

A STUDY OF LIGHTNING DEATHS IN SINGAPORE

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SYNOPSIS

Singapore has a high thunderstorm frequency and hence a high lightning death rate of 1.7 per million population. A study of 80 deaths in a 24-year period from 1956 to 1979 is conducted. The circumstances leading to death, the mode of death and post-mortem appearances are described. Some advice on how to avoid being struck by lightning are offered.

INTRODUCTION

Singapore experiences an average of 181 thunder/days and 229 lightning days per annum. These occur in two peak periods in April and November when there are about 20 thunderstorm days per month as opposed to January and July when there are 5 and 15 thunderstorm days per month respectively.

With this high thunderstorm frequency the chances of being hit by lightning are high. We decided to make a study of deaths due to lightning so as to offer some advice on the preventive measures to be taken on thunderstorm days.

MATERIALS AND METHODS

Sources of information are from (1) Meteorological Services Singapore, (2) Coroner's Court, (3) Report on Registration of Births and Deaths, (4) Department of Pathology, Ministry of Health and (5) Daily English and Chinese newspapers. Individual deaths due to lightning could be traced back as far as 1922, but details of cases are only available from 1956 onwards. Even then not all the relevant data are available for analysis in all the cases. Dividing into three time-periods 1922-1941, 1942-1960 and 1961-1979, the mean number of lightning deaths per million population is calculated at 2.6, 1.8 and 1.7 respectively. These calculations show that although there is a declining death rate probably due to better housing and public education, it has remained constant at 1.7 deaths/million. However when compared to available data from other countries, Singapore has the highest death rate from lightning (Table 1). This may be attributable to the year round high thunderstorm frequency. Comparative data from other tropical and sub-tropical countries are unavailable.

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**TABLE I
COMPARISON OF LIGHTNING DEATHS PER
MILLION POPULATION IN SOME COUNTRIES**

Country	Period	Death rate/million
United Kingdom	1951-60	0.2
Australia	1950-60	0.4
U.S.A.	1959-65	0.6
West Germany	1952-60	0.8
Austria	1964-68	1.3
South Africa	1963-69	1.5
Singapore	1961-79	1.7

PRESENT STUDY

For more detailed analysis, the period 1956 to 1979 is chosen. In this 24 year period there are 80 deaths due to lightning stroke which gives an average of 3.3 deaths per year. The male to female ratio is 66:14 or 4.7:1. Similar high male/female ratios are recorded in Australia (4.5) and USA (death 3.0 and injury 5.7) (1, 2). This may be due to the fact that more males are involved in outdoor work and activities.

The age distribution is shown in Table II. The highest number of deaths occurred in the 10-19 and 20-29 years age groups which together comprised 57.5% of all deaths due to lightning stroke, whereas the composition of these age groups in the population is only 38%. Young people are more prone to be hit by lightning as they are engaged in outdoor activities in sports, recreation and work. Many of them are ignorant of the dangers and do not take the necessary precautions. Comparative figures from other countries also show the same trend. In the USA 22% of those killed by lightning are under 18, and in Australia 23% are between 10-19 and 30% between 20-29 years.

Of greater concern is the change in pattern of recreation/work ratio in recent years. Previously most of the victims were workers who had to work outdoors

in stormy days and usually ended in single deaths. But now as more and more young people are going in groups in outdoor recreational activities, there is a greater chance of being hit by lightning in groups resulting in multiple deaths and injuries. The recreation /work ratio for the period 1965 to 1972 is 0.44 whereas in the period 1972 to 1979 it has increased to 0.79. Similar trends have also been observed in Australia and USA.

There is close relationship of the number of deaths by lightning to the number of thunderstorm days in the month. Figure 1 shows the distribution of deaths by lightning from 1956-1979. The two peak periods in April and November correspond with the highest number of thunderstorm days in these two months. Most of the thunderstorms occur in the afternoon (Fig. 2) and hence the highest number of deaths in this period (Fig. 3). About 65% of deaths occurred between 1330 and 1630 hours but none was recorded after 1830 hours and before 0500 hours.

As to the locations where death occurred it is noted that no deaths occurred in substantially well protected buildings. They only happened in partially sheltered and open areas. The partially sheltered areas were either (a) wooden huts and sheds, typically with a galvanised tin roof or in earlier days an attap roof; bus-stop shelters or (b) trees. Open areas included (a) small, open or partially covered boats, (b) golf courses, (c) football fields, (d) animal feeding areas, (e) other places including hilltops and slopes (Table III).

One-third of the deaths occurred in the open while two-thirds occurred in partially sheltered areas. The low unprotected shelters such as huts and sheds gave false sense of security for protection and claimed the highest number of deaths. Likewise, seeking shelter under a tree is not safe, especially if it is an isolated tree or the tallest tree in the area. When the tree is struck, initially the lightning current is discharged through the trunk. If a person is standing near the trunk, a side flash can occur killing the person. Similarly reports from other countries indicated that 10% to 20% of the injured or dead were seeking shelter

**TABLE II
AGE DISTRIBUTION OF LIGHTNING DEATHS
1956 - 1979**

Age Group in years	Number of Deaths	Percentage of Total Deaths	Percentage of age group on total population for 1967
0 - 9	7	8.75	29.5
10 - 19	25	31.25	24.5
20 - 29	21	26.25	13.9
30 - 39	12	15.0	11.8
40 - 49	13	16.25	8.6
50 - 59	1	1.25	6.7
60 - 69	1	1.25	3.6
Total	80	100.0	

under a tree (3).

In the open, those most frequently affected were in the sea, on the beach or in a boat. Other open spaces like golf courses, football fields and picnic grounds also had claimed victims and lives.

Types of Lightning Stroke

Lightning flash starts in the negatively charged lower region of a cloud and proceeds in a stepwise fashion towards the ground as a 'leader stroke'. When contact is made with the ground or with some upward streamer coming from a vertical conductor or objects such as a man standing in open field, a 'return stroke' of positive current begins to flow upwards. This current may have a peak of thousands of amperes but is of short duration in terms of microseconds.

According to Golde & Lee (3) lightning may strike a person in one of four ways:

(1) Direct stroke

As described above, the leader stroke coming to ground meet with an upward streamer from an object such as a man standing on open field. The entry point is usually on the head or upper part of body. If the person carries a metal object which projects above his head, lightning is likely to strike the upper end of the metal. The lightning current is then discharged through the hand

holding the conductor then through the trunk and feet. This applies to people holding umbrella, golf clubs and forks. Quoting the experiments of Berger (as quoted by Golde & Lee, (3)), they said that when the lightning current injected into the body reaches 1000A, the voltage drop between head and feet becomes 1000KV. Flash over then occurs outside the body or between the body and clothing. In the former case, hair and beard are often singed and clothings burnt or even set on fire. In the latter case, the current flowing over the body may be great enough to turn skin moisture or sweat into steam and the pressure will cause the clothing to be torn or ripped.

The same goes with shoes and boots. An illustrative case is as follows: A young couple was having a rendezvous on an isolated stone bench on a hill-top. They were reading "Romeo and Juliet" when a storm struck. Undaunted, they continued their reading under the cover of an umbrella. Multiple lightning flash followed, and their transistor radio was destroyed, a can of drinks was split open and the umbrella was torn to shreds. The girl was struck dead with face burnt, hair singed and clothing torn. The boy was stunned, his clothings and shoes were torn and he had burns on his face, side and legs. But he managed to struggle down-

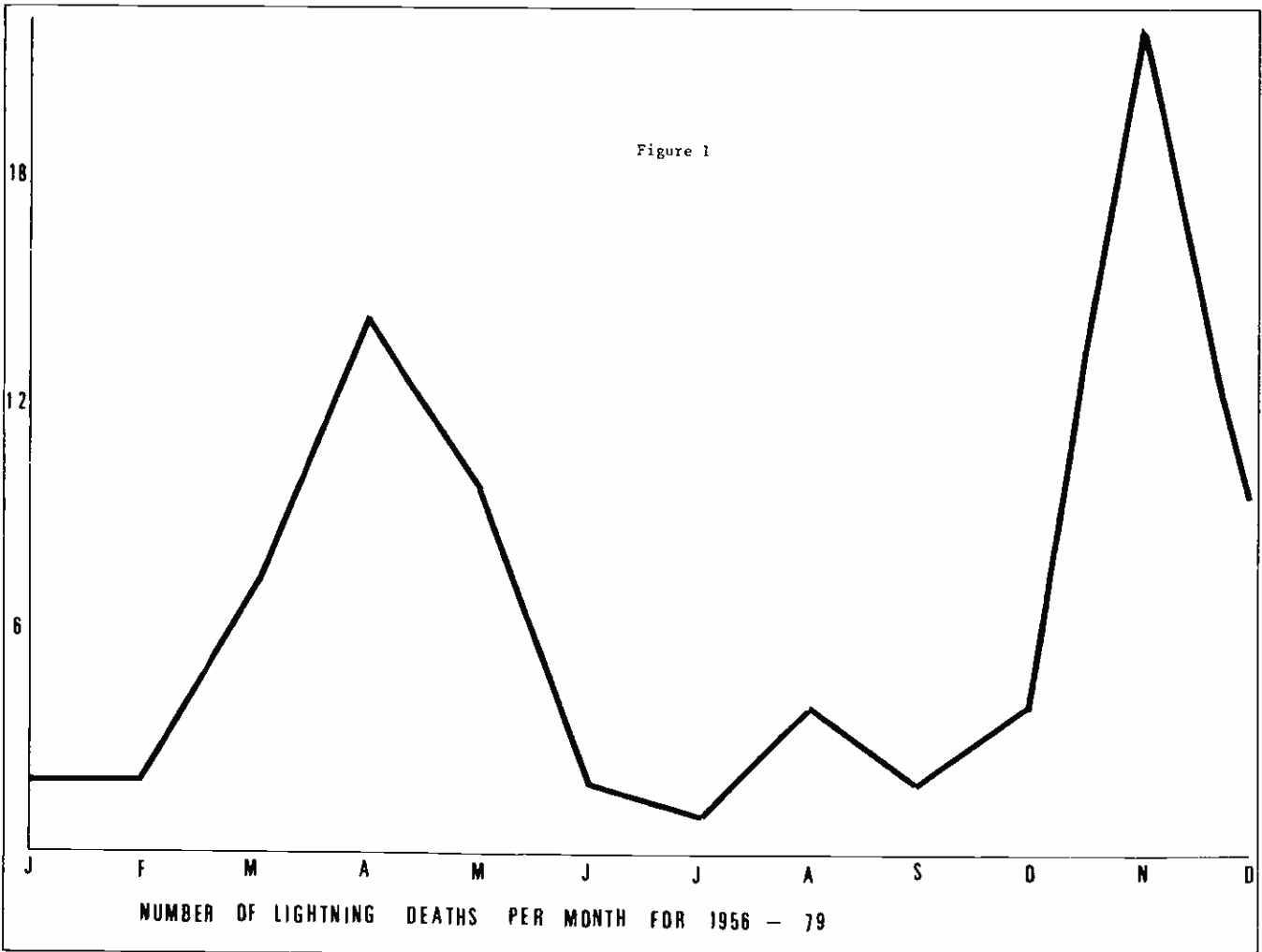


Figure 1

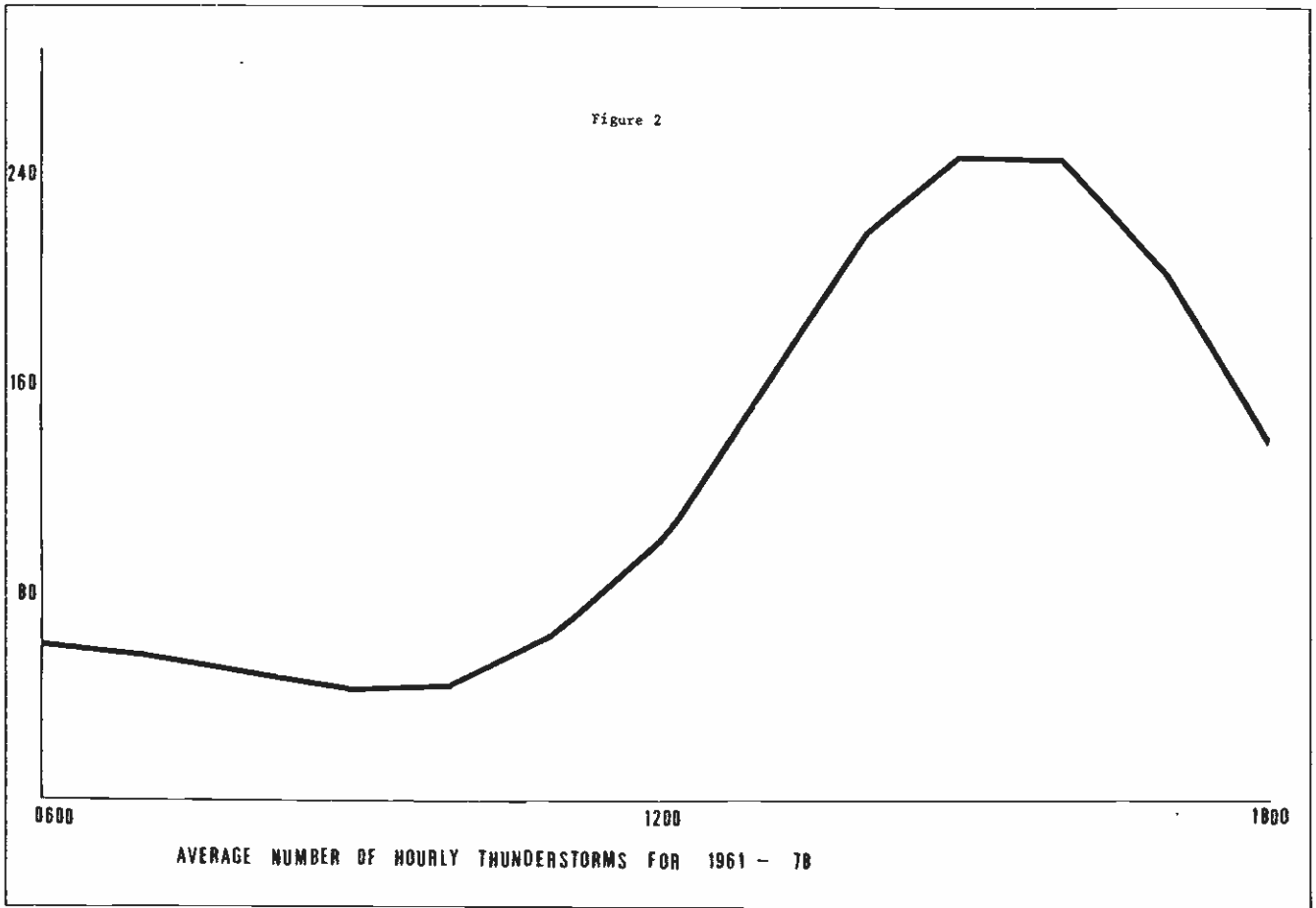


Figure 2

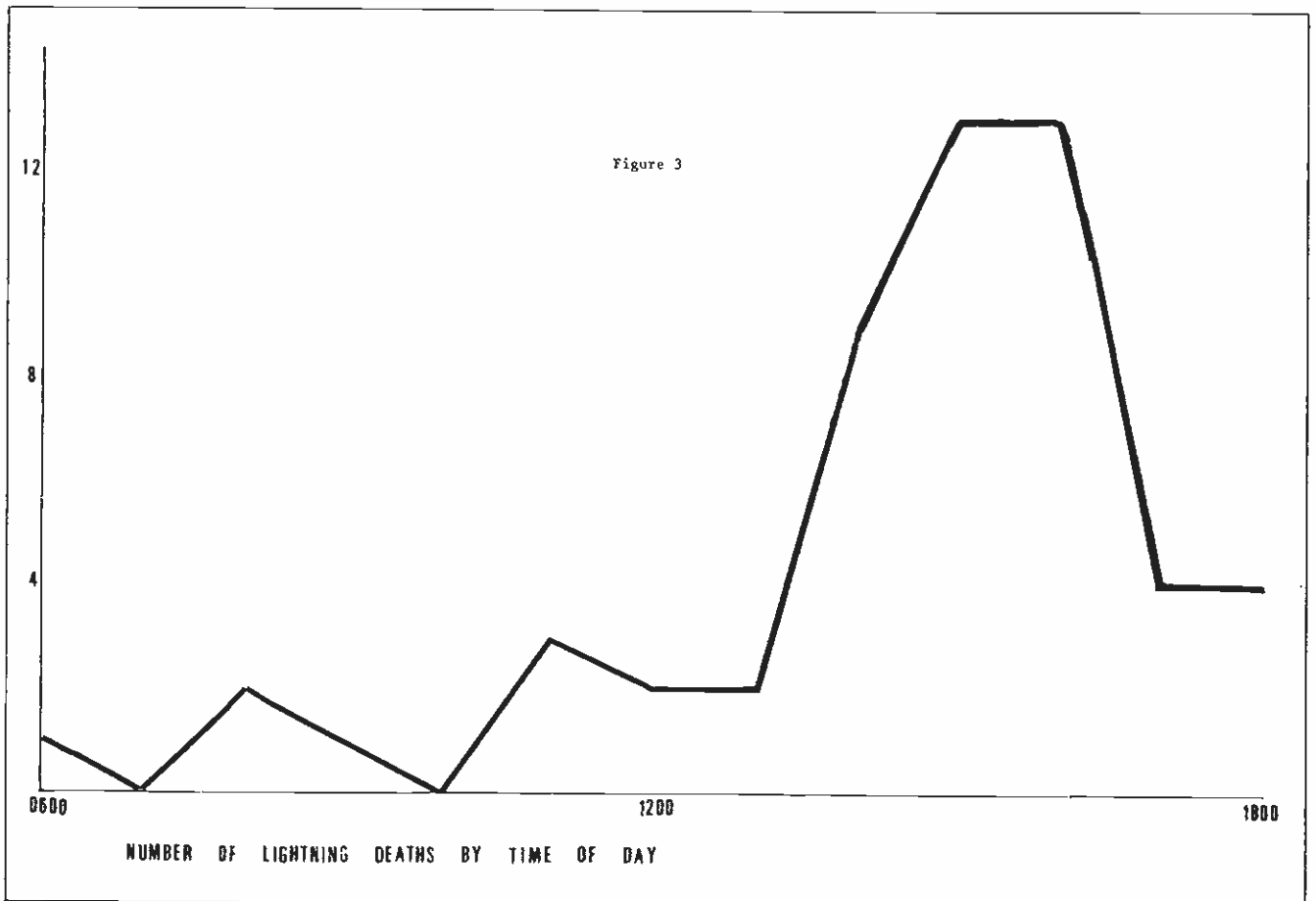


Figure 3

hill and sought help. He recovered but with retrograde amnesia of the event.

(2) Side Flash

When a tree is struck by lightning the current initially flows down the trunk and this may be followed by external flash over as the current increases. A person standing near the tree trunk can be affected by this side flash. Side flashes can also occur if a person is standing near metal support, pipes, frames etc which are struck by lightning. This occurs even if the person is inside a protected building. Two cases will illustrate this point. In the first case, a technician was using his telephone during a stormy night. He suddenly felt a jolt and was thrown to the ground. Fortunately he was stunned but unhurt. The second case involved a group of children having a picnic when a storm struck. They rushed to their belongings under a tree when it was struck by lightning. Two died and five children were injured.

(3) Step Voltage

When a lightning flash struck the ground directly the current is discharged to the earth in a regular pattern if the soil is of uniform composition. If the soil is irregular, the current distribution can be extremely irregular. A person or animal standing near the ground where it is struck is subjected to a potential difference between the legs. Current passes through the legs but not the heart or brain therefore death by this mean is rare. In quadrupeds the current flows between hind and forelegs, and therefore through the heart, resulting in death.

(4) Contact Voltage

This happens if a person is in contact with the object struck by lightning. An illustrative case involves a soldier who was inside a storehouse when a thunderstorm broke. Out of curiosity he climbed up a pile of boxes to look through a high

window with metal grille frame. Lightning struck and he fell to the ground. Resuscitation was to no avail. The mark of the grille was scorched on his forehead.

Postmortem Findings

Not all the cases in this series were subjected to post-mortem examination. Only 39 postmortem reports were available for more detailed study. In many of the cases examined the clothings were burnt, charred and torn to various degrees due to flashover effect as explained earlier. This is an important fact to remember otherwise the victim may be mistaken as a subject of assault (Fig. 4). Especially in the case of a female, it may be mistaken as a case of rape and murder. There were burns on the bodies ranging from erythema to full thickness burns of various sizes either in patches (Fig. 5) or in punctate form (Fig. 6) (4). The site of the burns often indicated the site of entry. In some cases, there was accompanying singeing of hair on head, chest, pubis and thigh (Table IV). It can be seen from the table that in 84% of the cases the lightning passed through the head and chest i.e. brain and heart thereby resulting in death. In the 3 cases with burnt marks on abdomen there were marks left by melting buckles and zips in contact with skin. In one case the seams of her nylon panties left a linear burnt mark on her hips. If the metal ornament had sufficient bulk and strength, it might direct a substantial amount of lightning current away. A necklace even if completely melted away by lightning current can save a person's life as the girl in Fig. 7. The mark of her necklace was scorched on her skin but her life was saved.

Another characteristic of lightning injury is the fern-like or spidery pattern of erythema on skin variously called arborescence, keraunographic markings, Lichtenberg's flowers or figures (Fig. 8). This occurred in 70% of the cases in this series. It is said to be invariable evidence of lightning stroke and would disappear in the living in 24 hours but present

TABLE III
LOCATION OF LIGHTNING DEATHS

Location		No. of Death	Percentage
Partially Sheltered	Hut, shed	13	24.0
	Tree	5	9.0
	Boat	7	13.0
	Sea or Beach	8	15.0
	Rooftop	3	5.5
Open	Golf course	1	2.0
	Football field	3	5.5
	Feeding animals	2	4.0
	Others	12	22.0
Total		54	100



Figure 4 Torn clothings on a lightning victim.



Figure 5 Lightning burns on head.



Figure 6 Punctate form of lightning burns.

TABLE IV

Site of Burns	No. of Cases	Percentage
Head, face, neck	29	74
Chest	4	10
Abdomen	3	8
No external injuries	3	8
Total	39	100

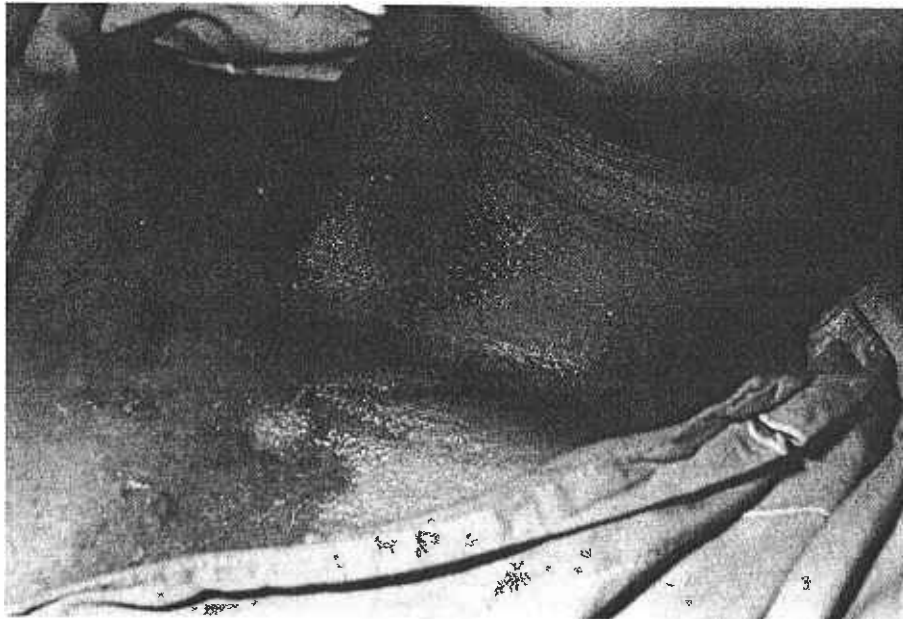


Figure 7 Mark of necklace scorched on skin.



Figure 8 Arborescence or Lichtenberg's figures on skin.

for a little while longer in the dead. It was thought to be due to the effect of breakdown of red cells within capillaries and subsequent escape of haemoglobin in the loose perivascular tissue (5).

Resuscitative Measures

Death by lightning may be due to (1) Ventricular fibrillation, (2) Respiratory arrest, (3) Asphyxia. Most of the cases died from ventricular fibrillation which is particularly true in cases where there are no external injuries or very little tissue damage. These cases could be revived if resuscitative measures are started early and sustained. There are many cases on record which are brought back from death and survived without residual damage though vital functions had been absent for some time after lightning injury (6, 7). Taussig (8) had particularly advised that "if you are with persons who have been struck by lightning, remember that those who are stunned but alive are not the ones who most urgently need help. Such persons will probably soon recover. It is the man who is "dead" with no heart action and no respiratory movements who needs cardiopulmonary resuscitation".

Precautionary Measures

Since thunderstorms are frequent occurrences in Singapore it is necessary to take precautionary measures to avoid being struck by lightning.

The following steps are to be taken in an approaching storm.

- 1) Seek shelter in a well-grounded building or within a metal bodied vehicle like a saloon car. If one is forced to seek shelter in an unprotected shed or building, keep away from metal objects, metal

pipes, electrical wiring, wooden beams or walls that are wet.

- 2) Do not stay out in the open such as beaches, rooftops, hilltops, golf courses or open fields. Get out of the sea or pool. Do not carry tall metal objects such as umbrellas with metal frame, golf clubs or forks. If caught on the open ground with nowhere for shelter, crouch down in the lowest point or depression with feet together. It is better to get wet then killed.
- 3) Avoid seeking shelter under tall isolated trees. Seek for a cluster of trees or dense woods. If there is no choice, keep away from the tree trunk and any overhanging branches and stand at the edge of the foliage.
- 4) Avoid standing near or touching tall metal structures, wire fences or pipes.

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