5-1-1937

Electrical shock

Orville Kroger
University of Nebraska Medical Center

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ELECTRICAL SHOCK

ORVILLE KROGER

SENIOR THESIS

Presented To The College Of Medicine,
University Of Nebraska, Omaha, 1937.
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INTRODUCTION

The present day has been described by a variety of descriptive phrases, none of which is more expressive than "The Electrical Age." Electrical energy has been so extensively developed for industrial and domestic purposes that a majority of the present population of the world uses it daily.

In the handling of this form of energy, spectacular accidents often occur. The nature of these accidents has attracted the interest not only of philosophers, but of the medical and engineering professions, and of the general public.

Experimental work is still being carried on to give further knowledge of the mechanism of these injuries, and it has seemed that this subject might suitably be reviewed as a topic for this thesis.
DEFINITION

The term Electrical Shock is used by most authors as a loose term covering all varieties of electrical injuries. As used in the restricted sense, Electrical Shock may be defined as a state of coma resulting from passage of electrical current through the body, with arrest of respiration, and with apparently suspended animation. The coma may be only temporary, or it may directly lead to death.
HISTORY

The ancients regarded lightning with superstitious awe. Records found in the ruins of the cities in the valley of the Tigris and Euphrates rivers show symbols of lightning as a weapon of destruction. The Greeks regarded lightning as an instrument of the Gods', and a person who received a non-fatal stroke was regarded as the recipient of a favor from the Gods. The Romans, more pessimistic, considered death by lightning as a punishment, and buried the victims without the customary honors. (27)

Little interest in the nature of deaths from lightning was shown until comparatively recent time. Interest in these problems may be said to have been initiated when Benjamin Franklin's experiments demonstrated the nature of lightning. Electrical energy was at this time being developed by a number of methods and soon the Leyden-jar was discovered, making possible the storage of electrical forces. At this time interest in the nature of electricity and it's biological effects led to many experiments on lower animals.

In the latter half of the nineteenth century electrical currents for industrial purposes came into use. A series of spectacular deaths occurred, leading to further interest in the medical nature of the deaths.
Many post-mortem examinations were made and a variety of conclusions were drawn as to the mechanism of death. Supplementing these findings further experiments on lower animals were carried on. The early experiments were made under a variety of conditions and the results varied greatly. For this reason a review of these experiments is not included in this paper.

In recent years, the extensive industrial and domestic use of electricity has enormously increased the hazard to human life. Since these were of interest not only to those engaged in the electrical industries, but to the general public and the medical profession, the Committee On Electric Shock, composed of engineers and medical research workers, was organized to study the effects of electrical currents and to formulate recommendations for reduction of the electrical hazard.
INCIDENCE

No great accuracy can be claimed for any statements of the incidence of electrical shock because of a variety of reasons. In the first place most electrical accidents occur among the employees of industrial concerns, and in most industries accidents are not reported unless they are of such severity that the employee loses at least one working day. This accounts for failure of reporting many cases where unconsciousness was of very short duration and followed by no ontoward effects. In other cases where death occurs, frequently the accidental death is reported as due to a complication such as a fall or burns, and not as due to electrical shock. No doubt there are many household electrical accidents where there is temporary unconsciousness that are not reported or are reported as being due to some other cause.

Harrison (16) reports the figures given by the British home office for the years 1912-1922. He states that in the years between 1914-1922 there were 79 fatalities in England due to electrical shock from voltages up to 500. During the years 1912-1922 there were 150 deaths in England from electrical accidents at voltages under 250. In the
same period there were:
29 fatalities at voltages from 250-650
17 ' ' ' ' ' ' ' ' ' ' 650-3000
31 ' ' ' ' ' ' ' ' ' ' 3000 up.

Schereschewsky (51) reports the incidence in the United States registration area for the years 1910 to 1920 as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Lightning Rate / Deaths, 100,000</th>
<th>Electric Rate / Deaths, 100,000</th>
<th>Total Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1910</td>
<td>150</td>
<td>.26</td>
<td>425</td>
</tr>
<tr>
<td>1911</td>
<td>235</td>
<td>.40</td>
<td>450</td>
</tr>
<tr>
<td>1912</td>
<td>239</td>
<td>.40</td>
<td>514</td>
</tr>
<tr>
<td>1913</td>
<td>309</td>
<td>.49</td>
<td>613</td>
</tr>
<tr>
<td>1914</td>
<td>279</td>
<td>.42</td>
<td>503</td>
</tr>
<tr>
<td>1915</td>
<td>221</td>
<td>.33</td>
<td>515</td>
</tr>
<tr>
<td>1916</td>
<td>340</td>
<td>.48</td>
<td>586</td>
</tr>
<tr>
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<td>359</td>
<td>.48</td>
<td>654</td>
</tr>
<tr>
<td>1918</td>
<td>402</td>
<td>.49</td>
<td>732</td>
</tr>
<tr>
<td>1919</td>
<td>414</td>
<td>.49</td>
<td>748</td>
</tr>
<tr>
<td>1920</td>
<td>409</td>
<td>.47</td>
<td>822</td>
</tr>
</tbody>
</table>

Ajello (1) reports figures of the incidence of fatal electric shock in Italy for the years 1908 to 1917. In that period there were 609 deaths officially recorded as fatal electrical accidents. For the first half of the year 1920 there were 131 recorded electrical fatalities. These fatalities from electrical accidents comprised one and one-half percent of all deaths due to violence.

Other authors without quoting statistics to support their claims, report an increasing incidence of electrical accidents. It is natural to assume that
these statements are well founded since the use of electrical equipment has become so widespread.

ELECTRICAL CONSIDERATIONS

Before discussing the biological effects of the electrical current it is necessary to discuss certain electrical terms. Electrical currents may be either alternating or direct. A direct current is one that flows continuously in one direction. An alternating current is one that reverses its direction of flow in the circuit regularly and frequently. For technical reasons electrical currents most commonly used are of the alternating type. The voltage of an electrical current is an expression of the electro-motive force or pressure that maintains the flow of current. The quantity of electricity flowing in a unit of time is measured in amperes. The resistance opposing the flow of an electrical current, analogous with frictional resistance, is measured in ohms. Electrical energy or the power of doing work, is measured in joules. One joule represents the energy expended in one second by one ampere through a resistance of one ohm.

When an electrical circuit is grounded at any point, the current passes off into the ground, since
the resistance is much less than that of the regular circuit, and electricity, like water follows the path of least resistance. The human body can act as a conductor in "grounding" a circuit, depending to a large extent upon the character of the contacts with the electrical circuit and with the ground. Under some conditions only a small amount of current is thus side-tracked but under other conditions large amounts can be diverted.

In the body the path of the current thus passing from the electrical circuit may follow two routes, a direct or an indirect route. Jellinek (24) states that the path may be directly through the body, or it may be over the surface of the body. The factors determining the path are the relative resistances of the tissues to the current. It seems logical to believe that under some conditions the current could pass largely over the surface of the body and have little effect on the deeper tissues. This view is supported by a statement of Ettinger (9) that it is more difficult to kill rabbits in summer months than in winter. The exact reason is not apparent but there must be some factor that causes lowered resistance of the skin. Such factors may be the amount of moisture, hair, etc. present.
The amount of current sidetracked from the electrical circuit depends to a large extent upon the character of the contacts. In all cases there are two points of contact. If the electrical circuit is interrupted by the body at only one point, a unipolar contact, some other part of the body must be suitably grounded before there will be passage of the current. Fisher(13) states that in electrical accidents most commonly one hand is in contact with the electrical circuit while some other part of the body, a foot usually, is grounded. Maclachlan (36) states that wet hands are an important factor in increasing the amount of the electrical current passing through the body. Jaffe (22) also comments on the importance of the character of the grounding in influencing the intensity of current received.

The path of the electrical current through the body depends upon the points of contact and the relative resistances of the tissues. Generally stated the resistance of the body fluids is negligible. For this reason blood vessels, and nervous tissue offers little resistance. The skin is skin is very highly resistant and the bone is even more resistant. Another factor must be considered in connection with the relative resistance of the tissues, that is their surface area.
Jex-Blake (27) considered the points of contact an important factor. He stated that he believed currents entering the left side of the body were more liable to be fatal because of the proximity of the heart. From experiments on rats, Langworthy and Kouwenhoven (33) concluded that the points of contact were important in regard to the pathway of the current. They based their observations on the fact that with both points of contact on the hind legs of the rat they observed fewer fatalities with currents of the same strength and duration as those which caused a high percentage of fatalities where both contacts were on the front legs. Maclachlan (36) made similar observations.

The type of current, whether direct or alternating is an important consideration. Jex-Blake (27) in summarizing the results of previous investigations concluded that direct currents were much less dangerous at low voltages than the ordinary alternating currents used industrially. At higher voltages the direct current was in his opinion more injurious to the nervous system. This was also the opinion expressed by Langworthy and Kouwenhoven (32). The rate or frequency of alteration of the current is also of great importance. Ordinary industrial currents in use have
frequency of alteration between 50 and 300 per second. When frequency is increased greatly, the tendency for fatal effects is reduced.

PATHOLOGICAL - PHYSIOLOGY

When an electrical current is brought into contact with the body, the effect is an immediate contraction of the skeletal muscle. With alternating current of sufficient intensity, there may result a cessation of respiratory efforts. Other effects depend upon a variety of circumstances, involving both the character of the stimulus and the manner of contact, and upon the physical condition of the subject of the experiment. The variety of results obtained by early investigators can be attributed to the type of equipment they used and to the lack of uniform experimental conditions.

The effect of electrical current on respiration was attributed by some investigators to an inhibitory effect on the central nervous system, and by others to tetanic contraction of the muscles. Jex-Blake(27) in reviewing the early experiments says that Brodie concluded that the cessation of respiration was due to tetanus of the respiratory muscles. He also described experiments of Richardson and Grange which led
them to believe that the cessation of respiration was due to injury to the nervous centers of respiration.

In all these early investigations the effect on respiration was secondary in importance in the minds of the investigators. Most of their observations were complicated by cardiac phenomenon which received most of their attention.

Urquhart (58) attempting to eliminate cardiac phenomenon and study the effect on the nervous tissue, performed the first work that demonstrates clearly the mechanism of respiratory inhibition. He chose rabbits for experimental animals since previous work had shown these animals less susceptible to cardiac deaths than other animals.

In his first experiments he applied the electrodes to the head and one hind foot of the rabbit. He found that the effects varied not only with the strength of the current, but also varied according to the exact location of the points of contact and even varied according to the exact design of the electrodes.

In order to direct the flow of current through the central nervous system without involving other tissues, he then designed electrodes so that one could be placed within the nose adjacent to the cribiform plate, and the other following laminectomy,
was placed adjacent to the medullary portion of the spinal cord.

On stimulation in this manner with various strengths of current he first noted an intense stimulation of all centers in the current path. Following passage of the current, the period of stimulation was followed by a profound depression or paralysis of these centers. The animals became limp and unconscious, and respirations were absent. Sensory reflexes such as the corneal reflexes were abolished.

The duration of the period of depression of the respiratory center was found to vary directly with the intensity of the current. In all cases where there had been no gross damage by burning at the points of contact of the electrodes the animals recovered providing artificial respiration had been administered during the period of depression.

The conclusion that the respiratory inhibition was due to paralysis or depression of the nervous center of respiration was reached following observation of other effects such as those of vaso-constriction and slowing of the heart rate, phenomenon which were also considered a result of change in the central nervous system.

In the same experiments there was noted together
with the generalized muscular contraction, a pronounced vaso-constriction. There was slowing of the heart rate due to vagus stimulation. On section of the vagi the inhibition was not completely obviated. This effect was due to the extra-vagal inhibitory fibers. When these were blocked with atropine no effect on the heart rate was noted on stimulation. The generalized vaso-constriction and slowing of the heart resulted in venous congestion. Following the passage of the current the blood pressure rose to almost twice normal and then fell gradually, even though the heart rate was increased. In this period, stimulation of the central end of the cut vagi had no effect on the heart rate. From these facts he concluded that it was the nerve centers themselves that became blocked by the passage of electrical current so that all impulses, sensory and visceral, were completely blocked, and the normal rhythmic discharge of the respiratory center ceases.

Observations very similar to these have also been made by Cunningham (5), Langworthy (31), and by Ivy and Barry (21).

The mechanism of the cardiac deaths as already pointed out attracted the attention of most investigators. As also stated, the lack of uniform experi-
mental conditions led to a variety of conclusions which are not of particular interest here.

Jex-Blake (27) credits early observations of effects of electric current on the heart to Ludwig and Hoffa. In 1850 they observed a state of fibrillary incoordination which they described as Herzilirium. Tatum (56) experimenting on dogs made early important observations in the cardiac phenomenon. He believed that the effect of electrical current on the heart was an intrinsic effect and not the result of extrinsic nervous stimulation. He observed that the strength of current had a definite relation to the effect on the heart and respiration and believed that the effect on the heart was due to injury of the heart muscle.

MacWilliams (39) conducted experiments on a variety of animals and expressed the view that the state of fibrillation was essentially an intra-cardiac phenomenon. He believed that the state of fibrillation was a result of a disorder of the intrinsic nervous conduction system of the heart. He described the state of fibrillation as characterized by: a. Complexity of movements, b. Persistence of the movements, c. Rapidity of the movements, fundamentally different from a rapid series of normal contractions. He noted
that the state of fibrillation could be produced by a variety of stimuli other than faradic stimulation of the ventricles.

Oliver and Bolam (47) as a result of their investigations concluded that death from high potential electrical currents was due chiefly to cardiac arrest. In their experiments on cats and dogs, they found no cases where respiratory arrest was the sole cause of the death.

Cunningham (5) refers to the preceding work as indicating the effect on the heart was the most important lethal effect of electricity, and further experiments verify this conclusion. He believed that all the previous work had shown was that the effect of electricity on the heart was an intrinsic effect. His experiments were made in an effort to investigate the nature of the cardiac effect more closely.

Working on dogs, Cunningham passed currents through the nervous system by exposing the cerebral cortex and applying one electrode there and the other one on the extremity. By means of double switches another set of electrodes was connected with the source of current and directed through the thorax. He noted that the amount of current necessary to produce a fatal effect was much less when passed through the thorax than when passing through the nervous system.
From this he concluded that the effect of electric current when passing through the brain and medulla was distinctly different than when directed through the heart. He made further experiments with currents passing through the thorax and observed ventricular fibrillation.

The nature of ventricular fibrillation appeared to him to be disorder of nervous coordination within the heart. That there had been no injury or death of individual muscle cells was indicated by the fact that on excision of the heart and perfusion with normal saline and a variety of other saline solutions he was able to restore the coordinate beat of the ventricular muscle. In intact animals Cunningham noted the dog heart did not recover from ventricular fibrillation even after extensive application of artificial respiration.

Jex-Blake (27) reviews the work of Prevost and Battelli which was done at the same time as the work of Cunningham. These investigators also worked on dogs and arrived at results and conclusions very similar to those of Cunningham. On other animals and with very much higher voltages they also observed phenomenon indicating injury had been produced in the central nervous system. In their work they used various inten-
sities of current, both alternating and direct. They found that direct currents at common voltages were much less fatal to dogs, cats, and guinea pigs than alternating currents. They also observed that in the cat there was a tendency for spontaneous recovery of the heart from ventricular fibrillation. In the rat the tendency to recovery from fibrillation was much greater.

Mac Williams (41) in further work with ventricular fibrillation reported that in the cat he had been able to restore the heart to normal rhythmic contraction by means of massage and intravenous injection of Pilocarpine. In this article, he makes further observations on the nature of fibrillation. He was able to produce fibrillation of the ventricles by use of a variety of depressants. These included intravascular injection of Potassium salts, bile, and various drugs. He reported that fibrillation of the ventricles could be controlled by intravenous injections of Urethane, Strontium, Chloride, Adrenaline, Hirudin, and Pilocarpine. In his opinion the process of fibrillation resulted from block of the inter-fascicular junctions of the heart neuro-musculature, while the intra-fascicular conduction remained functional.

Hooker (17) continuing on this line in an effort
to find some method of controlling ventricular fibrillation found that medication given by way of the coronary arteries might be effective in shortening the duration of fibrillation. His method was to inject a solution of Potassium Chloride under pressure into the cannulated carotid artery. This caused prompt arrest of the fibrillation even when cardiac massage was not given. Following the arrest of fibrillation the rhythmic contractions of the ventricle could be initiated by injection of a solution of Calcium salts which included a small amount of Adrenaline.

Wiggers (59) reported success in arresting fibrillation by intraventricular injection of similar solutions. In this method it was necessary to massage the heart during the injection in order to obtain the desired effect.

Wiggers made further studies of the effect of solutions of Potassium and Calcium salts in arresting ventricular fibrillation. He concluded that the effect of the Potassium salts was not to alter the state of fibrillation so much as to hasten it, so that the entire time of fibrillation was reduced. The effect of the Calcium salts and massage was to inaugurate a coordinated idio-ventricular rhythm, which was soon superceded by the normal supraventricular rhythm.
Hooker and Kehar (29) in further studies on ventricular fibrillation described physical and chemical alterations in the heart tissue during fibrillation. In excised preparations perfused with Locke's solution they noted a lowering of the freezing point, a liberation of potassium, and a hyaline deposition in the muscle fibers during fibrillation. From these observations, they suggest that the state of ventricular fibrillation is associated with an imbalance in the readily diffuseable Potassium ion.

Ettinger (10) as a result of his observations was led to associate the process of ventricular fibrillation with the glycogen content of the cardiac muscle. He thought there was a definite relation between the duration of ventricular fibrillation and the glycogen storage in the cardiac muscle.

Summarizing these experiments one can conclude that most evidence points to ventricular fibrillation as the cause of the cardiac deaths in electrical shock. It has been shown that there exists a definite difference in the susceptibility of various species to ventricular fibrillation. The exact nature of the process of fibrillation has not been conclusively shown. It has been associated with alteration in the
inter-fascicular conduction, diffusion of Potassium ions, and with glycogen storage of the cardiac muscle.

The existence of a state of pseudo-fibrillation distinct from true fibrillation in its shorter duration has been suggested by MacWilliams (41). The existence of a state of ventricular fibrillation in man has not been observed. Sigler and Schneider (55) report a case of electrical shock, and from the interpretation of successive electrocardiographic changes conclude that a state of ventricular fibrillation may have existed. Dock reported a case of transitory ventricular fibrillation. (6)

Wiggers (59) contends that there is no such thing as pseudo-fibrillation. He supports his statement with a review of his observations in experiments on dogs over a period of ten years. He states that in 208 cases in which the dogs' hearts were set into fibrillation, there were no cases of spontaneous recovery.

A variety of methods for restoring fibrillating ventricles to normal rhythmic contraction have been reviewed. The value of these methods under conditions other than experimental is controversial.
PATHOLOGY

Jex-Blake (27) summarizes the work done by the investigators previous to 1913 under several headings. Briefly they are: (1) Living animals are killed with electricity with different degrees of facility. (2) The sudden death of animals killed by application of electric currents may be brought about experimentally in several different ways, of which the following are the most important: (a) By asphyxia due to prolonged tetanus, (b) By primary heart failure, (c) By primary failure of respiration due to central nervous inhibition, (d) By simultaneous failure of both heart and respiration, (e) Death may occur after lapse of hours or days as a result of injury to tissues by the electric current. (3) After exposure to very high voltages the animals tend to show signs of grave involvement of the central nervous system. (4) The particular electrical details and considerations that determine whether a certain electrical current will be fatal or not to an animal in any given instance are very complicated. At least six factors must be considered. These factors are: a. Voltage, b. Amperage, c. Duration of the contact, d. Character of the current whether direct or alternate, e. Position of electrodes, f. Resistance at electrodes.
In no investigation has there been demonstrable cardiac pathology. With respect to the nervous system various authors have reported pathological alteration of tissues. Urquhart (58) reported chromolysis of the cells of the respiratory center, following passage of electrical currents through the brain. Langworthy (34) reports pathological alterations in the tissue of the brain and spinal cord of a degree directly proportional to the intensity of the current passed. The changes consist of alterations in the Nissl substance of the cytoplasm in minor injuries. In more severe injuries he observed a shrinkage of the nucleus. Most of the changes he observed were in the medullary center of respiration.

McMahon (38) followed the method of repeated administration of sub-lethal currents. On examination of the bodies of the experimental animals he found the injuries produced by the electrical current confined almost entirely to the nervous system. The changes involved primarily the nerve cells, the axones, and their myelin sheaths.

Many other authors reported finding hemorrhages in the brain and spinal cord, and in the skeletal muscles. Langworthy (31) attributes these findings to the rise in blood pressure observed following
passage of the current as was demonstrated by Urquhart (58).

PROGNOSIS

In any given case of electrical shock it is very nearly impossible to predict the outcome of the injury. So many factors must be considered that great variation is possible under any given set of conditions.

The most important factor in production of fatalities is of course cardiac failure. If this is not present, the chances of recovery are greater.

Cunningham (5) spoke of artificial respiration as "the only and almost invariably futile method of treatment". Against this view, Jellinek, (24) enthusiastically spoke of artificial respiration. In his opinion, in most cases of electrical shock death was only apparent, not real. Somewhere between these two extremes lies the truth. To evaluate the possibilities, two types of situation may be postulated. In the first place, where ventricular-fibrillation exists, the prognosis is extremely poor. In the second, where no cardiac symptoms are present, the prognosis is good.

The investigation of Langworthy (30) seems to indicate that there is a direct relationship between the severity of injury to the respiratory center and the duration of the respiratory block. The most im-
important factor in evaluating the degree of injury to the respiratory center is the duration of contact with the current.

The intensity or voltage of the current has an important bearing on the nature of the injury. Jaffe (22) refers to the work of Prevost and Battelli which indicated that currents of high voltage tended to produce respiratory depression alone, while currents of low voltage tended to produce ventricular-fibrillation. The investigations of Langworthy and Kouwenhoven (32) support this view. They also state that at lower voltages the alternating current is most injurious because of the cardiac effects. At high voltages they believe direct current more injurious to the central nervous system than alternating. They observed that with alternating current at high voltages the changes in the central nervous system were characterized by punctate hemorrhages. With direct currents at high voltages there was production of marked change in the nerve cells. The most severe damage in their opinion was the shrinkage of the cell nuclei, which became pyknotic.

The success of artificial respiration in resuscitation from electrical shock has been reported as good, bad, and indifferent. In 1928 The Engineering
Committee on Electric Shock (8) reported the success of this type of treatment in various Public Utilities of the United States and Canada. In cases uncomplicated by other factors such as falls and burns, out of 265 cases, successful resuscitation was performed in 200 cases, or 76%. Pearl (48) reports a series of 58 cases in which the mortality was 91%. Maclachlan (37) reported that in a 15 year period, trained men in public utilities resuscitated 49% of all cases of electrical shock they had attended.

TREATMENT

At the present time the only method of resuscitation of value is artificial respiration. The present methods for treatment of cardiac complications are applicable only under ideal conditions such as exist in the laboratory.

Prompt initiation of artificial respiration is most important. The percentage of successful resuscitations is much better when the elapsed time before application of artificial respiration is less than two minutes. This is borne out by the analysis of cases made by Maclachlan (37) and experimentally by Urquhart (58).
The immediate treatment of victims of electrical accidents is usually undertaken by untrained co-workers who are unable to judge the nature of the accident. It is important that all employees of public utilities be trained in the fundamentals of artificial respiration. Methods of freeing the victim from the current quickly and without undue hazard to other workers should be taught them. Fisher (12) emphasizes the necessity of prompt action. He states that in many cases the accident occurs in places remote from the switch, and one must use ingenuity in devising a method to free the victim. He advises that the rescuer keep one hand in his own pocket to avoid passage of the current through his thoracic region. He states that if it is possible to free the victim by use of ones feet, that should be done since it is much safer than using the hands. It is also important to avoid the pockets of the victim since these often contain metal objects from which it is possible to sustain severe burns. He advises use of a piece of rope, a belt, necktie, or even a coat to loop about the victims body and pull him away from the current. A piece of wood may also be used to pry the victim from the contact.
Once the victim is freed from the contact, artificial respiration should be begun. This should be continued and a physician called immediately to determine the nature of the accident.

In order to intelligently advise the further handling of the case, the physician should first examine the patient to determine if there is cardiac action. This is often difficult in this state of emergency. If the pulse is absent but there are pulsations in the neck it is probable that ventricular fibrillation exists. Pearl (49) advises instillation of a drop of ether into one eye, which will, by the redness produced, indicate even a feeble circulation. If the diagnosis of ventricular fibrillation is made, the physician is confronted with a grave emergency. Though a fibrillating heart is not a dead heart, no amount of artificial respiration will restore it to normal rhythm.

If the elapsed time since the occurrence of the accident has been very short, and it is at all feasible, injection of a solution of Potassium Chloride followed by Calcium Chloride through the carotid artery should be attempted. The experiments of Hooker (17) and Wiggers (59) show this method to be very effective
under laboratory conditions. It is essential that it be done promptly before the nervous system suffers from asphyxia. In the opinion of Pearl (48) it must be performed within ten minutes of the time of injury.

If this method is not effective, massage of the heart through an abdominal incision should be attempted. The heart should be massaged about 30 times per minute. Pearl (49). In any case with cardiac complications, the prognosis is very poor and these methods of treatment may also result in failure. Intra-cardial injections of camphor have been recommended but the value is problematical. If the diagnosis of ventricular-fibrillation is in doubt artificial respiration should be continued for a period of twenty minutes, in the hope that spontaneous recovery will take place. When the diagnosis of ventricular fibrillation is certain, and these methods of treatment have been to no avail, long continued artificial respiration seems illogical.

If the accident has produced respiratory cessation but left the cardiac action intact, the prognosis is good. Artificial respiration should be continued in these cases until the patient again breathes spontaneously, or until rigor mortis sets in. Jex-Blake (27).
The most efficient means of artificial respiration seems to be the prone pressure method. Administration of various stimulants has produced no marked beneficial results. Pearl (49) condemns the use of pressure and suction machines. Urquhart (58) in his experiments found no beneficial effect from intramuscular injection of adrenaline. The use of Lobeline is dangerous in the opinion of Pearl (49), and in a case reported by Morgan (44) was not effective.

Subjecting the patient to counter shock by various stimuli is unjustifiable. The experiments of Urquhart (58), Ivy and Barry (21) and others indicate that there is block of sensory impulses following electrical injury.

After response of the patient the use of Carbon-dioxide-Oxygen inhalations has definite value. The patient should be carefully watched for respiratory embarrassment and should cessation occur again artificial respiration should be continued.

Signs of increased intracranial pressure such as coma or convulsions, paralysis, increased irritability and excitability, mental derangement etc. should promptly be relieved by lumbar puncture. This procedure is highly recommended by Jellinek (25).
Treatment of accompanying burns is a problem in itself. Conservative management is urged by Jellinek (25) and others. The burn of electricity shows remarkable tendency to heal. The burns are aseptic due to the great amount of heat produced by the electric current on contact.

Late deaths sometimes occur following electric accidents. In the opinion of Jellinek (25) most of these late deaths are due to hemorrhages. Often there is injury to the wall of the blood vessels which is not immediately apparent. For this reason it is advisable to keep the patient in bed for a period of days or several weeks under close observation.
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