Erik K. Mitchell,[1] *M.D. and Joseph H. Davis,*[2] *M.D.*

Electrocution by Street Lighting

REFERENCE: Mitchell, E. K. and Davis, J. H., "**Electrocution by Street Lighting,**" *Journal of Forensic Sciences*, JFSCA, Vol. 29, No. 3, July 1984, pp. 836-842.

ABSTRACT: Four lethal and one nonlethal electrocutions from street lighting equipment are described. These cases have in common old installations, metal light poles, wet environment, 480-V power sources, and intact fuses. Identification of causative factors may permit future accommodation in design to reduce risk.

KEYWORDS: pathology and biology, electrocution, grounding

In Dade County, since 1976, there have been at least four fatal, and at least one nonfatal, accidental electrocutions related to ground fault currents from defects in 480-V circuits supplying metal poles used for municipal street lighting. This particular type of street lighting is common to many municipalities, so the social and legal ramifications of these cases may be disproportionate relative to the small series of cases described here.

The particular cases here discussed involve metal poles which functioned satisfactorily for upwards of 40 years, apparently developing defects in their circuitry with time. Other common factors included demonstrated potential ground faults, rain either during or immediately before electrocution, and pedestrian victims. One case was unusual in that no direct contact with the metal light pole occurred.

With the ubiquity of similar types of street lighting facilities, the potential for occurrence of these cases is large. The authors, however, remain unaware of any systematic description of deaths under similar circumstances.

Methods

Four deaths were determined to be the result of electrocution by faulty electric streetlight circuits. Cause of death was certified on the bases of: (1) if autopsy is compatible with and suggestive of an electrocution type of death, (2) history from would-be rescuers of shocks received from the body at the scene, (3) exclusion of common toxicologic agents as cause of death, and (4) medical history not suggestive of another cause of death. Follow-up investigation of the suspect electrical circuit included subsequent demonstration of specific and reasonable sources of ground fault. The autopsy and toxicologic examinations were performed by the Medical Examiner's Department. The background history was collected by police and medical examiner personnel. Electrical testing was performed by the affected jurisdiction of street lighting.

Received for publication 16 July 1983; revised manuscript received 14 Sept. 1983; accepted for publication 15 Sept. 1983.

[1]Medical examiner, Onondaga County, Syracuse, NY.
[2]Chief medical examiner, Dade County, Miami, FL.

All decedents were examined extensively for electrical burns which were not found in any instance.

In the separate nonfatal electrocution, verbal report of the shock and consideration of the circumstances of contact, of wet ground, and faulty circuit was accepted as adequate evidence for the event.

Case Histories

Case 1 (762009)

At 10:30 p.m. on 23 Aug. 1976, a 50-year-old white male was seen by a passing motorist lying motionless on a median strip next to a light pole. Through a CB radio communication medical rescue personnel were dispatched to the scene.

The first person to reach the decedent received a palpable shock and a finger blister on contact with the body of the decedent. Subsequently, the power supply to an adjacent streetlight circuit was interrupted and safe removal of the decedent was effected. No respiratory, cardiac, or neural activity could be detected or elicited by rescue attempts which continued at a local hospital.

Scene investigation revealed the light pole in question to be surrounded by standing water from a recent rainfall. The electric circuit was 480 V to ground, single phase, supplied to a metal pole mounted on a concrete pad. Wire inside the pole had frayed insulation allowing contact of bare wire to metal pole. The installation was old, having been transferred from one municipal jurisdiction to another, and could be estimated at about four decades at a minimum.

Anatomic findings were an unkempt male with wet clothing, no external burns, and no catastrophic process requiring sudden death. There was an isolated focus of atherosclerotic deposit with 75% obstruction of the lumen in the proximal left anterior descending coronary. Blood was fluid. The lungs were congested and weighed 500 and 560 g, respectively, for right and left.

Case 2

During investigation of Case 1, police interviewed a 21-year-old white male who claimed, while crossing the street after a storm, to have received a shock previously from a metal light pole adjacent to the one immediately in question in Case 1. The affected pole was replaced without further tests of its electrical integrity.

Case 3 (803237)

At 8:30 p.m. on 11 Nov. 1980, a 48-year-old white female, apparently intoxicated, was seen walking across a four-lane highway after a rainstorm. Shortly thereafter, a passerby saw the decedent lying in the median strip and summoned medical rescue personnel. The body was immediately adjacent to a light pole. Contact with both decedent and the wet base of the pole resulted in electric shock of such perceptible severity that protective gear was donned before removal and unsuccessful resuscitative attempts.

Examination of the underground wired metal light pole showed an area of brown dead grass circumferentially about the concrete base. The base plate was open and defective because of vehicular damage. The wires within were exposed to rain. The 480-V, single-phase circuit was not tested for fear of further injury but did show improper wiring with a potential for ground fault. There was the possible reversal of ground and live wire. The installation was at least 40 years old and in the median strip of a busy highway.

Anatomic findings at autopsy showed no burns, respectively 560- and 540-g right and left lungs with congestion and edema fluid, and a 1500-g fatty liver with rounded edges. The blood analysis revealed a 0.21% ethanol.

Case 4 (813140)

Between the hours of 8:00 and 8:30 p.m. on 2 Nov. 1981, after a rainstorm, three teenaged males walked past an aluminum metal light pole where one received a shock on accidental contact with the pole. Another of the males then touched the pole, likewise receiving a shock. The third male, a 15 year old, grabbed the pole with both hands and started to shake and then to yell for help. The victim was pulled from the pole and stopped breathing. Medical help was sought but resuscitation was ineffectual.

The aluminum pole stood on a concrete base and had puddles of water about it. The lighting circuit was an underground, 480-V, single-phase system approximately 10 years old and had loss of insulation over a split-bolt connector within the light pole thereby allowing the pole to become energized.

Postmortem examination showed visceral congestion and no disease processes. There were no external burns. There was no ethanol and no common drugs of abuse were found in the blood on a toxicologic screen.

Case 5 (82699)

After a rainstorm on 6 March 1982, at about 5:20 a.m., a 58-year-old black male was seen lying on a traffic island close to a metal light pole. Three police officers lifted the victim to a sitting position. A passing car showered water from the puddle onto the officers from whose grasp the victim slipped to end with head on the wet pavement and feet in a puddle. At no time was there contact with the metal light pole or its base. The victim then became rigid with clenched fists and foam from the mouth. One officer received a shock when he then tried again to assist the victim so the victim was dragged some distance by his clothing. The victim thereafter appeared without vital signs and resuscitative efforts failed.

The traffic islands on which the poles stood had a single light pole (Fig. 1) within which was found a wire bared by loss of insulation which could have allowed grounding of the 480-V single-phase circuit through the pole. This was a top-wired pole with a ballast in the base to which wires had to run. The base of the pole was open (Fig. 2) allowing the entrance of water, the rainwater possibly contributing a circuit for a ground fault. The installation was approximately 40 years old. Records of installation and maintenance were not available. Test of the grounding circuit demonstrated this to have a very high resistance, essentially not providing a ground.

Postmortem observations showed a well-developed, black male with left ventricular hypertrophy in a 550-g heart as well as visceral congestion. The liver was 1910 g and red. There was nodular adrenal cortical hyperplasia. No cutaneous evidence of injury or burn could be found.

Discussion

Diseases uncovered at autopsy were compatible with continued existence. An isolated focus of coronary atherosclerosis, though without anatomic evidence of myocardial effect, could cause sudden death, but was considered in the context of a known source of electric shock. The fatty liver seen in Case 3 would be unlikely to cause sudden death in view of a 0.21% blood ethanol [*1*].

All cases here described have certain common factors (Fig. 3). These are metal light poles with a 480-V service where a ground fault develops after a rainstorm. Passersby incidentally

FIG. 1—*Traffic island and light pole with victim of Case 5.*

coming in contact or into the ground fault circuit are electrocuted as demonstrated by shocks received by would-be rescue personnel.

Aging light installations must be a common problem on worldwide scale considering the expense of both their maintenance and replacement. With increase in age, there is potential increase in insulation defects and electric shock danger.

An examination of a single median strip, where lighting circuits of the type discussed were in use, showed a total of 155 poles. Only 45 had not sustained visible external damage. The others were damaged most likely as a result of automobile impacts. Forty-five had their base plate doors off thereby allowing direct access of water, dirt, and beer cans to internal wiring (Fig. 4).

In each instance where electrocution was demonstrated, the source was a short circuit coupled with a ground fault which prevented fuses from interrupting the circuit. Fuses were provided primarily for the protection of equipment which would be damaged by excess current flow to ground if there was a short circuit into an adequately grounded pole.

In the particular circuits involved, fusing was beyond the actual amperage requirements for the service itself in order to reduce voltage drop and to prevent nuisance outages as a result of temporary overloads by lightning or other temporary defects in the poles. The circuits were supplied through time delay fuses at 30 to 60 A at a main source. Each pole was then individually fused at 10 A (Fig. 5).

A logical overview of the situation suggests the ground faults were not isolated momentary events but were present for some time after the proper conditions for their occurrence had developed. With contact of a poorly insulated current carrying wire to a pole, one might expect, in the face of an adequate ground, to have had rapid development of a current that

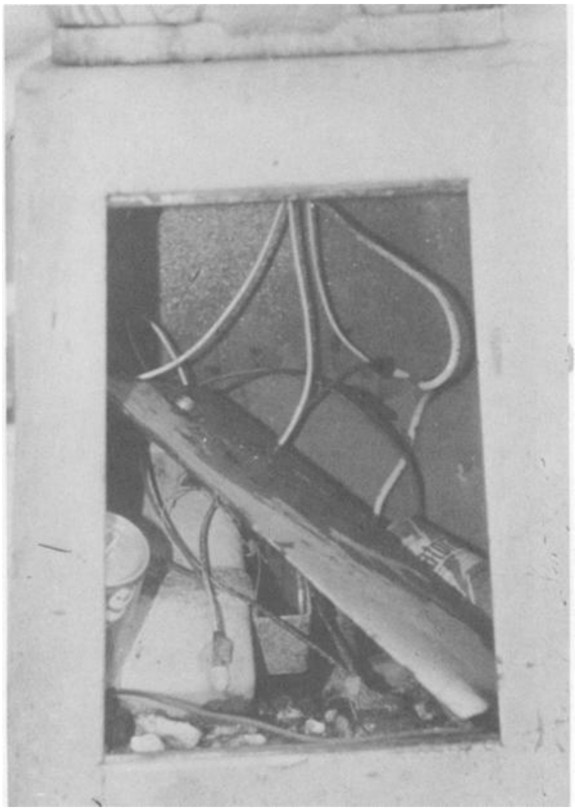

FIG. 2—*Open base of light pole in Case 5.*

COMMON FACTORS

OLD INSTALLATIONS

FUSES NOT BLOWN

RAIN STORM

480 VOLT SOURCE

METAL LIGHT POLES

PEDESTRIANS

FIG. 3—*Factors common to all streetlight electrocutions.*

would activate the fusing system. In the one circuit tested for adequacy of ground, this was, in fact, inadequate. In retrospect, in all instances there was a strong possibility that an adequate ground no longer existed. This loss of ground was a problem attendant upon corrosion. In Dade County, corrosion has been a constant problem in electrical circuit design.[3]

[3]Frank Seeley, chief of roadway lighting, personal communication, Dade County Department of Public Works.

MEDIAN STRIP METAL POLES

NUMBER	TOTAL	155
	DOWN	15
	INTACT*	45
	DOOR OFF	45

*INTACT=REPAIRED/MAINTAINED AT ORIGINAL STDS.

FIG. 4—*Pole damage inspection of one affected street.*

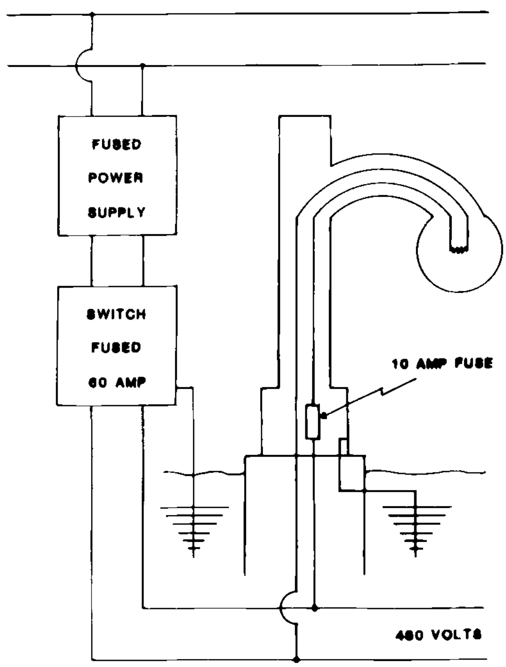

FIG. 5—*Circuit design for typical streetlight installation.*

That each electrocution occurred in a rainstorm could be the result of several factors. Rain may have penetrated the wiring as in Case 5 where the base plate was open to expose wire within. The light circuitry was not designed as a functional underwater circuit.

Evanescent faults on the basis of rain-increased electrical conductivity were a potential. These faults might have disappeared after pole and surrounding earth had dried; the time when most electrical testing of circuitry might be expected to occur.

The final effect of rain would be to increase the contact area and decrease resistance of human skin involved in each instance. Such effects helped to explain the lack of cutaneous burns on any of the decedents. It might also explain the distance from the pole at which a fatal shock could be received, as in Case 5.

The 480-V source used for these lighting circuits is inexpensive to operate as it requires a thinner gauge of wire than needed for a lesser voltage. The ease of transmission gives a considerable financial incentive for continued use of such voltages. For example, the economic impact of a 12-V circuit would be insurmountable.

The lethal potential of the 480-V circuit is, however, considerable. It can obviously overcome greater intrinsic resistances than can lower voltages. Should current leak to the pole it will require a larger area of earth to dissipate than with a lower voltage.

The metal light pole is in common use as a result of its durability and, in the past, relatively low expense. It is easy to install, relatively easy to repair, and relatively easy to maintain. Impact safety advantages have been demonstrated with metal pole designs where a frangible base attachment is desirable. Other pole types exist such as concrete, fiberglass, and wood, and each of these offers potential alternatives, though ease of installation, expense, highway safety, and electrical safety must be considered. From the electrical viewpoint a fiberglass pole with its high intrinsic resistance, might be optimal.

The protection of pedestrians from shock can be addressed in several fashions. A reduced access to poles by careful pole placement, as much as possible away from pedestrian walkways, could obviously reduce risk somewhat. Humans are, however, by nature quite mobile and the installations themselves will require attention to design detail. In light poles adjacent to highways, crash damage to the poles with resultant electrical defects and ground faults must be considered. By their very use for highway lighting they are subject to vehicular impact and electrical damage.

Proper maintenance might avoid many of the encountered difficulties but is prohibitively expensive for the large number of lighting circuits now in use. Periodic testing of circuitry with a special emphasis on test of adequate ground might serve to catch many of the faults early in their development. However, as noted, some of these faults may be temporary in nature and develop only during wet weather, where circuit testing would be less likely to occur. A false sense of security could thus develop when no insulation faults are identified.

A new fusing requirement could conceivably show some potential for protection of the pedestrian. Ground fault interrupting circuits might be developed sufficiently to become useful as additions to existing systems. For instance, with time delay ground fault interruptors, existing requirements for relatively high amperage fuses, and a certain time delay, to account for temporary overvoltages such as lightning, might be met and still allow only a relatively short existence for any developed ground fault, even of minor portions.

New systems will need to be designed with improved pole insulation and possible inclusion of new fusing devices. One may also take into consideration development of National Electrical Code requirements to reflect our increased awareness of potentially hazardous external lighting sources. It is an interesting note that the National Electrical Code sets no minimum standards for municipal outdoor lighting [*2*].

Aspects of design to be addressed in the future must include attention to protection of poles from damage. As documented here (Fig. 4), these structures are at high risk for accidental damage from automobiles. While the electrical faults seen in the cases presented cannot be related directly to a specific automobile impact, the structural defects caused by car crashes compromise the integrity of the circuitry. Pole placement, structure, circuit design, and protection must be brought in harmony with well lit streets.

References

[*1*] Randall, B., "Fatty Liver and Sudden Death: A Review," *Human Pathology*, Vol. 11, 1980, pp. 147-154.

[*2*] National Electrical Code 1981, National Fire Protection Association, 470 Atlantic Ave., Boston, MA.

Address requests for reprints or additional information to
Erik K. Mitchell, M.D.
Onondaga County
330 W. Onondaga St.
Syracuse, NY 13202