical picture of post-traumatic neurosis, which had supervened in a man aged 38 who had been unconscious for two hours as a result of lightning stroke, and had later developed a temporary paralysis and dysphagia. A second man who showed symptoms of cerebral irritation became depressed, paranoid, and hypochondriacal, and later committed suicide. Haemorrhages in the occipital cortex were seen and reference was made to other similar cases in the German literature, and also to the findings described by Hassin in the brains of electrocuted criminals. Among the more clearly defined neurological sequelae are several references to cases of paralysis of both upper and lower motor neurone types (Critchley, 1934; Langworthy, 1936), and cases presenting as amyotrophic lateral sclerosis are described (Leys, 1942; Woods, 1952). Sphincter disturbance appears to be uncommon. A variety of ocular changes have been reported by Critchley and others, of which cataract seems to be the most common. Abnormal E.E.G. recordings have been noted; Cambier has reported minor changes in the theta rhythm.

The Inquiry

In view of the diversity of neuropsychiatric sequelae described, as well as their uncertain incidence, it seemed desirable, as Panse (1925) urged long ago, to inquire further into the consequences of lightning stroke. In describing the Koenigsberg incident of 1925, when three were killed and 26 injured as a result of lightning stroke, Panse referred to four cases (16%) as having reacted "psychopathically" to the trauma. Fear and anxiety were the common immediate effects. In no case did a traumatic neurosis ensue.

In the recent Aldershot incident a party of men were struck by lightning, and one man was killed. There were five other casualties, and medical reports were received relating to four of them. A month after the incident two men were still disabled by psychiatric symptoms. One, who had earlier displayed signs of cerebral irritation, had developed a mild anxiety state with loss of weight, poor appetite and sleep, tremors, apprehension, and dizzy spells; and the second, who was a close friend of the man killed in the incident, has continued to complain of weakness of the legs, dizzy spells, and headache, symptoms which are regarded as hysterical in nature.

An opportunity presented itself for an inquiry into the late effects of the Ascot incident. A questionnaire was sent to 50 patients who were treated at various hospitals and casualty departments as a result of the incident. The following questions were asked: (1) What were the immediate after-effects in your case? (2) Did you develop any further symptoms subsequently? (3) Are you now in good health? (4) If not, what symptoms do you now have? There were 28 replies, as shown in Table I.

TABLE I

Total number of cases admitted to hospital	..	19
Number replying to questionnaire	..	14 (74%)
Total number of cases not detained in hospital	..	31
Number replying to questionnaire	..	14 (45%)

TABLE II

Type of Symptom	Early*	Late†
Headache	11 (34%)	3 (11%)
Paraesthesiae	10 (31%)	3 (11%)
Loss of consciousness	8 (25%)	—
Paralysis	7 (22%)	1 (4%)
Anxiety or hysterical states	6 (19%)	3 (11%)
Fatigue	4 (12%)	0
Limb or neck pains	4 (12%)	2 (7%)
Deafness	3 (9%)	1 (4%)
Dysphasia	2 (6%)	0
Depression	1 (3%)	2 (7%)
Ocular	1 (3%)	1 (4%)

* Ascot and Aldershot. † Ascot only.

Neuropsychiatric sequelae present after six months (referred to as "late" sequelae in this article) occurred in 11 cases (39%). The total number of early sequelae in the Ascot and Aldershot cases was found to be 30 (94%). An analysis of the symptomatology of the cases studied is shown in Table II.

The following cases illustrate some of the neuropsychiatric sequelae found.

Illustrative Cases

A boy aged 10 was apparently blinded by the flash of lightning for several days. He had told his mother that he was watching the lightning dancing along the rails of the racecourse. He complained of acute pain in the eyes and had photophobia, and both eyes were reported to be mildly injected. There were peripheral opacities in the left eye, and vision in this eye rapidly deteriorated. Two months after the incident the left eye became acutely inflamed and oedema of the macula was reported. Nine months later a rosette cataract was present, and the macular changes were confirmed.

A woman of 57 became quite deaf following the incident, and a year later some degree of deafness was still present.

A man of 63 said he shook all over for three hours after the lightning. Giddiness and paraesthesiae in the arms were present. A year later he was reported in poor health. He had numbness of the fingers, he dropped objects, and his wife had to do his buttons up. He still complained of persistent paraesthesiae in the right arm and also of dizziness, although he had never lost consciousness. He was always, so it appeared, of a restless, nervous disposition and had done very little regular work. Most of his time was spent in helping bookmakers on racecourses. Since the Ascot incident he had become depressed, was afraid to go into busy thoroughfares, and had done practically no work at all.

A man of 65, knocked unconscious for a short period by the stroke, subsequently had a transient aphasia. He complained of severe headaches, stiffness of the neck, and on admission to hospital was regarded as suffering from a post-concussional state. He reported a year later an intensification of headache of a migrainous type.

A woman of 63 who had not been rendered unconscious by the stroke said she had developed fears and had become very excitable since the accident.

The mother, aged 38, of the lad of 10 referred to above was dazed as a result of the stroke. She has had bouts of

depression since, and has complained that she has been unable to go to the cinema or watch television, and seemed to feel "the vibration of electricity very strongly."

Case Showing Unusual Features

A single woman of 46 developed an hysterical ataxia. There were unusual details in this case which merit further description. This patient, an assistant nurse, was admitted to hospital in November, 1955, complaining of difficulty in walking. She had formerly been in domestic service and had volunteered for the Civil Nursing Reserve at the outbreak of the war. At the age of 12 she had sustained an injury to the left leg in a road accident. Seven years before admission to hospital she was "coshed" on the head and sexually assaulted in the grounds of her own hospital. She was badly shocked and sustained a large laceration of the scalp as well as injuries to the vulva. Her assailant was captured and there followed the ordeal of identification and the prolonged trial proceedings. She became very depressed and tremulous, and for several days her legs were weak. "My legs just would not go," she said. Troublesome headache and insomnia followed and persisted, and she was referred to a psychiatrist and given barbiturates. She had returned to light duties at her hospital and gradually improved, although she remained moody and was irritable at times.

She attended Ascot with a party, and was struck by lightning. She was rendered unconscious for an hour and sustained several burns on the scalp and on the left shoulder, elbow, and thigh. There was apparently very little retrograde amnesia, but the post-traumatic amnesia and confusion extended to about 36 hours. On admission to hospital after the accident, she was reported to have been conscious but incoherent. There was paralysis of the fifth, seventh, and ninth nerves on the right side, all deep reflexes were very much diminished, and the plantar reflexes were equivocal. Deafness, greater on the left side, was present, and lasted about two weeks. There were no sphincter disturbances. She was out of bed and had practically left her wheelchair at the end of two weeks after admission, but complained persistently of numbness and shakiness of her legs. Her gait was jerky and ataxic, and she clung to an assistant for support. Physiotherapy produced little improvement, and she was referred to a neurologist, who considered the gait hysterical. She left hospital after three weeks to return to her lodgings, but continued to have difficulty in walking. She also complained of showers of paraesthesiae, especially in the left arm, which on effort tended to become tremulous. She was practically confined to the house, but in spite of this stated that she felt much brighter and more cheerful since the Ascot incident than she was before.

Her complaint on admission to the neurosis centre four months after the disaster was that her legs just would not go and that there was no feeling in them. She also complained of shakiness and pins-and-needles in her left arm and leg, particularly on exertion or change of posture.

She was of short stature and pyknic build. There were healed burns of the left shoulder, elbow, and thigh, and a dry scab over the scalp burn. The cranial nerves were normal, apart from a slight degree of deafness on the left side. There was no wasting, and active movements in the lower limbs were full, apart from slight impairment of flexion and extension of the left knee and of dorsiflexion and plantar flexion of the left foot. Tone and co-ordination were normal and all tendon reflexes were brisk and symmetrical. Plantar reflexes were flexor. Anaesthesia of glove and stocking distribution was present, somewhat more extensive on the left side. The gait was a series of tremulous jerky steps. With encouragement she walked slowly in this fashion, like a clockwork toy, and complained of the great effort it required and the severe fatigue it caused. She was mildly euphoric and appeared more concerned with her paraesthesiae and burn scars than with her stiff awkward gait. She was quite certain that she had no neurotic illness,

and, although she was co-operative enough and was prepared to undergo investigation and treatment, she was rather passive, aloof, and incredulous. Her own explanation for her symptoms was that a nerve was being pressed on in her spine.

Well-meaning friends had told her that just after the lightning stroke her face was blue and set like one dead, and she was also told that her spine was affected, causing a partial paralysis, and that the resulting disturbance of gait would take at least six months to clear up. She regarded herself as a "living miracle," but wondered why she had been singled out for such trauma. There was a purpose behind it all, she supposed, and she was at least instrumental in placing a dangerous sadist behind bars. Now she would give anything to walk normally again, so that she could return to nursing. The E.S.R. was 4 mm. in one hour (Wintrobe). The E.E.G. was within normal limits. Blood W.R. and Meinicke test were both negative.

The disturbance of gait which had been present since admission was regarded as hysterical. The opinion of the consulting neurologist was that there had been an organic effect on the spinal cord, but it had practically cleared up.

Strong suggestion given under intravenous sodium amylbarbitone produced an excellent response. She walked easily and even briskly with no jerkiness, and on her first weekend leave managed to climb the stairs. She held on to her opinion that the symptoms were organically determined. Removal of the hysterical gait had been followed by a complaint of more pain, particularly over the old lightning burns on the leg and in both hands, although the actual numbness was beginning to clear up. Physiotherapy and walking exercises were instituted concurrently and the improvement was maintained. When discharged in mid-January she walked quite normally, but still had some anaesthesia of the typical glove and stocking type. She said that until recently she felt that she was owed some suffering; it had been uncanny and quite past her understanding why she had not suffered more after such a severe shock. Now she realized that she had been through a serious illness and was making a complete recovery. A follow-up 12 months later showed that she had maintained the improvement, and had resumed full nursing duties, which included night duty.

Other Effects

Critchley (1932) has noted the apparently beneficial effects of lightning on the course of intercurrent disease. Two women in our series, aged 52 and 57, both reported that their rheumatism had noticeably improved since the Ascot incident. In contrast, however, a man who had sustained multiple burns in the accident stated that he had subsequently developed pains in his elbows and hands, and added that he had since been under treatment for early arthritis.

A woman of 36 was thrown to the ground and rendered unconscious; she sustained burns on the head and arms, and subsequently complained of headache and dizziness. She was discharged after four days in hospital. Eight years previously she had been admitted to a mental hospital on certificate, and was reported as being suspicious, antagonistic, and at times mute and inaccessible. She had made three attempts at suicide. She was given E.C.T. and then deep insulin therapy, in the course of which she had an irreversible coma. On recovery she admitted that earlier she had been hallucinated, and had heard spiritualistappings. She was discharged as recovered after five months in hospital. Her husband had rigid and narrow views, and was no great support apparently. Her subsequent history was more like that of a manic-depressive. She had periods of elation followed by bouts of depression, for which outpatient E.C.T. was given. A year before the lightning incident she was severely depressed and retarded for several months, and had once more attempted suicide. In hospital E.C.T. was again given, and in the course of treatment she went abruptly into a state of elation. This persisted for two months, and at the time of her discharge, only eight months before the lightning incident, she was still a little

hypomaniac. A year after the incident she was in good nervous and physical health. She had made an unexpectedly rapid recovery from the effects of the lightning stroke, which in her case may have acted as an E.C.T.

A freak effect occurred in the case of a man aged 39, who complained of frequency of micturition for about three days after the incident. He stated that he was wearing a pair of trousers with a metal zip-fastener at the time of the accident, and added, "That's where it seemed to hit me."

Discussion

In both the Ascot and the Aldershot cases headaches and paraesthesiae were found to be the most common early after-effects. Second only to these in frequency were cases presenting transient paralyses of the limbs. Dysphasia was noticed twice in this series, and in both cases was mild and temporary. There are frequent references in the literature (Critchley, 1932; Langworthy, 1936; Cambier, 1953) to spinal atrophic paralysis as a not uncommon sequel of lightning stroke, but not a single example was found in any of our cases. We did not encounter an example of a post-traumatic syndrome of any appreciable duration, nor, with the possible exception of one case, was there an instance of a post-traumatic personality change. These findings are in keeping with Panse's experience in the Koenigsberg disaster. In contrast, although the trauma is not strictly comparable, Denny-Brown (1945) found in 200 cases of closed head-injury in military personnel (53% resulting from traffic accidents) that psychiatric symptoms occurred in 70 (35%) and the post-concussion syndrome in 30 (15%). Headache was the commonest sequel, as with the lightning cases in our series.

It is tempting to speculate on the virtual absence of traumatic neurosis as a sequel of lightning stroke. The nature of the traumatic experience could be shattering enough. Several of the victims at Ascot did not lose consciousness, but were rendered helpless, were badly shocked, and had their clothing burnt off them. Through torrential rain they could hear the cries of terrified children and the groans of the stricken victims. Nevertheless, this traumatic experience has tended to be regarded as a true "act of God," and passively accepted as such, with mingled feelings of thankfulness and relief, not only by an Evangelist victim of the Ascot incident, but, one sensed from the replies, by many other victims too. The nature and circumstances of the trauma were such, therefore, that the psychopathological factor of guilt and the closely related factor of compensation would not be expected to play any considerable part.

A prolonged neurotic disability could be said to have occurred in only two cases. One of these, that of the man of 63, briefly reported above as having become depressed, phobic, and practically unemployable, had, it is noted, a poor previous work record and was possibly of inadequate psychopathic make-up. In the second case, which is the one more fully reported, the ataxia was undoubtedly hysterical. This particular patient had suffered much trauma in the past, and on previous occasions under stress had developed hysterical weakness of the legs. The lightning stroke had in this instance released a similar pattern of neurotic symptoms. She felt in some way singled out for some special attention, and she made an oblique reference to herself as having some special role as a victim of God's mysterious ways.

Summary

A review of neuropsychiatric sequelae of lightning stroke has been made in the light of the literature on the subject, and with special reference to cases occurring as a result of the incidents at Ascot in 1955 and at Aldershot in 1956. The incidence and nature of such sequelae are described, and one case which shows special features is more fully reported. The incidence of early after-effects was high, although prolonged sequelae occurred in only two cases.

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A CASE OF PODOPHYLLUM POISONING WITH INVOLVEMENT OF THE NERVOUS SYSTEM

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There are a number of toxic substances which, after absorption via one route or another, may lead to the development of a disturbance of function in the nervous system with or without ensuing structural damage. Quite often the peripheral nerves appear to be principally involved, this resulting in the production of a more or less symmetrical type of peripheral neuropathy; moreover, in such cases there may be severe structural changes, with the result that recovery of function, although tending ultimately to be complete, may be long-delayed. There may also be involvement of the central nervous system by the toxic action of the ingested substance, and, although the exact *modus operandi* may not be known, it seems likely that in many such cases the upset of function in the nervous system may well be the result of interference with various enzyme systems.

The following case report is of a patient who developed a fairly severe disturbance of central and peripheral nervous function after taking an overdose of a podophyllum extract by mouth. We have not been able to find a similar case in the literature. For this reason, and also because the effects of this substance upon living tissue have recently been the subject of investigation, we felt that the case should be placed on record.

Case History

A married woman aged 25, believing herself to be pregnant, drank 1 fl. oz. (28.4 ml.) of a proprietary concentrated alcoholic extract of American podophyllum root

(*P. peltatum*) one evening on the advice of a friend. There were apparently no immediate ill effects, but the next day she began to vomit repeatedly, becoming confused and finally comatose within 24 hours. The same evening vaginal haemorrhage also supervened and she was transferred to hospital as a gynaecological emergency. On admission she was found to be confused, noisy, and restless, hiccupping, yawning, and retching in turn. A bruise was present over the right eye, but her colour was good and her tongue moist and clean. The ocular fundi and pupils were normal, the knee-jerks were present and equal, but the abdominal reflexes were absent and the plantar responses extensor. The pulse rate was 60 a minute, the temperature 97.8° F. (36.6° C.), and the blood pressure 120/80 mm. Hg. On clinical examination no abnormalities could be detected in the cardiovascular, respiratory, or gastro-intestinal systems, and, although a gynaecological examination revealed the presence of a blood-stained watery discharge from the vagina, the cervix and vagina itself were normal in appearance, there being no evidence of enlargement or abnormality of the uterus.

A provisional diagnosis of poisoning was made in view of the clinical history, and gastric lavage was performed shortly afterwards. From the time of admission the patient was able to take fluids by mouth, and a marked lessening in the severity of her confusional state had occurred two days after admission. It was recorded at this stage that the tendon reflexes had become sluggish, while a lumbar puncture revealed a clear cerebrospinal fluid at a pressure of 210 mm. of water; it contained: protein, 45 mg. per 100 ml.; chlorides, 680 mg. per 100 ml.; sugar normal in amount; and about 3,000 red blood cells per c.mm.; the latter was probably the result of accidental contamination.

The patient was first seen by one of us (M. J. P.) eight days after her admission to hospital. She was then mildly confused and somewhat restless, and uninhibited in her behaviour. Neurological examination revealed no abnormalities of the cranial nerves apart from a sluggish reaction of the pupils to light and an inconstant horizontal nystagmus on conjugate lateral deviation of the eyes. There was, however, a fairly severe degree of general weakness of the limbs, which were hypotonic and exhibited gross incoordination with associated pseudo-athetotic movements of the outstretched hands and fingers. The plantar responses were flexor in type, but the tendon-jerks were either extremely sluggish or absent, and there was impairment distally in the limbs of all modalities of sensation, postural sense being lost in the digits. A further lumbar puncture next day showed a spinal fluid pressure of 105 mm. of water; the fluid contained: protein, 200 mg. per 100 ml.; chlorides, 620 mg. per 100 ml.; sugar within normal limits; cells, nil. At this stage the blood pyruvate level was 0.85 mg. per 100 ml., the serum alkaline phosphatase level 11 units (King-Armstrong), the serum bilirubin 0.4 mg. per 100 ml., and thymol turbidity 0.9 unit, the thymol flocculation test being negative.

On the eleventh day of her illness the patient was transferred to a neurological unit for rehabilitative treatment. By this time her mental state had become almost normal. Examination of the cranial nerves disclosed that there was still an inconstant horizontal nystagmus on conjugate lateral deviation of the eyes to the right, together with sluggish responses of the pupils to light. The weakness, hypotonia, and incoordination of the limbs were unchanged. The tendon reflexes had remained virtually absent and the previously observed sensory changes were still demonstrable.

Progressive improvement in the symptoms and signs ensued during the course of the next three weeks, at the end of which a further lumbar puncture was performed. The fluid was under a resting pressure of 35 mm. of water, and the Queckenstedt test was negative; it contained two cells per c.mm. (one polymorphonuclear leucocyte and one lymphocyte) and had a protein content of 60 mg. per 100 ml.; the Pandy test for globulin was weakly positive, but the sugar content was within normal limits (47 mg. per 100 ml.). Both the Lange gold curve and W.R. were negative. No abnormalities were found in the urine, spectroscopic examination