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Electrocution : a case report of acute myocardial necrosis.

Prayong Moolla-or*

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An 18-year-old Thai male construction worker was electrocuted at work. On admission his heart stopped beating and there was apnea. His heart resumed normal rhythm at the first cardiac shock, but he expired after going into cardiac arrest the third time. The autopsy revealed acute extensive necrosis of the cardiac muscles, congestion of the internal organs and edema of the lungs. These findings were the pathologicl effects of electrocution.

Key words : *Electrocution acute myocardial Necrosis voltage ; ampere, ohm*

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ผู้ป่วยชายไทยอายุ 18 ปี อาชีพก่อสร้าง ถูกกระแสไฟฟ้าแรงสูงดูด ขณะกำลังทำงาน ผู้ป่วยหัวใจหยุดแล้วขณะมาถึงโรงพยาบาล ภายหลังกระตุ้นด้วยกระแสไฟฟ้าครั้งแรก หัวใจกลับเต้นปกติได้แต่ผู้ตายก็มีหัวใจหยุดอีก 2 ครั้ง ครั้งสุดท้ายไม่สามารถจะช่วยให้หัวใจกลับคืนมาได้ ตรวจศพพบว่าการตายเฉียบพลันของกล้ามเนื้อหัวใจเป็นบริเวณกว้าง นอกเหนือไปจากการคั่ง เลือดของอวัยวะต่าง ๆ โดยเฉพาะปอด ทั้งนี้เป็นผลโดยตรงของกระแสไฟฟ้าที่ผ่านหัวใจ

Electrocity may be divided into three types according to voltage.(1)

1. **domestic** : the voltage of domestic supplies of electricity varies from country to country and within countries. For example, the standard domestic voltage in the United States is 110 volts of alternating current (60 cycles), whereas in Great Britain, it is 240 volts at 50 cycles, and in Thailand 220 volts at 50 cycles.

2. **Industrial** : the voltage used to drive hand-operated tools is low for safety reasons, but very high voltages (up to 400,000 volts) are used to drive heavy machinery.

3. **Lightning** : lightning may reach energies of up to 100 million volts of direct current with amperage varying from 100 to 200,000 amperes.

Electrical current for domestic and industrial use is generated by large electromagnetic devices and transmitted over great distances at high tension often exceeding 100,000 volts. Transformers are used to reduce this voltage usually by stepping it down to 7,620 volts, which is the usual voltage in residential and industrial high-voltage distribution lines. Generally wire-to-wire voltage is approximately 15,000 volts. Electrocutation in humans usually is a line-to-ground event. Only rarely will it be line-to-line.(2)

Case report (F 5934)

An 18-year-old Thai male construction worker was brought to the emergency room of Chulalongkorn Hospital; he had been electrocuted while at work about 10 minutes previously.

Physical examination

He had neither pulse nor heart beat; apnea; with severe cyanosis was present. His pupils were fixed in mid-position and did not react to light.

The patient was resuscitated by adrenaline (bicarbonate 3 doses) and cardiac electrical shocks (50-10-200-300 joules). He then recovered with normal heart rhythm, and was put on a Birdés respirator. Laboratory studies revealed the following data: blood sugar, 280 mg/100 ml; blood urea nitrogen 7 mg% sodium 145 mEq/L; potassium 2.8 mEq/L; chloride 100 mEq/L; hemoglobin 14 mg%; leucocyto count, 13,000 cells/cumm, with 22% polymorphoneuclear cells, 2% eosinophils, 1% monocytes and 75% lymphocytes. The urinary examination was within normal limits.

Electrocardiography showed sinus tachycardia and increased ST injury pattern; echocardiography showed a heart of normal size with poor, generalized ventricular contraction; chest roentgenogram revealed bilateral alveolar infiltrations.

Progress in the ward

The patient was unconscious and was put on a Birdûs respirator while being administered intravenous fluid dopamine, NaHCO₃ and intermittent adrenaline, isoptin and xylocaine.

He also went into cardiac arrest three times, but did not recover from the third one. He was pronounced dead after 48 hrs he had been admitted.

Autopsy findings (The autopsy was performed 48 hours after death) **External examination**

Examination revealed a well-developed young Thai male, 173 centimeters in height weighing 50 kilograms. He had tattooes on his left arm as well as three small "punch-out" skin lesions (dry burns) on his left hand at the mid-hypothenar eminence, the proximal part of his thumb and at the tip of his index finger. These lesions represent the entry point of the electrical current; no exit point was found anywhere (Fig. 1).

Internal examination

The skull was unremarkable; the brain weighed 1,310 grams. There was a moderately severe degree of congestion and edema of the brain parenchyma. Petechial hemorrhages were seen in the white matter on the serial cross sections.

The heart weighed 280 grams. There were large areas of hemorrhage on the anterior interventricular septum as well as in the myocardium of the left ventricular

wall and interventricular septal muscles. The valvular wall was smooth, shining and semitransparent. The valvular circumferences were aortic 8 cm; mitral 9 cm; tricuspid 11 cm; pulmonary 7 cm. The right ventricular wall measured 0.3 cm and the left ventricular wall measured 1 cm, in thickness. The right and left coronaries were unremarkable. Microscopic examination revealed areas of extensive necrosis of muscle fibers as well as extravasation of the red blood cells. (Fig. 2,3).



Figure 1. Show electrical contact burns.

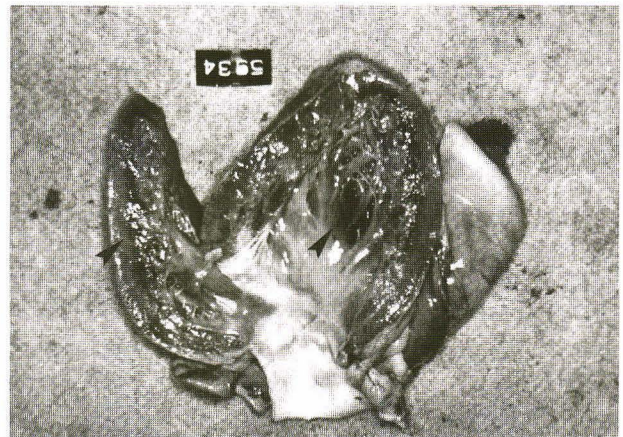


Figure 2. Gross findings of the heart; arrows point at areas of hemorrhages.

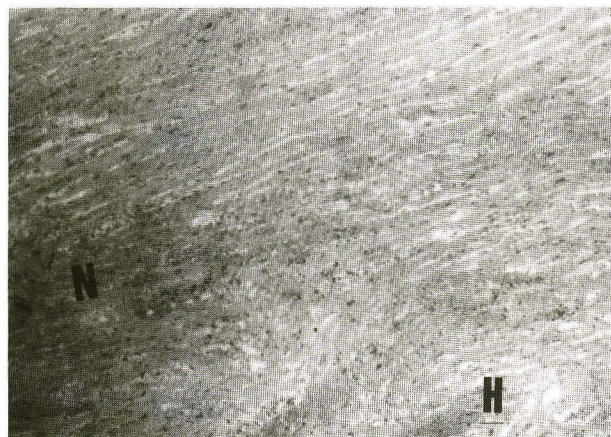


Figure 3. Microscopic examination shows areas of hemorrhages (H) and myocardium necrosis (N) (H&Ex100).

The lungs together weighed 1,400 grams. There was a moderately severe degree of congestion and edema of the lung parenchyma. Spotty areas of early pneumonia were also seen. Postmortem culture yielded α -streptococcus species.

The rest of the organs were unremarkable.

Discussion

According to the studies of Wright and Davis, the amount of current (amperes) is the most important single factor in human electrocution. Predictions of the effects of the electricity can be made based on the interrelations between ohms, volts and amperes. The human body has a minimum internal resistance of less than 500 ohms. Hands and feet have minimal values of 1,000 ohms. Dry skin easily reaches resistances of 100,000 ohms. The effects of current flow in humans (for 60 hertz of alternating current) are generally accepted as follows : (2-6)

- 0.001 ampere - barely perceptible tingle
- 0.016 ampere - ùlet goù current
- 0.020 ampere - muscular paralysis
- 0.100 ampere - ventricular fibrillation
- 2.000 amperes - ventricular standstill
- 20.000 amperes - common household fuse will blow

Although the general rule is that there will be skin burns at the entry and exit (grounding) points in the human body, this rule is often violated. Even at voltages in the 7 kilovolt range, skin burns may be absent in fatally electrocuted persons, if the exposure time is short and the exposure area is large. (This may explain the lack of and exit in our patient) Another factor is moisture : when the skin is soaked by perspiration or water the resistance will drop from 100,000 ohms to 1,000 ohms (our patient was electrocuted by high voltage, perhaps 2,000 volts. The above mentioned effect of current may be determined by applying the following equation :(1,2,6-8)

$$\begin{aligned} \text{amperes} &= \text{voltage/ohms} \\ &= 2,000\text{V}/1,000 \text{ ohms} \\ &= 2 \end{aligned}$$

Two amperes can cause ventricular standstill, which explains why our patient went into cardiac arrest. In cases of massive current flowing through the body, the heart stops completely; when the circuit is broken, the heart may commence beating normally again.(9) However, although the heart may restart, breathing often does not, and cardiac death occurs from 10 to 20 minutes after electrocution.(10)

According to Wright and Davis, any case that indicates a potentially grounded was near a potential source of low voltage current. Anyone who is heard to scream, swear, or shout and then is observed to die after a few seconds must be considered a possible victim of electrocution.

According to Fisher,(9) there is another important factor in electrocution, i.e. the pathway of the current, such as from one hand to the other hand and from one hand to the opposite leg. The circuits in such cases obviously involve the heart.

The gross autopsy findings characteristic of fatal electrocution are not specific. They consist of congestion of internal organ, edema of the lungs (as a result of ventricular fibrillation)(1,2,11) and fluidity of the blood. In our 18- year-old patient his coronary arteries were unremarkable. In the world literature, there is no report of acute myocardial infarction in a man this young, except that Zeanall and Walton(12) had reported acute myocardial infarction in a 16-year-old boy following electrocution as well as the studies of Quinard(14) et al. and James(15) et al. Our patient was electrocuted by high-voltage (AC) current entering the left hand to ground somewhere (may be the right hand or either leg). This was followed by three applications of DC shocks when he went into cardiac arrest. This explains the myocardial necrosis.

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