Original Article

Forensic Histopathological Approach to Electrocution

Raji Hussein Mohammad Al-Hadithi *, M. B.Ch. B., M. Sc., F. C. A. P.
Nabeel Ghazi Hashim Al-Khateeb **, M. B. Ch. B., M. Sc., F. I. B. M. S. (Forensic Pathology)
Muthana Abdul- Jabar Abdullah*, M. B. Ch. B., F. I. B. M. S. (Forensic Pathology).**

J Fac Med Baghdad
Vol. 50, No. 3, 2008
Received: April.2008
Accepted: Sep. 2008

Summary

Background: Few Studies had been done on the role of histopathology in the medico-legal diagnosis of Electrocution even abroad.

Aim of the study: To determine the main histopathlogical features in cases of electrocution especially at the entry site of the electrical current which help in the diagnosis of those cases.

Methods: A full medico-legal autopsy had been done on 64 cadavers of persons died as a result of electrocution chosen randomly out of a total number of 144 cases of electrocution during the year 2005 in the medico-legal institute of Baghdad including histopathological examination by ordinary method of different specimens from those cadavers at histopathology department of the mentioned institute to reach the aim of this study.

Results: Electrocution constituted only 1.4% of all causes of death during the year 2005 in the medico-legal institute of Baghdad. Males were more than females in a ratio of 2:1. The most affected age group was 30- 39 years old. In 62% of the case the entry of the current was with no exit. In 46.9% of the cases the entry site was in the form of charged centre surrounded by gray elevated area and took other shapes in the rest of the cases. Microvesicural formation was the commonest histopathological finding in the skin. Pulmonary edema was the commonest histopathological finding in the lung.

Conclusions: Although they are non specific, histopatological features could help the forensic pathologist in the medico-legal diagnosis of electrocution in addition with other findings especially in cases with less typical gross features or with incomplete information about the case, in addition to other conclusions of the study.

Key Words: Forensic, Histopathological Approach, Electrocution**.**

Introduction :

The passage of electrical current through the tissues can cause skin lesions, organ damage and death. This injury is commonly called electrocution, though some would use this term only if death occurs. [1]

The effects of electricity on the human body depends upon the amperage that is to say the amount of the current, voltage, and resistance which form the constituents of electrical current, in addition to the time of exposure, the surface area of the affected region, the path of the current through the body, and the nature of the current whether alternating or direct. [2, 3]

The external signs of electrocution include the entry and exit injuries. The entry site could be in the form of Joule sign which is the print of the conducting object. Both or none of the entry and exit sites could be in form of circular or elliptical dry burn.

**Professor of Histopathology in Al-Nahrain College of Medicine.*
***Lecturer of Forensic Medicine in the Department of Pathology- Baghdad Faculty of Medicine.*
****Specialist of Forensic Medicine in the Medico-legal Institute of Baghdad.*

Sometimes we see what is known as Mineralization due to heat effect of the current which dissolute the conductor at the entry site and this of course would help to differentiate the entry site from the exit. In some cases there is charring at the entry site. [3] It is important to mention that there are certain cases of electrocution with no obvious entry or exit lesions and this occurs in case of large contact area as in the presence within water medium. [4] While the gross internal signs include subserosal petechial hemorrhages on the surface of the heart and lungs which could bee seen also in the subconguctival region in addition to the fluidity of the blood. [2]

In relation to the histopathological appearance of the electrical injuries we can see vacules or multiple small cystic spaces in the epidermis giving it a Swiss cheese appearance and sometimes those vacules are seen in the dermis. In some cases there is detachment of the epidermis with elongation of the epidermal cells and horizontal arrangement of the nuclei of the lower epidermal cells; what is known as streaming of the basal epidermal nuclei. The electrical burn at the entry and exit sites is accompanied by focal coagulative necrosis at the microscopical level. Sometimes we see fine metallic particles from the conductor. The dermal

blood vessels are engorged and filled with hemolysed blood. [1, 2, 3, 5, 6, 7, 8]

The death in electrocution depends on the path of the current through the body and hence may be due to ventricular fibrillation, inhibition of the respiratory center, or tetany of the respiratory muscles especially the diaphragm. The accompanied injuries especially those resulted from falling from a height could be the cause of death in certain cases. [4]

Most of the electrocution cases are accidental with few suicidal and homicidal cases. [4]

Electrocution cases constituted 4.3% of autopsies in the medico-legal institute of Baghdad during the years 1977- 1981; while it constituted only 0.6% of autopsies in London during the same period according to the study done by Al-Guriry due to different medico-legal systems. [9]

Materials and Methods:

A prospective study to find the histopathological features of electrocution had been carried on 64 cases of electrocution out of 141 cases which constituted the total number of fatal electrical injuries that had been referred to medico-legal institute of Baghdad from the 1st of January to the 31st of December 2005.

The 64 cases had been chosen randomly and their study included full complete medico-legal autopsy which began by collection of information on each case from the official request of autopsy written by the legal authority and by direct question to their relatives which included sex, age, occupation, the story of fatal electrical accident, and the notes of hospital if there was any. This was followed by external and internal examination of each case with special attention to the signs of electrocution and whether there was any other factor that contributed directly or indirectly to ultimate cause of death.

Microscopical histopathological examination on small samples taken from different organs including the entry site of electrical current had been done in the department of histopathology in the medico-legal institute of Baghdad on all the sixty four cases using the ordinary stain hematoxilin and eosin.

Photography was done for some cases both gross and microscopical in addition to some statistical analysis.

Results:

The total number of all cases that had been referred to the medico-legal institute of Baghdad during the period of study was 10105 cases; out of them 141 electrocution cases; 64 cases of them were chosen randomly to be included in this prospective study.

Table (1) shows age groups in years correlated to sex in the 64 cases included in this study.

Table (1): Age Groups (in years) with sex distribution

Age Groups (years)		Sex		
		Male	Female	Total
<9	No.	5	2	7
	%	7.8%	3.1%	10.9%
9 - 19	No.	10	5	15
	%	15.6%	7.8%	23.4%
20 - 29	No.	7	2	9
	%	10.9%	3.1%	14.1%
30 - 39	No.	12	6	18
	%	18.8%	9.4%	28.1%
40 - 49	No.	5	2	7
	%	7.8%	3.1%	10.9%
50 - 59	No.	3	2	5
	%	4.7%	3.1%	7.8%
> 60	No.	2	1	3
	%	3.1%	1.6%	4.7%
Total	No.	44	20	64
	%	68.8%	31.2%	100.0%

In relation to the occupation 23.4% of the victims were workers (with free work) which were the highest percentage among other occupations. The second percentage was 15.6% (students). The lest and the last percentage was 3.1% (policemen).

Most of the cases were accidental (60= 94%) and only (4=6%) were criminal cases.The study of electrical current entrance and exit and the macroscopical features of entrance are demonstrated respectively in figure (1) and table (2).

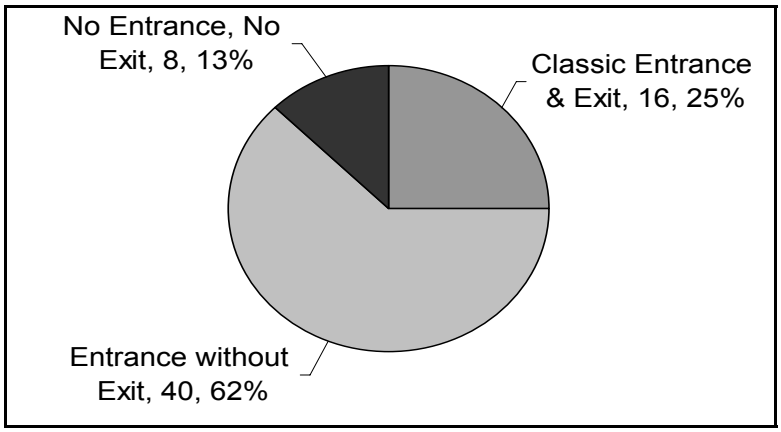

Figure (1): Percent of occurrence of entrances and exits on bodies of 64 victims.

Table (2): The macroscopical description of the electrical-current entrance

Entry Color&Shape[a]	No	Percent
I	22	34.4
II	30	46.9
III	6	9.4
IV	6	9.4
Total	64	100.0

a. I White nodule surrounded by edema
II Charred center surrounded by gray elevated area
III Gray blister with erythema
IV Black sharp wound, full thickness reach the bone.

Mouth froth was present in 68.37% of the cases. Petechiae were present in all the cases with the highest percentage 68.73% in the heart and lungs.

Histopathological examinations was requested for the 64 cases studied. The examination was done for the following tissues: skin and muscles at site of electrical current entrance, brain, heart, lungs, liver, and kidneys. The final categorization of various hisopathological findings had been summarized in table (3).

Table (3): (64) ESD cases classified according to the histopathological findings revealed by examination of various tissues.

Tissue	Histopathological Findings			
Skin	NIL	Coagulative Necrosis	Microvesicular Vaculations	Hyperkerato
No.(%)	1 (1.6%)	4 (6.3%)	58 (90.6%)	1 (1.6%)
Brain	NIL	Congestion	Edema	Reactive Gli
No.(%)	50 (78.1%)	9 (14.1%)	4 (6.3%)	1 (1.6%)
Heart	NIL	Congestion		
No.(%)	59 (92.2%)	5 (7.8%)		
Lungs	NIL	Congestion	Pulmonary Ed	
No.(%)	1 (1.6%)	8 (12.5%)	55 (85.9%)	
Liver	NIL	Congestion		
No.(%)	63 (98.4%)	1 (1.6%)		
Kidneys	NIL	Congestion		
No.(%)	60 (93.8%)	4 (6.3%)		

Nil: *No histopathological changes*

Photograph (1) shows the gross appearance of electrical current entry in one of our cases. While photographs (2-6) show the histopathological features at the site of entry in the skin and in some other organs that had been found in our study.

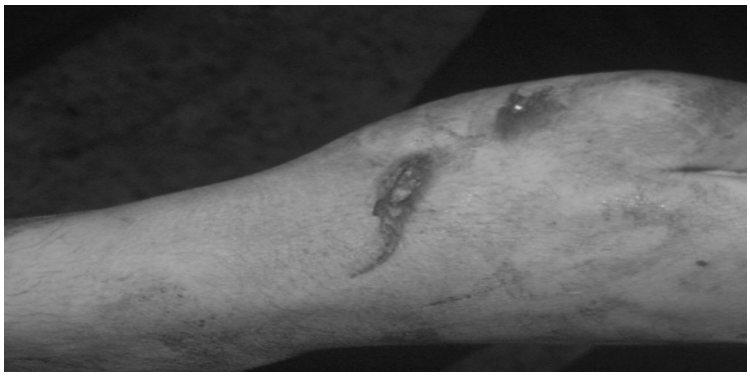

Figure (1): Electrical marks at dorsum of right hand, a gray elevated edge and area of hyperemia can be seen

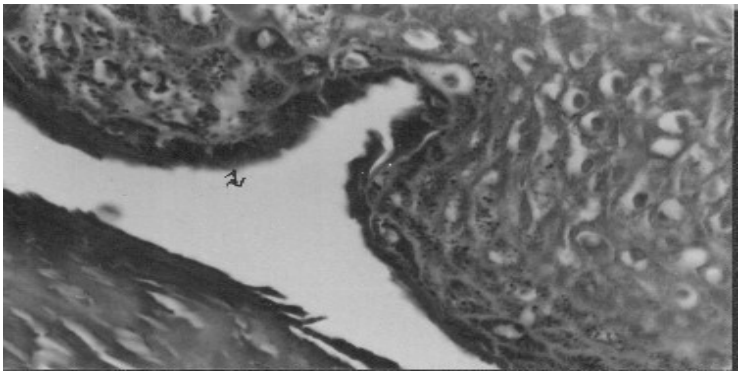

Figure (2): Skin - section showing upper epidermal microvesicle formation at site of entry (H&E X 400)

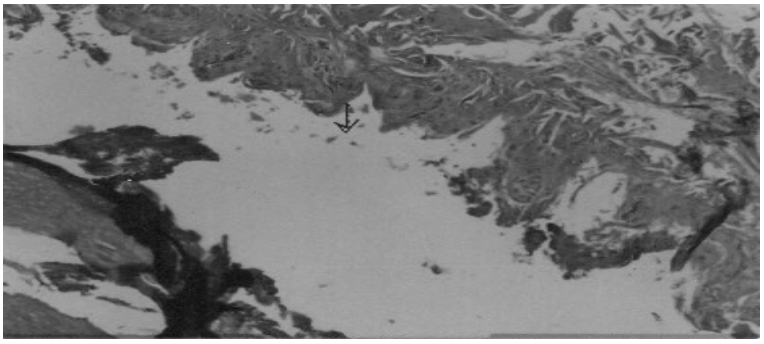

Figure (3): Skin - section showing separation of lower epidermis at Site of entry (H&E X 400)

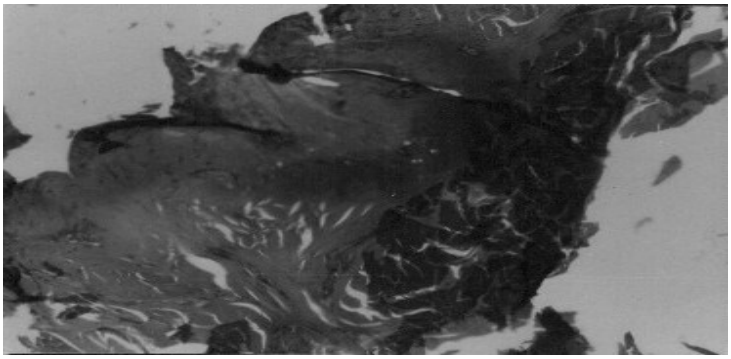

Figure (4): Section showing feature of coagulative necrosis at site of entry (H&E X 200)

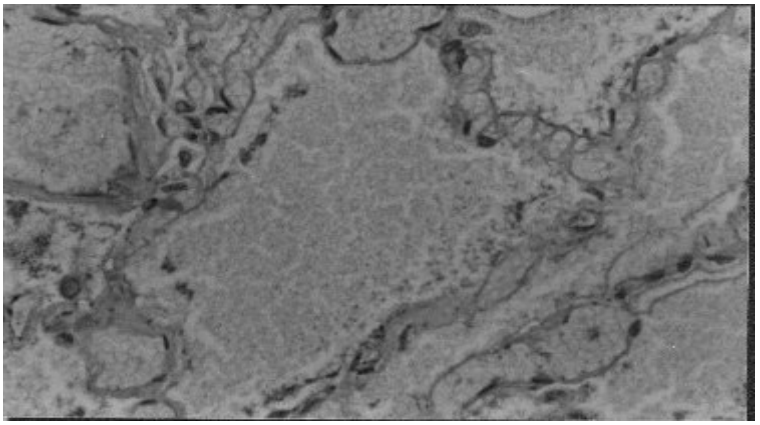

Figure (5): Section showing alveolar spaces filled with proteinous eosinophic Fluid-pulmonary edema (H&E X 400)

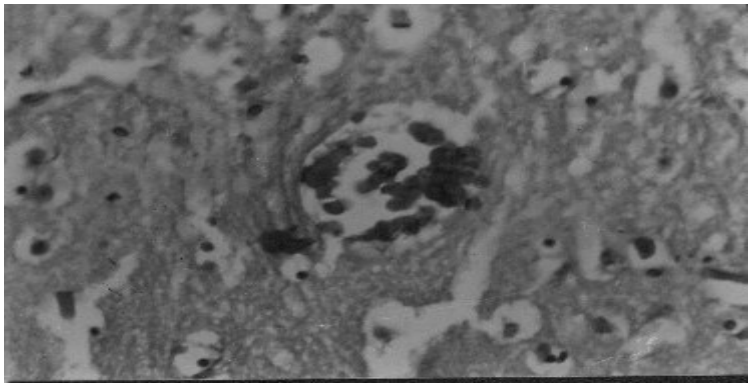

Figure (6): Section showing brain tissue with degenerative effect of astroglial cells with prominent vascular congestion (H&E X 400)

Discussion:

Our aim from this work was to study the histopathological features in cases of electrocution specially at the site of entry of electrical current; those which were not studied well even in foreign studies, but certainly have an important role in the diagnosis of those cases in addition to the other findings, because they are alone are not specific for electrical burns and can also be seen in thermal burns. [(2)] So we concentrate on histopathological features and on some of other facts that have medico-legal importance and relation with the aim of the study and we did not mention other facts that might be mentioned by other studies on electrocution specially those which concentrated on macroscopical features.

There were 114 cases of death due to electrical injury during the year 2005, while the total number of deaths in the same year was (10105). This means that the incidence of electrocution in Baghdad during the year 2005was 1.4% among other causes of deaths that referred to the Medico-legal institute of Baghdad and this differs from the results of (Al-Khateeb) who found that electrocution cases constituted 5.2% of all cases during the year1996.[(10)] The differences in the results are explained by increasing in the incidence of violent causes of death during current study which affected the real percentage of electrical injury and did not mean a decrease in the incidence of the electrical injury in comparison with the mentioned study.

In the current study 28.1% of the cases were at an age group of (30-39) years and 23.4% were at an age group of (9-19) years (Table-1-) which is similar to the results of Wright [(11)] and to that of Martinez and Nguyen. [(12)] This probably reflects exposure opportunities more than differences in susceptibility.

In the current study there is a male preponderance, the total number of males was 44 (28.8%) and the total number of females was 20 (31.2%). And this is nearly similar to the result of Al-Chalebi [(13)] in the period 1962-1971 who found that 75% of the victims were males, and to all global studies which proved that males are more susceptible to electrical injury in general.

Regarding the occupations of victims, the results are not very accurate because in most of the cases the occupation was not recorded in the autopsy request from the police, so we depend on the information from the relatives of victims. The peak incidence was in people with free work. This could be explained by the high percent of free work people in our community during the last years.

The present study found that 94% of the cases happened accidentally and 6% were homicidal. This finding is in accordance with many previous Iraqi and western studies. [(14)]

Entrance without exit was found in most of the cases (62%). This probably was due to wider surface of the exit, presence of humidity and water at site of exit, low voltage and shorter period of exposure. While in 25% of cases entrance and exit of current were both found. Absence of both entrance and exit were also found in 13% of cases (Figure-1-). This is probably due to wider surface of contact at both sites, presence of water and humidity at both sites and short period of exposure.

Regarding the macroscopic description of electrical entrance we found in 46.9% of cases charred center surrounded by gray elevated area. This is due to the effect of heat burning the site of entrance and the gray color due to the boiling effect of heat (Table-2-).

Micro-vesicular formation with nuclear streaming was the commonest histopathological

finding in the skin (90.6%) and pulmonary edema was the commonest histopathological finding in the lung (Table-3-).

Conclusions:

1. Histopathological study in cases of electrocution could help the forensic pathologist in their diagnosis especially in cases with less typical findings or obscure circumstances, although those microscopic features are none specific.
2. Electrocution is uncommon in comparison with other causes of death during 2005.
3. Electrocution displayed male preponderance with two peak incidence in age group 9-19 years and 30-39 years.
4. Heart, lungs and skin are the commonest sites for the effects of electrical current.
5. Most cases of electrocution are associated with pulmonary edema.

In order to have accurate results about the pathological effects of electrical current on the human body, electron microscope and high frequency ultrasound studies are recommended.

References:

1. Knight B. Forensic Pathology. 3rd. ed. London: Arnold, 2004: 326- 338.

2. Di Maio V, Dana S. Forensic Pathology. 1st. ed. Austin: Landes Bioscience, 1998: 199- 208.

3. حسن ضياء نوري. الطب القضائي واداب المهنة الطبية. الموصل: مطابع دار الكتب للطباعة والنشر، 1980: 163- 172.

4. محمدعلي وصفي. الطب العدلي علما وتطبيقا (الجزء الاول). الطبعة الخامسة. بغداد: مطبعة الانتصار، 1980: 313- 325.

5. Rao NG. Textbook of Forensic Medicine and Toxicology. New Delhi: Jaypee Brother, 2000: 255-256.

6. جنيد عدنان. الطب الشرعي. حلب. مديرية الكتب والمطبوعات الجامعية، 2007: 218

7. Abdul-Jabar Abdullah Muthana. Postmortem medico-legal and Histopathological Study of Electrocution in Baghdad. A Thesis Submitted to the Scientific Council of Pathology as Partial Fulfillment of Requirement for the Degree of Fellowship of the Iraqi Board of Medical Specialization in Forensic Pathology. 2006: 54.

8. Thomsen HK. Early Epidermal Changes in Heat and Electrically Injured Pig Skin. I: A Light Microscopic Study. Forensic Science International 1981; 17: 133-144.

9. الغريري طريف سرحان. دراسة حالات الطب العدلي المشرحة في لندن وبغداد للفترة 1977- 1981. المجلة الطبية العراقية (القسم العربي) 1988؛ المجلد السابع والثلاثون (الجزء الثاني) 23- 30.

10. الخطيب نبيل غازي. دراسة طبية عدلية لحالات الصعق الكهربائي المميتة في بغداد. المجلة العراقية لطب المجتمع 2004؛ المجلد السابع عشر(1) 5- 10.

11. Wright RK. Electrical Injuries. E-Medical Journal Nov. 2004; 1-15.

12. Martinez JA, Nguyen T. Electrical Injuries. Journal of Southern Medicine December 2000; 93 (12) 1165- 1168.

13. الجلبي عبد الوهاب. الصعق الكهربائي. مجلة طب الموصل 1972؛ المجلد الثالث: العدد الثالث والرابع.

14. Bjornstig, Johanna, Hedlung. Karin and Bjornstig, UIF, Injuries caused by domestic Electrical Equipment, Based on Swedish data from EHLASS, 1998, Report.