

Thus, if our premisses have been rightly taken, this important fact is brought out—that, of the patients admitted to the London asylums, more than twice the number than is at present stated, owe their entrance, partly at any rate, to the abuse of alcohol.

THE LETHAL EFFECTS OF ELECTRICAL CURRENTS.

By H. LEWIS JONES, M.D., F.R.C.P.,

Medical Officer in Charge of the Electrical Department,
St. Bartholomew's Hospital.

SINCE the introduction of electric lighting as an industry, fatal accidents have occurred from time to time to those employed in connection with it. These have usually been the result of contacts with conductors charged to a potential of 1,000 volts or upwards, whereby the body of the victim has become the path of a considerable current, discharging in most cases to earth, but sometimes to the other conductor of the system. In ordinary engineering practice these high voltages occur in the mains of the alternate current supply systems, where the pressures range between 1,000 and 2,500 volts. In the case of one London company, the enormous pressure of 10,000 volts is reached. Direct current at high tension also occurs in street lighting by arc lamps, where a number of these are connected in series and worked by a direct current, steady or pulsatory, at a pressure which may amount to 1,500 volts or more. These high potentials are not permitted by the Board of Trade regulations to be used in dwelling houses; and we may say at once that with the pressures (not exceeding 200 volts) which these rules allow in dwelling houses, there is no danger of fatal shocks from accidental contacts with the conductors. The high tension current supplied by the alternating supply companies does not enter the houses, but is used to excite a transformer fixed outside, from which a low tension current is led to the lamps within.

In this country it is the rule that high potential conductors shall be laid underground, consequently the persons exposed to the risk of fatal electric shocks are mainly those employed in the generating or transforming stations, those at work upon "live" high tension mains, or those engaged with "series" arc lamps, and almost all the accidents which have occurred in this country have been to persons engaged in one or other of these ways. Where high-pressure wires are allowed on poles overhead there is a chance of the wires breaking and falling down among the people in the street, and deaths have been caused to several persons abroad through incautiously meddling with such wires. The two accidents lately recorded, in which a creeping discharge along the surface of the ground has proved fatal to horses, are of peculiar interest but are not so likely to cause serious damage to human beings; still it is to be hoped that they will not often recur.

The mode in which electric shocks cause death is one of considerable interest because it underlies the questions of the prevention of such accidents and of the mode of treatment when they arise. Recently attention has been called to this question afresh by the writings of Professor d'Arsonval on the subject, which have given rise to much discussion in the technical journals and in the public press. His belief is that it is not the heart but rather the respiration which fails. He has even declared that in his opinion the criminals executed by electricity in the United States died from the effect of the *post-mortem* examination; that the shocks had only rendered them insensible, and that they might have been revived by artificial respiration.

Other writers following him have lamented the deaths of other victims of electricity which they consider might have been prevented by timely assistance. A case has even been recorded¹ in which a man was resuscitated in this way when he was apparently dead, although the artificial respiration was not commenced until three-quarters of an hour after the accident. Too ready an acceptance of d'Arsonval's theory is likely to be a source of danger by leading people to think less of the risks of electric shock, and already an American

medical man is said to have offered to submit to an electrical discharge provided only that his special method of resuscitation be carried out upon him afterwards.

Against d'Arsonval's views we would note that artificial respiration has been employed in vain in some of these accidents, and that in the *post-mortem* examinations upon the American criminals the heart was not found beating—I write from memory, not having a report at hand—although the necropsy was begun immediately after the execution; in fact, the stoppage of the heart's action was taken as the sign of the patient's death.

In a case reported by Dr. J. W. Brown in the *New York Medical Record*, 1893, the victim survived the first shock, the dynamo breaking down, and he began to recover. The published account states that the current was kept on for fifty-two seconds; the man remained apparently dead for twenty seconds more, and then gasped; five seconds later no pulse could be felt at the wrist, but after thirty seconds it was felt, breathing became gradually re-established, the pulse grew stronger, and some movements of a purposive nature were performed. He was then killed by a shock from an arc lighting machine. In this case the heart and respiration were both profoundly affected. Respiration recovered first, and then the heart.

In a report by Dr. Clowes² of an accident in Brompton, the patient was seen five minutes after the accident. The heart and respiration had stopped; artificial respiration was performed but was of no use. In d'Arsonval's case referred to above, three quarters of an hour had elapsed before artificial respiration was begun, and it seems unlikely that respiration could have been completely arrested for so long a time and the patient not die. It is probable that the man was in a dazed or senseless condition only, and might have come round equally well without artificial respiration.

The examination of the bodies of those killed by electric shock may afford little information as to the mode of death. In one of the earliest cases³ recorded in the medical journals, no signs of injury could be found except a small superficial burn of the thumb. It is usual to find some marks of burning at the part which has been in contact with the wire or point of entry of the current, and a careful search should always be made over the whole body for other burns at the point (point of exit) at which the current passed from the patient to the earth or to the other conductor. When the discharge has been to earth the current usually leaves the body at the feet, and these should always be examined for marks of burning, and the soles of the boots should also be looked at. When the shoes and socks are damp there may be no burn of the feet, even when a current of fatal magnitude has passed through them. The soles of the feet and the socks are almost always damp from perspiration, and the soles of the boots of working men are often full of nails; the boots, therefore, offer but little in the way of insulation resistance. The severity of the burns is to be taken rather as a measure of the duration of the contact than of the magnitude of the fatal shock, and the same may be said of the heating of the tissues which has been sometimes observed. They may be slighter in those who have been killed on the spot than in those who have escaped with their lives. When the body remains in circuit, burns of great extent may be caused by the prolonged action of the current upon it subsequent to death.

In the accounts of the necropsies mention is often made of congestions, extravasations of blood, or internal hemorrhages; these may be the result of violent muscular tetanus caused by the shock and the rise in blood pressure associated with it; they are not themselves the cause of death. It is difficult to assign its proper value to the statement which so often crops up about the fluidity of the blood in these cases. The heart is often noted to be relaxed and empty, and this is not in accord with the theory of death from asphyxia. For electric shock to cause death a current of considerable magnitude must pass through the body and must traverse a vital part. An extremity may be completely destroyed by a current without the patient himself being killed by the shock, provided that the current does not pass through the trunk as well. It is not volts which kill, and in this lies a

¹ *Comptes Rendus*, vol. xcvi.

² *Lancet* of December, 1892.

³ Sheild and Delépine, *BRITISH MEDICAL JOURNAL*, 1885, 1, p. 531.

common source of error; people are said to have received so many volts, which tells one very little; whereas if we could be told what amperes or current had passed through them, the cases of shock would soon arrange themselves in order, and the magnitude of the current required to kill would be no longer a speculation.

The voltage of the source of electricity determines the magnitude of the current through the patient; but another factor, the resistance of the patient, is equally important. By the resistance of the patient is understood the resistance through the patient's body, his clothing or boots, and, in the case of a discharge to earth, of the floor on which he is standing. When protected by trustworthy and adequate resistances a man may take hold of a conductor of high potential unharmed, and in cases of accidental shock the dampness or dryness of the boots, or of the floor on which a workman stands, may easily make the difference between life and death. In general the magnitude of the current traversing the tissues can hardly be even roughly guessed at from a knowledge of the voltage of the conductor, because the resistance of the path through the patient may be of almost any magnitude; in fact, no definite answer has yet been given to the question what current is required to kill a man, though probably the minimum current is over half an ampere. The body may be traversed from hand to foot by a current large enough to cause extensive and deep burns without a necessarily fatal result. The vigour of the patient's heart is most likely an important factor in the case. Experiments on animals have been made by several observers. Dr. Tatum, of New York, published in 1890⁴ some results of his experiments on dogs which are valuable. He made use both of alternating and continuous currents. The current required to kill varied with the size of the animals, and ranged from 0.1 to 1.3 of an ampere. Alternating currents seemed to be twice as fatal as continuous, but under either this difference became much less marked; the periodicity of the alternating current seemed unimportant; the anæsthetic increased their chances of survival to a considerable extent with alternating currents, though not with continuous. The path of the current in his experiments was between the skull and the thigh. He came to the conclusion that the fatal mischief done by electrical currents to dogs is done chiefly or entirely within the actual substance of the heart.

In some experiments, carried out in the laboratory of the Royal Colleges of Physicians and Surgeons by Mr. Bokenham, which I was enabled to witness through his kindness, the current required to kill cats which were deeply anæsthetised was half an ampere, and this, which seems, comparatively speaking, an enormous current for so small an animal, proved always fatal when passed transversely through the thorax, although when passed through the skull by means of electrodes placed one on each side of the head or the upper part of the neck the animals were but slightly affected. The same difference between the susceptibility of the brain and the heart was noticed also in guinea-pigs. The currents used were continuous.

Tracings taken during the experiments (see Figs. 1 and 2)

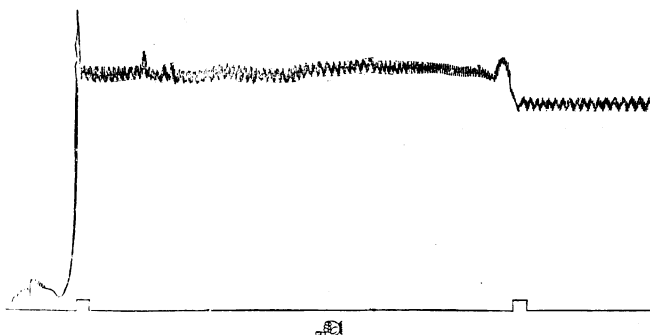


Fig. 1.—Blood-pressure tracing of cat; to be read from right to left. The first break in the base line indicates the discharge of 0.5 ampere through skull; the second rise a similar discharge through thorax.

⁴ The Electrical World, May 10th, 1890.

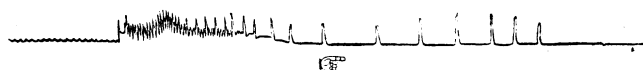


Fig. 2.—Forcible respiratory movements of cat after electrical discharge through thorax; to be read from left to right. The normal movement is shown in the first part as a finely waved line.

showed conclusively that death was caused by failure of the heart, and the negative results of shocks of equal strength through the head and neck suggest strongly that the action is upon the heart muscle rather than upon its nervous mechanisms. Experiments by Dr. Tatum on animals under atropine and with divided vagi point in the same direction. Though carefully tried, in no case could the animal be revived by artificial respiration when apparently dead. Indeed, the stoppage of the heart was always followed by a period of dyspnoea, with very forcible spontaneous respirations, due no doubt to the action of the respiratory centre, stimulated by the sudden failure of the supply of arterial blood which followed the stoppage of the heart; and it is interesting to note that a similar condition of laboured breathing has been recorded in some of the cases of accidents from electric shock. An examination of the animals' hearts showed them relaxed, with tremulous movements of the auricles and auricular appendices; by no stimulation of the exposed heart could it ever be made to beat again. These experiments show clearly that the effect of the shocks was to arrest the heart's action, while respiration was not seriously affected; nor with the animals employed, and under the conditions of the experiment, was any state observed of suspended animation or apparent death from which the animal could be restored by artificial respiration. When the shocks through the thorax were insufficient to stop the heart, its action became feeble for a time, but quickly recovered. Respiration was somewhat altered in rhythm, though not profoundly so. The results in fact are directly opposed to the views expressed by d'Arsonval. It is possible that the effect in man may be different from that in cats and in guinea-pigs, and it is not unlikely that there may be a stage on the borderland between life and death, with the patient rendered insensible, but with the heart's action not completely arrested, and, in these, artificial respiration might be of some service. Certainly it should always be tried if the patient's heart is still beating. Although the labours of d'Arsonval upon matters connected with the physiological actions of electricity entitle his views to our highest respect and attention, I cannot help believing that upon this question he may be mistaken, and I fear that death in the victims of severe electric shock is too often real, not apparent, and that they are, as a rule, quite beyond resuscitation by artificial respiration, or by any other means with which we are acquainted. In fact, it is certain that electrical discharges can kill a man as dead a doornail. The majority of the fatal accidents have been due to discharges from one conductor to earth through the body; of fifteen cases of which I have notes, ten were certainly, and some of the others were probably, of this nature. This makes it important to consider what step can be taken to protect workmen from such accidents. An obvious method is to insulate them from the ground, and it seems that this might best be done by covering the floors of all high-pressure stations and sub-stations with a thick layer of asphalt, or with insulated platforms of considerable extent, and by covering the walls as far as possible with a non-conducting lining of wood, the insulation resistance of which might be increased by impregnating it with paraffin wax, or tar or varnish. The arrangements should be such as to make it impossible for a workman to touch any high potential conductor or machine, except when he stands upon a non-conducting surface, nor should he be able to touch at the same time a high potential conductor, and any part of the building which is in electrical connection with earth. In the case of men at work through unavoidable necessity upon "live" high-pressure street mains or arc lamp circuits, it is probable that the use of india-rubber sea boots without nails would be a better protection than the rubber gloves, which have been several times found lacking; at least the use both of boots and of gloves would decrease the risk. The danger of street mains, however, is best met by permitting no work to be done upon them until they have

been cut out of circuit. When, unfortunately, an accident has happened, artificial respiration should be put in practice as soon as possible, in the hope that the injury has not been severe enough to arrest the heart permanently; and if the heart show signs of beating, however feebly, the artificial respiration must be persevered in. By the enterprise of the *Electrical Review*, a card of directions for the best method of giving first aid to victims of electric shock has been issued, and is likely soon to find a place in all central stations. It is drawn up on the lines of the well-known card of the Royal Humane Society for the restoration of the apparently drowned.

A CASE OF FUNCTIONAL DEAF-MUTISM.

By W. B. RANSOM, M.A., M.D., M.R.C.P.,

Physician to the General Hospital, Nottingham.

THE following case appears to me of sufficient interest to merit publication.

A. H., aged 19, a miner, was brought on November 16th, 1894, by his father to the General Hospital with a letter from Dr. Dykes Robson, of Somercotes, to whom I am indebted for the history of the case. It appeared that three weeks earlier he had gone to bed in his usual health, but woke up in the morning unable to hear or to utter a sound. The deafness was so complete that the loudest and most sudden noises made near him were unnoticed, and he gave no sign of hearing a cannon let off close to him on November 5th. Not only had speech entirely gone, but he had not been able to make any sound at all. He could neither talk, whisper, nor utter inarticulate noise. The intellectual faculties had apparently remained intact, and he had communicated with his friends by reading and writing, in which processes he had had no difficulty. His conduct had been rational, and he had shown no signs of undue emotion or of hysteria. He had slept rather badly, and had complained of some pain in the occipital region and in the temples. The special senses had appeared normal, as had general sensation, and there had been no paresis, fits, sickness, vertigo, or tinnitus.

In regard to his past history, the father said that he had been in no way peculiar, not at all nervous or hysterical, and of average intelligence and conduct. The only important point in the history was that a year earlier he had suddenly lost the use of his right arm, which had remained paralysed for three weeks. Whether recovery was gradual or sudden was not ascertained. The patient's mother had died of paralysis of a year's duration. She was said to have lost the use of both legs, and towards the end to have become slightly demented. Death came by sudden coma. She had had several miscarriages, but no definite history of congenital syphilis could be made out in regard to the patient. When the lad walked into the out-patient room there was nothing unusual about his appearance or manner. He was well developed, of healthy aspect, and showed no signs of a neurotic or hysterical tendency. It was not till we obtained no response to questions that anything abnormal became evident. On testing hearing further I found he was obviously deaf, but when I spoke in very loud and distinct tones into either ear a simple order, such as to shut his eyes or put out his tongue, that the order was in some instances obeyed; the more sudden and peremptory the command the more chance there seemed of the responsive movement being elicited. The father thought that the deafness was not now quite so intense as at first. He could not hear a watch through air or bone. All attempts, however, to make him speak or utter any sound failed. He promptly did whatever he was told to do in writing, except this; he could not repeat a word spoken to him, or read aloud what he clearly understood or had himself written; nor did moderate pain produce any cry. A severe test of a painful nature was not then applied. He wrote in a good hand intelligent replies to written questions.

On the objective side of the nervous system things were practically normal. The movements of the eyes, face, lips, tongue, and limbs were normal; there was no stridor and no cough. There were no paresis, inco-ordination, tremors, or spasms. The gait was normal, and there was no swaying with eyes open or shut. The right knee-jerk was but slightly

marked, and the left was not obtained. The pupils were a trifle large, but reacted normally.

Vision appeared normal, both as regards acuity and extent, but no exact perimetric examination was made. The fundi of the eyes were normal, except for one small pigment spot in the nasal half of the left retina. There was no cephalic or mastoid tenderness; there never had been an ear discharge, and the drums of the ears were normal, except for a little dried cerumen attached to them. The teeth were not pegged or notched, and the pharynx, lungs, abdomen, and generative organs appeared healthy. The pulse was regular, but jerky, and rather soft; the artery was not thickened. The cardiac apex was displaced half an inch outwards, but there was no other sign of disorder of the heart or aorta.

A fortnight later the patient presented himself again, the symptoms having remained unchanged. He now, however, showed also anæsthesia of the palate and loss of the palate reflex; and a sudden movement of the hand before his eyes failed to make them blink.

The diagnosis of "functional" or "hysterical" deaf-mutism being now fairly certain, the faradic current was sent through the larynx by means of an intralaryngeal electrode and one on the front of the neck. The result was a kick and a yell. He was then told that he could speak, and at once answered, "Yes, I can." The next minute he could answer questions uttered in a whisper. He went home hearing and speaking normally, after having been deaf and dumb for five weeks.

Hysterical mutism has been well described by Charcot¹, who has pointed out its existence as a clinical entity, and its differences from aphasia and aphonia of organic origin. In the third volume of his lectures are reports of twenty cases, but in only two of these was the mutism associated with deafness as in my patient.

The diagnostic points are: (1) Sudden origin; (2) existence of absolute aphasia and aphonia; (3) absence of signs of labio-glossal paralysis, and usually of any paralytic phenomena, though hysterical hemiplegia may coexist; (4) preservation of intellectual faculties and the power of writing; (5) frequent coexistence of hysterical stigmata; (6) usually rapid recovery, though it may be gradual. These characteristics distinguish the affection from simply hysterical aphonia, from aphasia due to lesions of Broca's convolutions, or from aphemia due to disease of the medulla or its nerves.

The question of diagnosis from wilful simulation is perhaps one which will impress itself upon English minds; but, as Charcot points out, the clinical picture of mutism is not such as would probably suggest itself to a malingerer, while certain of the coexistent stigmata, such as contraction of the visual fields and anæsthesia of the palate, could not be counterfeited by one ignorant of the symptoms of organic disease.

The present case is remarkable for the deafness as well as the mutism, and although the former was not absolute when the patient came to hospital, yet severe tests, such as the cannon, showed it to be real.²

The onset of the affection in this case was a little unusual, as there seems to have been no antecedent shock or emotion, and the patient could not say exactly when it began. All he could say, in answer to questions after his recovery, was that when he woke up in the morning he found himself unable either to hear or speak.

This case also was peculiar in presenting hardly any ordinary symptoms of hysteria. Neither his family nor Dr. Robson considered him inclined that way. Previously to the occurrence of the deaf-mutism and anæsthesia of the palate, the only evidence of a liability to functional nervous disease was the history of a temporary paralysis of the right arm.

The mode of cure is of interest inasmuch as a severe shock applied to the organ of voice not only restored speech, but hearing at the same time. The intimate association of the ideational centres is thus well illustrated. Perhaps excitation of the ears would have restored speech as well as hearing.

¹ Charcot's *Lectures*, vol. iii, Syd. Soc.

² It may be noted that the character of the deafness was quite unlike that of a malingerer; for he never started at the loudest noise made unexpectedly behind his back, whereas he did seem occasionally to comprehend simple orders made before his face, such orders being those that the doctor might be expected to give. A malingerer would have done exactly the reverse.