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).

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 histopathological 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. Microvesicular 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, histopathological 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.

Sometimes we see what is known as Mineralization due to heat effect of the current which dissolve 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 be seen also in the subconjunctival region in addition to the fluidity of the blood. (2)

In relation to the histopathological appearance of the electrical injuries we can see vacuoles or multiple small cystic spaces in the epidermis giving it a Swiss cheese appearance and sometimes those vacuoles 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

*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.
blood vessels are engorged and filled with
hemolysed blood. (1, 2, 3, 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>
<thead>
<tr>
<th>Age Groups (years)</th>
<th>Sex</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>&lt;9</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>9 - 19</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>20 - 29</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>30 - 39</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>40 - 49</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>50 - 59</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>20</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Entry Color&amp;Shapea</th>
<th>No</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>22</td>
<td>34.4</td>
</tr>
<tr>
<td>II</td>
<td>30</td>
<td>46.9</td>
</tr>
<tr>
<td>III</td>
<td>6</td>
<td>9.4</td>
</tr>
<tr>
<td>IV</td>
<td>6</td>
<td>9.4</td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
<td>100.0</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Histopathological Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NIL</td>
</tr>
<tr>
<td>Skin</td>
<td>1 (1.6%) Coagulative Necrosis</td>
</tr>
<tr>
<td>No. (%)</td>
<td>4 (6.3%) Microvesicular Vaculations</td>
</tr>
<tr>
<td>Brain</td>
<td>50 (78.1%) Congestion</td>
</tr>
<tr>
<td>No. (%)</td>
<td>9 (14.1%) Edema</td>
</tr>
<tr>
<td>Heart</td>
<td>59 (92.2%) Congestion</td>
</tr>
<tr>
<td>No. (%)</td>
<td>5 (7.8%) Pulmonary Edema</td>
</tr>
<tr>
<td>Lungs</td>
<td>1 (1.6%) Congestion</td>
</tr>
<tr>
<td>No. (%)</td>
<td>8 (12.5%) Reactive Gli</td>
</tr>
<tr>
<td>Liver</td>
<td>63 (98.4%) Congestion</td>
</tr>
<tr>
<td>Kidneys</td>
<td>1 (1.6%) Concentration</td>
</tr>
<tr>
<td>No. (%)</td>
<td>4 (6.3%)</td>
</tr>
</tbody>
</table>

*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)
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. 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 2005 was 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. 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 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 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.

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. 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.

In the current study we found that 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.

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.

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