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Lightning strike induced injuries and its treatment

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ABSTRACT

Background and Objectives: Lightning is one of the most powerful and spectacular natural phenomena. Consequential lighting strikes (CLS) is lightning events causing physical injury, unconsciousness or death to humans. While the chance of being struck by lightning is statistically very low, that risk becomes much greater in those who frequently work or play outdoors. The risk of being struck by lightning is dependent on regional, seasonal and temporal factors.**Materials &Methods:**It is a descriptive cross sectional retrospective study was done in lightning injury cases presented in Emergency ward of BPKIHS. The data were taken from medical record section of age >16 years with history of lightning strike injury over the period of five (5) years from 2016-01-01 to 2020-12-30. Using below mentioned equation, the sample size was calculated as 177. But 187 samples were taken and analyzed.

Sample size (n) = $\frac{z^2pq}{d^2}$

Results:168(89.8%) male and 19 (10.2%) female were injured. Commonly involved age groups were 20-29 years and 60 to 69 years. Most of the lightning strike cases were from April to August. There were 13 mortalitiesout of total 187 victims who had severe burn and other complications like acute kidney injury, cardiac arrhythmia, rhabdomyolysis.**Conclusion:** Lightning strike injury is one of the major problems in eastern Nepal and the lightning strike rate is quite common compared to other parts of the world. Lightning strike occurs more commonly to the adult male working outdoors. Complications related to lightning strike is 20.3%. Management of lightning strike victim is mainly supportive and involves management of the organ-system affected by the strike.

Key words: Lightning strike, Side flash, Direct strike, Lichtenberg figures

I. INTRODUCTION :

Lightning is one of the most powerful and spectacular natural phenomena. [2,3] Consequential lighting strikes (CLS) is lightning events causing physical injury, unconsciousness or death to humans. [4]While the chance of being struck by lightning is statistically very low, that risk becomes much greater in those who frequently work or play outdoors. [5-7] The risk of being struck by lightning is dependent on regional, seasonal and temporal factors.[8-11]

Though almost all parts of the body are vulnerable to be struck by lightning, most serious lightning injuries occur when there is damage to either the cardiovascular or neurologic systems. The nervous system is particularly susceptible to damage from lightning strikes. [12,13]The majority of cutaneous injuries seen in victims struck by lightning are superficial and heal without sequelae. Common cutaneous findings associated with lightning strike include punctate full-thickness burns, linear charring, and contact burns from overlying metal objects. Branching or ferning marks are an uncommon and unusual cutaneous manifestation. These ferning patterns are called Lichtenberg figures. [14]

Lightning is the transfer of electrical charges between clouds or between the ground and clouds and occurs when a difference in potential of 30,000 V or higher exceeds the inherent resistance of the air. [7]A typical lightning burst carries an enormous charge between 10,000 and 200,000 A and a current of between 20 million and 1 billion volts, with a temperature estimated to be near $8,000^0$C. While the voltage and temperature of a lightning burst are massive, they dissipate once contact is made with the ground. This rapid dissipation is the reason that the majority of lightning strikes do not result in injuries typically

encountered with a long-exposure electrical injury. [15,16]

Lightning strikes are not uniformly distributed around the Earth. Regions with frequent thunder- storms have more lightning strikes. Thunderstorms are formed by 3 atmospheric elements: moisture, warm air on the surface of the earth, and a lifting wind. As the warm, moisture-laden air is pushed upward by vertical updraft, it condenses and cools, forming cumulonimbus clouds. Water freezes into ice particles near the top of this cloud. It is believed that the movement of these ice particles forms an electrical gradient (or differential), which is eventually discharged as lightning. [3]

World- wide, rural populations have been at greatest risk. Demographically this risk has been attributed to higher occupational exposure (rural farmers). These populations typically do not have access to substantial buildings that could provide shelter [6]. Even though the general risk of being struck by lightning is low, it is increased in an outdoor mountain or wilder- ness environment. Worldwide, more than 100 lightning strikes occur each second. [1] Men are generally at greater risk of suffering lightning strikes than women. [7,12-14]

Injury Type:

Six mechanisms have been described for lightning to conduct through and injure the body.

1. Direct strike: Occurs when the victim is in the open, away from protection, and directly injured by a cloud-to- ground burst. [15,17]
2. Contact: Often associated with indoor strikes or when a victim is within a locationconsidered safe (i.e., when talking on a corded telephone, showering, or doing dishes while indoors). Occurs when an electrical surge passes through wiring, scaffolding, or plumbing and transmits to the victim by direct contact with that object. [15]
3. Sideflash (also known as ‘‘splash’’): Occurs for up to 30% of injuries. Where victim seeks shelter beneath a tree or within a shelter that has not been grounded. May affect several members of a group if they are clustered together. [15,17]
4. Step voltage (ground potential): The conductive nature of the earth acts to transport a current from a potentially distant strike to the victim. The voltage difference is increased with a greater separation of contacts. For example, a hiker lying down on the ground will have a greater potential for injury than one who is crouching down with their feet only a few inches apart.
5. Upward streamer: This injury occurs when the victim acts as a conduit for the positively charged upward streamer from the ground and helps transmit the charge toward the negatively charged stepped leaders coming from the clouds. [18]
6. Barotrauma: This most-recently described mechanism of injury is associated with the sonic blast and pressure differential that accompanies a lightning strike. This mechanism may account for traumatic brain injury and ruptured tympanic membrane. [19, 20]

RATIONALE:

There is quite significant number of lightening injury cases coming to emergency ward ofBPKIHS. Some present with simple superficial burns some with deep burns with complications but we don’t have proper data at estimate what is the total number of cases, what is the proportion of cases with complications, what proportion of cases need admission.

Knowing these data, we can estimate the magnitude of problem, which group of patients have complications, we can give attention to that group during the management process, we can be prepared beforehand to manage such cases. Some community awareness programme can be launched.

OBJECTIVES:

1. **General Objectives:** Assess clinical presentation, complications and treatment of lightning injury patients.
2. **Specific Objectives:** Determine types of injury and complications related to lightning strike injuries.

II. REVIEW OF LITERATURE:

Ströhle et al in Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine (2018); They have taken data from “The Austrian Alpine Police database” containing 109.168 patients for the years 2005–2015, was screened for lightning accidents. Sixty-four patients had been hit by lightning in the Austrian Alps, 54 were male. Four persons died on scene; survival rate was 93.8%. Two deceased persons were hunters, who were killed by the same lightning strike. Sixty-three patients suffered a lightning strike while doing a recreational activity, mostly hiking (n = 55), a few hunting and only one doing occupational timberwork. Sixty-three patients suffered a lightning strike between June and August with nearly half (46.9%) of the accidents happening on a Saturday or Sunday, and mainly (95.3%) between 12:00 and 22:00 h. [1]

Carmen A. Pfortmueller et al in Hindawi Publishing Corporation Emergency Medicine International Volume 2012; All data were collected

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prospectively and retrospectively analysed. The database was searched for patients aged ≥16 years admitted between 1 January 2000 and 31 December 2010. During the study period, 9 patients presented to emergency room because of lightning-related injury with a median age of 41 years. Four were women, and five were men. The most common site of injury was the nervous system (6 out of 9 patients) followed by the cardiovascular system (5 out of 9 patients). The most common neurological symptom was paraesthesia which occurred in 4 cases. Two of these patients also hadparalysis that resolved spontaneously. Further neurological symptoms were one case of vertigo, one of headache, and one of unreactive pupils. Most of the cardiac symptoms were arrhythmias (4 out of 5 patients). Three patients suffered skin injuries. Two patients sustained minor skin damage, and the third suffered second- and third-degree burns around the entry and exit wounds on his left chest and right-lower leg (9% body surface area) and also had first-degree burns on the whole right-lower leg. One case of deafness following lightning-associated acoustic shock was found. [2]

Monique Borgerhoff Mulder et al in PLoS ONE January 2012, Volume 7, Issue 1; they identified 225 lightning strike resulting in 454 victims (1–8 victims/ strike) between 1979 (the earliest remembered event) and 2010 in Nkhata Bay District, Northern Province, Malawi. Of 450 victims with known outcome, 61% resulted in unconsciousness, 8% unconsciousness with other injuries, 3% injury alone, and 26% in death (referring to immediate outcome not to differential care or medical treatment). Data on the long-term outcome of 317 survivors revealed that 85% made a full recovery, although permanent symptoms included hearing damage (8%), headaches (3%), other lasting pain (3%), and psychological damage (2%). Strikes occurred during day and night (before midnight) but mostly in the wet season. A rapid increase in lightning strikes since 2007 was probably due to changes in activity patterns that put people at greater exposure. [4]

III. MATERIALS AND METHODS:

It is a descriptive cross sectional retrospective study was done in lightning injury cases presented in Emergency ward of BPKIHS. The data were taken from medical record section of age >16 years with history of lightning strike injury over the period of five (5) years from 2016-01-01 to 2020-12-30. Patients with other associated injuries and case file with inadequate or incomplete data were excluded from the study.

Sample size calculation:

In the literature review complications was found as minimal prevalence than death and other clinical features therefore for sample size calculation, the study considers complication rate among lightning injury patient which is one of the general objective of this study.

The study considers 95% confidence interval and 80% power to estimate the sample size, in this regards it was found that complications related to lightning injury (severe lightening injury) was found in 10.9%. [1]

Now using the following formula,

Now using the following formula,

$$\text{Sample size (n)} = \frac{z^2pq}{d^2}$$

where z=1.96 at 95% confidence interval

p=10.9% i.e., about 11%

then q= 80%

d= 20% of p at 80% power

i.e. 20% of 11 = 2.2

putting the values in the equation, sample size (n) = $\frac{1.96^2 \times 11 \times 80}{2.2^2}$ = 698.5

Now adding 10% at calculated sample size to reduce various biases, the sample size now will be 698.5+698 x 10%= **768.34**

Now using finite sample size formula (sample size) (N) =

Calculated Sample Size/(1+ Calculated Sample Size/Estimated Population)

According to medical record the lightning injury of last year (2019-01-01 to 2020-01-01) was 37 then, N =

[768.34/ (1+768.34/37)] = 768.34/ (1+20.76) = 35.3 x 5 years = 176.5 **= 177**

Thus, required sample size is: 177

But all cases of light injuries attended in ER will be included during the

study period.

Criteria for Sample Selection:

All patients >16 years of age with history of lightning strike injuryadmitted to BPKIHS over the period 2016-01-01 to 2020-12-30.

Data Collection Technique / Methods:Case sheet analysis with close ended or open ended proforma.

Data Collection Tool: Proforma Questionnaire

Data were searched and collected from case files in medical record section of BPKIHS with ICD 10 code for lightning injury: T75.0, T75.00, T75.01, T75.09 and ICD 10 code for burn injury: T21.0 to T21.3, T22.0 to T22.3, T23.0 to T23.3, T24.0 to T24.3, T25.0 to T25.3, T26.0 to T26.4, T29.0 to T29.3, T30.0 to T30.3, T31.0 to T31.9

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Statistical Analysis:

Collected data was entered in Microsoft excel 2010 and converted it into SPSS 11.5 for statistical analysis. Descriptive statistical data like percentage, frequency, mean, SD, were calculated along with graphical and tabular presentation. For inferential statistics, Chi square test, independent t-test or Mann Whitney u-test was applied between death, lab parameters and demographic variables.

Ethical consideration:

Ethical clearance was taken from "Institutional Review Committee (IRC)" of BPKIHS.

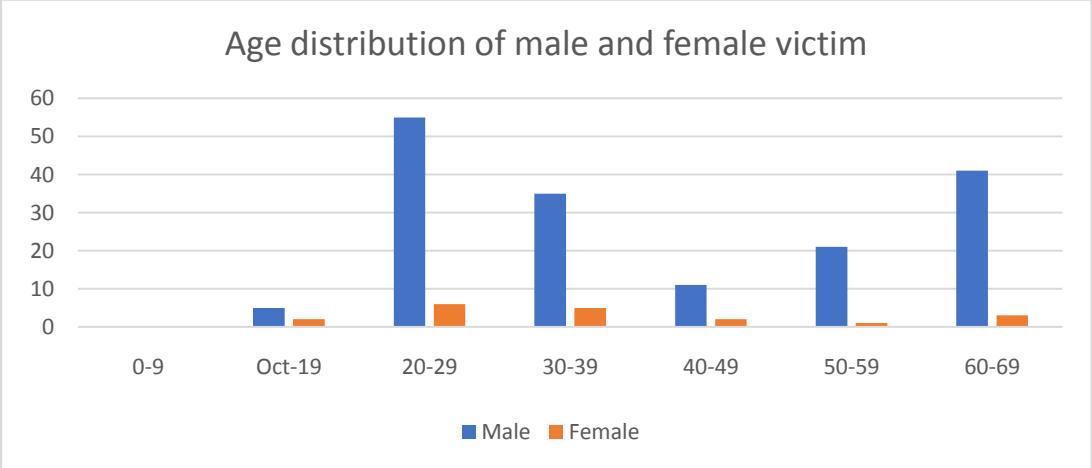
IV. RESULTS:

The total number of lightening injury cases registered in the medical record section of BPKIHS over the period of five years from 2016-01-01 to 2020-12-30 was 191. Among 191 registered cases, four cases had incomplete data. Therefore only **187** cases were taken into consideration for analysis. Dharan is situated in the eastern part of Nepal which is a plain land surrounded by mountains from three sides (east, north and south). May be due to this reason the incidence of lightning strike is much more in this part.

Demographics:

In this study it was found that male victim was much more than female victim this finding could be becausemen undertake more outdoor activities, and thus their lifetime risk for being struck by lightning is five times higher. In the United States, the calculated lifetime risk for both sexes are 1:12 given a life-expectancy of 80 years [1]. 168(89.8%) male and 19(10.2%) female were injured. Commonly involved age groups were 20-29 years and 60 to 69 years.

Table 1. Age distribution of male and female victim.



Month,Day and Time of lightning strikes:

Greatest risk of sustaining lightning injury is in summer and rainy season.Cherrington et al. reported that the highest frequency of lightning strikes in the Rocky Mountains occurs between 11:00 and 21:00 from April to September [10]. In Dharan most lightning strikes occur from March to September with a peak in July. Most of the cases were from April to August. Furthermore, the incidence of lightning strikes slightly increased on Second half of the week from Wednesday to Saturday, which is because outdoor activity is increased in weekends by the working population and decreased in early week days. About 80% of cases occurred from 10:00Am to 08:00 PM. This is because during this time most of the people are working outside. But there are also reported cases from 08:00 PM to 10:00 AM. Most of the cases (32 out of 36) that occurred during this time occurred while they are indoor in thatched house. Thatched house is not protected from lightning strike.

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Table 2. The months in which lightning strikes occurred (n = 187)

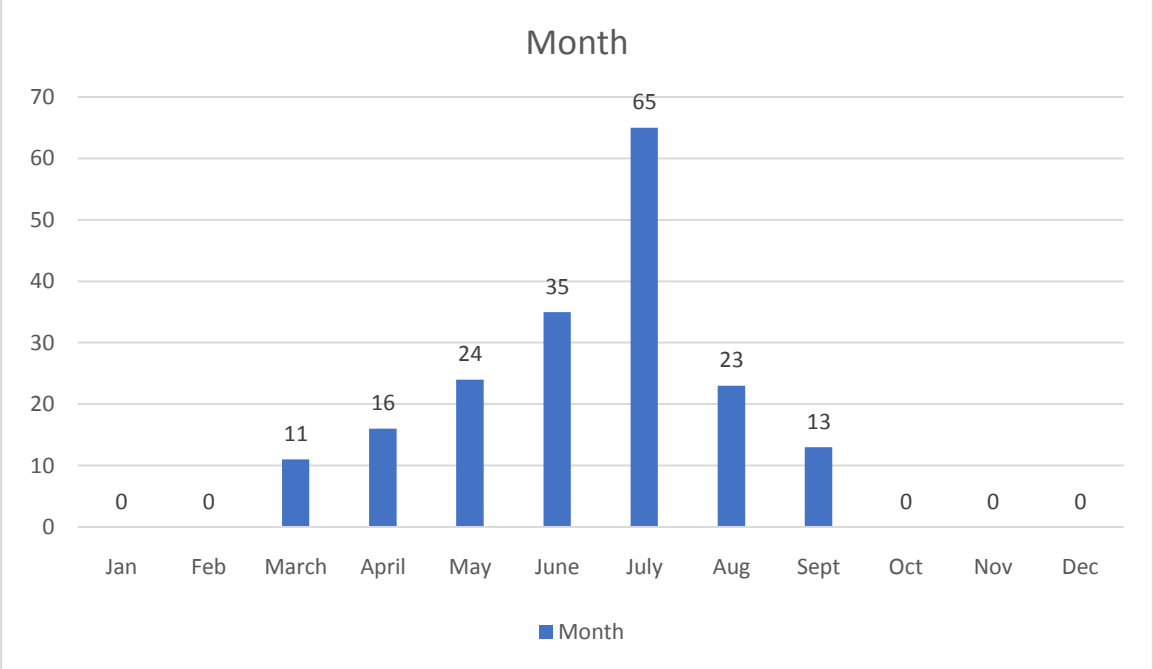

Table 3. The day of the week on which lightning strikes occurred (n = 187)

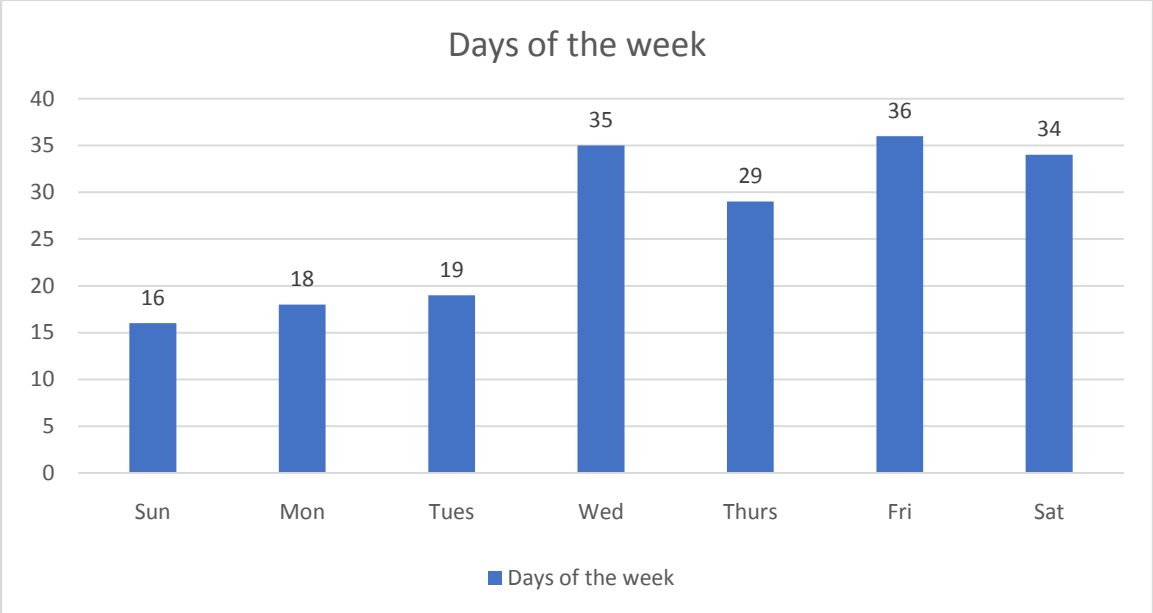

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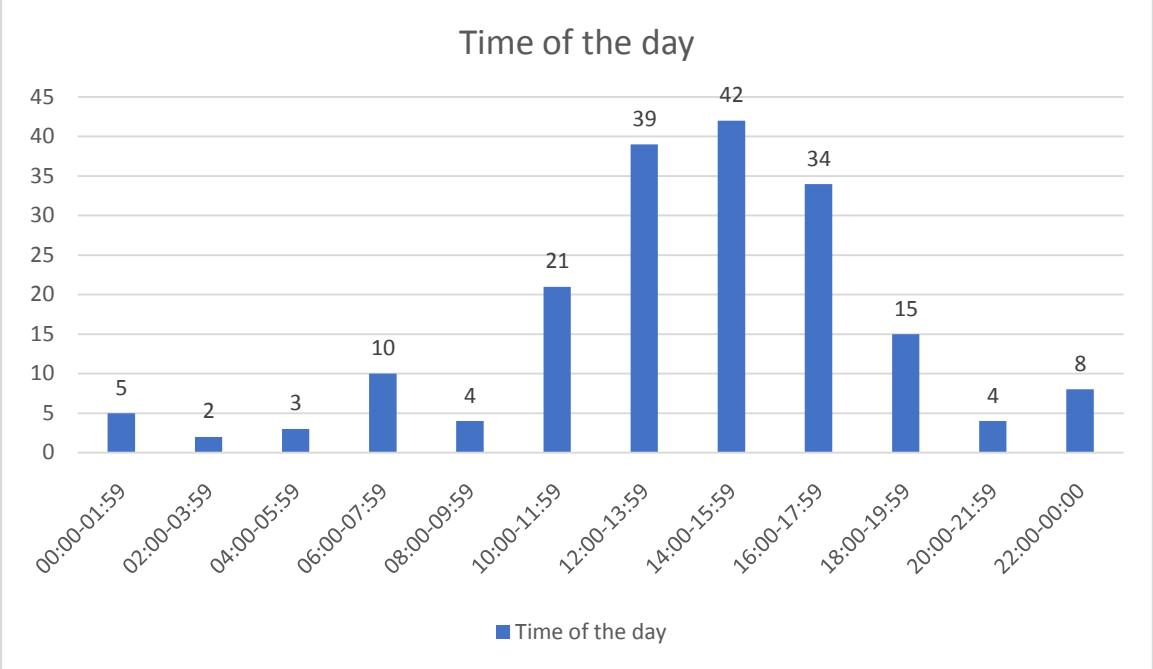
Table 4. The time of day at which lightning strikes occurred (n = 187)



From table 4, it can be seen that majority of lightning strike injuries (165 or 88.24%) occurred between 6:00AM to 8:00PM i.e., day time during working hours when victimswere outside their home. Only 22 injuries (11.76%) occurred at night time from 8:00PM to 6:00AM while victims were inside their home.

Types of injury, injury severity and survival:
People involved in outdoor activity are more prone to lightning strike injury.

Table 5: Types of lightning strike and ways they affect the human body.

Type	Mechanism	Number of victims
Direct strike	Most of the current flows through the body; highest mortality	13
Contact voltage	Occurs when lightning strikes an object such as a car or metal pole that the victim is touching	5
Side flash	Splashing of current from a nearby object or person onto the victim.	156
Ground current	Ground current passes from the strike point through the ground into the victim.	
Upward streamer	Passage of lightning from the victim upwards.	
Blast injury	Sudden expansive explosion of the air around the lightning channel causing blunt trauma.	13

The table explains the different possible ways a victim can be affected. **There were 13 mortalities**out of total 187 victims who had severe burn and other complications like acute kidney injury, cardiac arrhythmia, rhabdomyolysis. 5 (five) patients gave history of shock from contact with objects in the field like electric pole, metallic roof, agricultural equipment standing nearby. Studying the case sheet, it couldn't be ascertained the number of victims by side flash, ground current and upward streamer. Blast injury was found in 13 cases with involvement of GI system, Respiratory system and hearing system (mainly temporary hearing loss and two with rupture tympanic membrane.

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Table 6: Type of injury by lightning strike. Mild injuries included closed fractures, open wounds without hemodynamically relevant bleeding, arrhythmia or paraesthesia.

S.N.	Type of injury	Injury severity			
		Mildly injured	Severely injured	Dead	Unknown
1.	Acute stress reaction	7			
2.	Cardiovascular disorder	10	2	2	
3.	Traumatic brain injury	4	2		
4.	Acute kidney injury	5	3	1	
5.	Burn injury whole body	4	3	1	
6.	Burn injury shoulder	3	2		
7.	Burn injury upper arm	15	3		
8.	Burn injury forearm	12			
9.	Burn injury foot	17	2		
10.	Burn injury ankle joint with multiple injuries lower leg.		5		
11.	Injury not further specified, forearm	16			
12.	Blast injury	13			
13.	Fracture lower leg	2			
14.	Paraesthesia lower arm with vertigo	9			
15.	Unknown injury pattern				35
16.	Total	117	22	4	35
17.	Dead on arrival at EW	9			

There were different types of lightning strike injury presented in Emergency ward (EW). 117 (62.56%) had mild injury. 22(11.76%) had severe injury and 13(6.9%) patients died because of direct effect of lightning strike. Out of 13 dead patient9 (4.8%) patients died before reaching the hospital (was declared dead on arrival) and 4 (2.1%) patients died because of severe injury. Two (2) of them died because of severe cardiovascular complications. Cardiac enzymes were positive with associated ventricular arrhythmia. One (1) died because of burn involving large body surface area (about 75%). Patient died on 7th day of admission because of combined effect of acute kidney injury, metabolic acidosis and sepsis with septic shock. Another one died due to Acute kidney injury secondary to rhabdomyolysis and hyperkalaemia on 4th day of admission.In the case sheets of 35 (18.71%) patient, details of the injury couldn't be taken apart from lightning strike. This group of patients were discharged after successful treatment.

Treatment received by lightning strike injury patients:

The treatment system of this hospital (BPKIHS) in EW (Emergency ward) starts from triaging. Triage is the initial assessment and categorisation of patient into five categories ATS 1

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to ATS 5 depending upon patients' severity and urgency of treatment. BPKIHS is following Australasian Triage Scoring (ATS) system. ATS 1 being most severe and has to be seen at Zero minutes of arrival and ATS 5 being least severe to be seen within 120 minutes of arrival. So, same thing was also followed for lightning strike victim. Severely injured patients were categorised into ATS 1 and ATS 2 while other less severe into AST 3, 4 and five according to severity.

Table 7: ATS categorisation of lightning injury victims.

ATS category	ATS 1	ATS 2	ATS 3	ATS 4	ATS 5
No. of patients	18	27	35	68	39
No. of Death	10	3	0	0	0
Average duration of hospital stay	3.4 days	5.7 days	3.2 days	4.5 days	1.5 days

This table shows 18 cases of ATS 1 which was immediately life-threatening condition of which 9 were dead on arrival but all cases of dead-on arrival cases received advanced life support care but didn't revive another 9 cases presented in critically ill condition out of which one (1) died and 27 patients presented with AST 2 scoring which were in potentially life-threatening condition like severe pain, active bleeding, conscious with low blood pressure. Out of 27 patients in this category 3 died due to complications. No patient died from the categories ATS 3 or AST 4 or ATS 5.

There is no separate guideline for the treatment of lightning strike victims but the victims were treated with standard treatment guidelines for the particular condition victims presented with.

12 patients presented in shock (BP<90/60) these group of patients were resuscitated aggressively with i.v. fluids mainly 0.9% NaCl out of which 4 patients needed ionotropic support. 66 patients had recorded burn injury, these patients were resuscitated initially in the emergency department and 5 needed further management by surgery team.

Table 8. Admission and outcome of lightning injury patients.

Ward Admission	No. of patients	Discharged	Died	LAMA (left against medical advice)
EW	187	144 (77%)	10	2
Surgery	5	4 (2.13%)	1	0
Medicine	18	15 (8%)	1	2
Orthopaedics	2	2 (1%)	0	0
ICU	6	4 (1.6%)	1	1

From table 8 it can be seen that most of the patients(144) were discharged from EW (Emergency Ward) and there was 10 death and 2 left against medical advice (LAMA). 18 patients were admitted in Internal Medicine ward, out of which 15 were successfully discharged and 1 death and 1 LAMA. Similarly, there was 5 admissions in surgery ward, 4 discharged and 1 died of sepsis. 6 patients admitted in ICU of which 4 discharged 1 died and 1 left against advice.

Table 9. Complications related to lightning injury and its clinical course.

Complications	**No. of patient**	**Treatment received**	**Outcome**
AKI	9	Close monitoring and fluid resuscitation	8 improved and 1 death
Hypovolemic shock	12	Fluid resuscitation	All improved

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Severe burn	4	Debridement, dressing, antibiotics, fluids	3 improved 1 death
Cardiac arrhythmia	5	Antiarrhythmic drugs	3 improved 2 death
Fracture	2	Splinting and definitive management by orthopaedic team	All improved
Traumatic brain injury	6	Management of ICP and definitive by neurosurgery team	All improved

From table 9 its seen that the lightning injury patients had different kinds of complications. 9 patients had AKI (acute kidney injury), these patients were monitored closely by both emergency and internal medicine team and fluid management were done with 0.9% NaCl. One of them needed two cycles of haemodialysis for AKI and rhabdomyolysis but that patient died on 5th day of admission. 12 patients presented in hypovolemic shock with features of dehydration. All were managed with fluid resuscitation and improved, four of them needed ionotropic support. Four of them had severe burn from 5% of TBSA to 40% of TBSA. All burns were managed with antibiotics starting with ceftriaxone and later upgraded with cefuroxime, tetanus toxoid, dressing of the wound. Two patient needed wound debridement. All severe burn patients were admitted by general surgery team for definitive management. One of the burn patients died on 7th day of sepsis and septic shock. Out of total lightning injury patients 5 had cardiac arrhythmia. Three had atrial fibrillation (AF) and two had supraventricular tachycardia(SVT). Two SVT cases were reverted with inj. Adenosine one with 12mg and another with 6mg. Three AF cases were reverted with inj. Metoprolol 5mg i.v. along with other management cardiac arrhythmia patients were monitored for 48 hours then discharged. Two patients had fracture of leg. One had fracture of lt. fibula middle 3rd managed by non-operative measures and other with fracture of Rt. Leg both bone by operative method both by orthopaedic team. 6 had traumatic brain injury due to fall on ground. All patients were consulted with neurosurgery team. Two needed admission in neurosurgery ward, four discharged after emergency treatment of 24 hours observation. None of them needed neurosurgical intervention.

V. DISCUSSION:

Similar to other studies (Ströhle et al.), this study also has more male victims than female. As in most of the countries men do more outdoor activities than women and the chances of being struck by lightning is more in outdoor than indoor that is the reason men victims are more than women. In some countries male and female work outdoor more or less equally and the studies done in those countries shows almost equal victims of both male and female i.e. Carmen A. Pfortmueller et al.

In this study, the common age group involved by lightning strike is biphasic i.e. 20-29 years and 60-69 years while in other studies commonly involved age group were 20-29 years and 40-49 years (Ströhle et al.), this again can be associated with age group involved in outdoor activities. In our country pre-job age group and post-job age group are more involved in outdoor activities mainly in recreational activities than another group.

According to Ströhle et al. and Cherington et al. [1,10], the greatest risk for sustaining a lightning strike is given in summer, more specifically in the afternoon. At that time, the meteorologically strongest lightning activity co-incides with the largest number of people in mountain terrain. Being on a mountain in the afternoon entails great danger for mountaineers and climbers, since they may have been physically active for hours, may be tired and still far from safe shelter. Cherington et al. reported that the highest frequency of lightning strikes in the Rocky Mountains occurs between 11:00 and 21:00 from April to September. In this study we found the cases of lightning injury from March to September and the time from 10:00 AM to 8:00 PM.

According to a review by Lederer et al., injuries of the cardiovascular system are common in lightning strike victims [7]. It has been found that the entire myocardium is depolarized when lightning strikes and that the heart remains in forced, sustained contraction until termination of the current [7, 9]. This may cause cell necrosis, heart enzyme elevation, T-inversion, and QT prolongation similar to that reported after DC cardioversion or pacing [6]. Lightning strikes may also cause myocardial damage, pericardial effusion, conduction disturbances, and dysrhythmias [7, 8, 9]. Secondary damage to the myocardium may also occur due to catecholamine release or autonomic stimulation [7, 10]. In this study cardiac injury is

also common two cases of death due to cardiac arrest and other 12 cases with revivable form of cardiac injuries are seen.

Davis C et at, Transient neurologic symptoms with immediate onset accounts for the majority of neurologic manifestations of lightning injury. These include loss of consciousness, seizure, headache, paraesthesia or weakness, confusion, and memory loss. Transient paralysis after lightning strike has also been documented in numerous case reports and is postulated to result from an overstimulation of the autonomic nervous system leading to vascular spasm. Permanent neurologic symptoms with immediate onset can manifest after lightning strike, such as hypoxic encephalopathy resulting from cardiopulmonary arrest. Lightning induced intracranial haemorrhage may also occur instantly, most commonly affecting the basal ganglia or brainstem; this is believed to be attributable to preferential conduction of electricity through these areas of the brain. [3] In this study we found nine cases of upper limb paraesthesia with vertigo and six cases of traumatic brain injury. Though minor neurologic injuries are more common in traumatic brain injury but some form of neurologic damage in victims of lightning injuries are seen in most of the literatures.

According to Carmen A et al [2], Severe burns after lightning strikes are rare, observed in this case series. Third-degree burns do, however, occur— especially at entry and exit burns—and were present in one of these patients. One of these patients suffered from deafness, which is common in lighting strike victims. Two of the patients had myoglobinuria which is not unusual in lightning strikes victims. Two cases had severe skeletal muscular pain. This may be caused by sudden skeletal muscular contractions due to electrical shock. In our study, we also found severe burn in four patients out of which one died. There must be some form of deafness to the patients of our study but we couldn't find the data regarding the hearing loss in the available case sheet. Nine patients had acute kidney injury in our study and one of them died though it was not mentioned in the case sheet this AKI could be because of myoglobinuria and hypovolemic shock. So, we can see the pattern of injury is more or less same in our study and other studies.

Again, Carmen A et al [2] describes, lightning-related cardiac arrest occurs without any physical damage to the body in about 10% of cases. They suggest that magnetic field changes associated with lightning may induce a loop current within the human torso. If this loop occurs during the repolarization phase, asystole or ventricular fibrillation may occur. Generally, resuscitation should be attempted on all lightning victims who appear lifeless because extraordinary recoveries even after prolonged resuscitation have been reported. It is very important that wide unreactive pupils are not interpreted as a sign of a poor prognosis or brain death. Taking this into account in our study we also found that all patients who did not show signs of life at presentation, resuscitation attempts were done but unfortunately the treating doctor couldn't revive those patients without signs of life. This could be because of late presentation of the victim to the hospital.

The management of complications related to lightning injury is similar to those in other conditions. Cardiac complication like arrhythmias, renal complication like AKI, burn and brain injury were managed in similar way as in other conditions and the outcome of the patients were also good.

VI. CONCLUSION AND RECOMMENDATION:

Lightning strike injury is one of the major problems in eastern Nepal and the lightning strike rate is quite common compared to other parts of the world.Lightning strike occurs more commonly to the adult male working outdoors of the age group 20-29 years and 60-69 years. It used to occur more commonly at the day time during the weekends on rainy months.

The death rate is also high (about 7%) in lightning strike but in-hospital mortality is low (1.7%). Complications related to lightning strike is 38 (20.3%). Management of lightning strike victim is mainly supportive and involves management of the organ-system affected by the strike. Though complication related to lightning strike is high but mortality is low.

The "30-30'' rule is recommended for safety. This rule states that you should be wholly within a safe structure when the thunder is heard within 30 second of seeing lightning (6 miles away), and activity should not resume for 30 min after the last thunder is heard or the last lightning seen. The current slogan of the National Weather Service is ''When thunder roars, go indoors'' [21].

The risk of injury from lightning may be reduced significantly by seeking shelter when thunderstorms develop. Safe shelters include a well-grounded, substantial building or a metal topped, enclosed motor vehicle. Small structures (huts, sheds) are not safe as they are not usually electrically earthed. Nor is standing under a tree safe. If caught out in the open, adopting the 'lightning crouch' (crouch down, head tucked down, heels together, arms resting on your knees,

and hands covering your ears) has been advocated as a 'last resort' by the Wilderness Medical Society (WMS) which provides lightning safety guidelines. However, many believe this does not provide a significant level of protection from being injured or killed by a direct lightning strike. People on exposed hill or mountain slopes are advised that it is better to continue moving downhill to a safe shelter even though it may take some time to reach. Lightning is more likely to strike hill peaks so descending to a lower altitude reduces the risk of being struck. If in a group, spreading out increases the chances for survivors who could come to the aid of any victims from a lightning strike. [3]

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