Section: Pathology

Original Research Article

A HISTOMORPHOLOGICAL STUDY OF LUNG IN DEATH DUE TO BURN: A CROSS SECTIONAL STUDY IN A TERTIARY CARE HOSPITAL.

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Abstract

Background: Burn is the most devastating injury a person can sustain. It is one of the top causes of death and disability in the world. Injuries can be caused by friction, cold, heat, radiation, chemical or electrical source. Multi organ dysfunction Syndrome (MODS), respiratory failure and sepsis are the leading cause of death in severe burn patient. Medicolegal autopsies are done to establish the identity of the decease, injury source and extend on the corpse, determination of the manner of death (Accidental/suicidal/homicidal), time since death and cause of death. **Aim:** To study the histopathological changes in lung specimens of deaths due to burn. **Materials and Methods:** A two years cross sectional study was carried out on histomorphological changes of lung in death due to burn in the department of Pathology, AGMC & GBP Hospital for the period December 2019 to November 2021. A total of 150 cases of lung in death due to burn were included in the study. All the cases were evaluated grossly and histopathologically. **Results:** Among the 150 burn victims examined, most common age group was 21-30 years (34%), female constitutes 71.3% of cases. Most victims were from rural areas (64.7%). Suicide (64.7%) was the most common reason of burn followed by accidental (31.3%). Congestion and edema (40.66%), followed by congestion with areas of consolidation (30%) were common gross findings. Most common histological finding were inflammatory cells and RBC (70.66%) followed by widened septa and dilated blood vessels (40%). **Conclusion:** From this study we can conclude that the main causes of death in burn patients are burn injury itself and sepsis related organ dysfunctions. Histopathological examination can support to estimate the extent of lung injury in response to severity and duration of survival in fatal burns.

INTRODUCTION

A severe Burn injury is the most devastating injury a person can sustain and yet hope to survive. Burns are still one of the top causes of death and disability in the world.[1] Out of all patients attending in the emergency departments with burn injuries, between 4 to 22% are admitted into the burn units.[2] The injuries can be caused by friction, cold, heat, radiation, chemical or electric sources, but the majority of burn injuries are caused by heat from fire, hot liquids or solids.[3] The most common cause of death due to fire is inhalation of smoke and toxic gases. The main cause of poisoning is due to effect of toxic substances which can cause structural and functional disorders of the respiratory organ.[4]

Fire or "Agni" is the fourth element of Indian panchabhuta. It has both eternal and perishable elements. The essential character of fire is to generate heat. According to Hindu mythology, Agni is one of the Eight guardians who guards our universe and is known as Asta- dik- palakas (Asta- eight, dik- Zone, Palakas- Guardian).[5] India has an ancient culture where fire was worshiped since civilization started. Along with water (Jal), air (Vayu), earth (Prithvi), fire (Agni) is perceived as one of the basic components of universe.[6] Fire was regarded by Darwin as the greatest discovery made by humanity, excepting only language.[7]

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The earliest humans were terrified of fire just as animals were. Yet, they had the intelligence to recognize that they could use fire for a variety of purposes. Fire provided warmth and light and kept wild animals away at night. Fire was useful in hunting.[8] It has played a significant role in the development of human civilization since ages and its extent and advancement has been equated with the extensiveness of use of fire. In modern civilization, the extensive use of fire in daily activities has made men excel in multiple quarters of life. Though fire is most useful agents, it is also one of the most destructive and has achieved the dubious distinction of being a potent 'double edged sword'.6

Every year across the globe, fire wipes out thousands of lives. Burns account for over 300,000 deaths each year throughout the world.[9] In the U.S., one civilian fire death occurs every 2 hours 53 minutes. In 2016 alone, there were 3,390 civilian deaths from fires, which includes 2,800 deaths from residential structure fires, 150 deaths from non-residential structure fires and 355 from vehicle fires. The lifetime odds of a U.S. resident dying from exposure to fire, flames or smoke are 1 in 1,498.[10] In 1998, India was the only country in the world where fire(burns) was classified among the 15 leading causes of death. Burn injury causes severe medical complications; it not only destroys the cutaneous barrier protecting the patient from a hostile environment, but it also causes a cascade of patho-physiological changes in every organ system. The extent and duration of organ function alterations are directly related to the extent of thermal injury.[11] Burn injuries result in life long physical & psychological scarring,[3] causing pain & influencing mental health, quality of life, ability to return to work & subsequent mortality.[3]

In India, over 1000000 people are moderately or severely burnt every year. Reportedly, around 173000 children of Bangladesh are moderately or severely burnt every year. In Bangladesh, Colombia, Egypt & Pakistan, 17% of children with burns have a temporary disability & 18% have a permanent disability.[12] The exact figure of burn injuries is still unavailable in many states of India. The pattern of burn injuries in the north-eastern states of India are different due to factors like unique social structure, hilly terrain, and practice of shifting (Jhum) cultivation. Many studies and research on the epidemiology of burn injury had been published but studies in the north-eastern states of the country other than Assam are still lacking.[13] Average ratio of fire-related deaths of young women to young men was 3:1.[14] Amongst children, accidental burns are common due to lack of awareness among children about dangerous substances and poor settings where living environments are hazardous.[15] Community studies in India have shown that dowry-related violence is an important cause of bride burning or dowry deaths of women.[16] About 86% of burns are thermal burns (43% from fire/flame, 34% from scalds, 9% from hot objects), 4% electric burns, 3% chemical burns, and 7% are other types of burns.[17]

The exact cause of death in burned patients is not known. Tests of blood, serum electrolyte values, and other laboratory determinants may be normal, yet sometimes patient succumbs to death. In such cases exact reason behind his/her death remains unsolved. Many explanations have been offered including electrolyte imbalance, shock, infection, renal, hepatic, adrenal or respiratory insufficiency.[18]

Burn injury often followed by a profound hyper-metabolic response that persists long after injury in those that survive.[19] Severe burns covering more than 40% of total body surface area (TBSA) are typically followed by a period of stress and hyperinflation, characterized by marked and sustained increases in catecholamine, glucocorticoid, and cytokine secretion.[20] Failure to attenuate the hyper-metabolic response leads to irreparable damage which impair the immune function and increases the risk for nosocomial infections and sepsis, which may in turn cause multiple organ dysfunction syndrome(MODS) and ultimately death.[21,22] MODS is defined as the presence of dysfunction in two or more organs or organ systems induced by a variety of acute injuries. Recent studies have demonstrated that the incidence of MODS in patients with burns ranges from 30%-40%.[23] Burn injuries can also induce micro-vascular hyper permeability that leads to hemodynamic instability and organ damage.[24] MODS is also a major cause of death if the patient survives within the first 24 hours.[25]

According to other studies, respiratory failure and sepsis are the leading causes of death in severely burnt patients.[18] Ventilator-associated pneumonia is also a common finding in patients with severe burn injuries.[26] The effects of the burn on the bronchial mucosa as well as pulmonary parenchyma depend on the degree of penetration of hot air steam into the system. Damage to the lung parenchyma causes both epithelial and endothelial damage resulting in pulmonary edema and possibly acute respiratory distress syndrome (ARDS) due to widespread alveolar-capillary leak.[27] The incidence of acute respiratory distress syndrome (ARDS) in burn patients is about 20-56% and is one of the leading causes of death among severe burn patients.[28]

Role of post-mortem & histopathological examination

An autopsy or post-mortem examination is a surgical procedure that consists of a thorough examination of a corpse by dissection to determine the cause, mode and manner of death or to evaluate any disease or injury that may be present for research or educational purposes.[29]

The principal medico-legal issue in the assessment of a burn injury is.[29,30]

- Establish the identity of deceased
- Injury source and extent on the corpse

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- Determination of manner of death- Accidental/ suicidal/ homicidal
- Time since death
- Cause of death

Medico-legal autopsies are a mandatory legal requirement in unnatural deaths to assist the law. The autopsy, if combined with relevant details and histopathological examination, is of great value in establishing reasons which lead to death.[31] Histopathological examination is commonly asked by autopsy surgeon to establish the cause of death when he recognizes any morbid anatomical changes in tissues and suspect that it may be the reason for cessation of vital functions of deceased.[30]

Burn injury is associated with an intricate patho-physiological response with rapid involvement of various organ systems and which in turn impact the patient with multi-system disruption. The major cause of death in burn patients includes multiple organ failure and infection. These damages can be attributed to the changes occurring at tissue and cellular level involving the alteration of the cellular architecture of the organs. It is suggested that they can be understood better with a pathological study of internal organs.[19]

It is a well-known fact that all organs are affected due to burns. But most commonly the morphological changes are seen in brain, heart, lung, liver, spleen, kidney and adrenals.[32] Although it is difficult to decide the exact cause of death in most cases of burns, an attempt had been made by various authors to determine roles of various factors like sepsis, acute renal failure, burns shock, neurogenic shock etc. in causation of death in case of burn injury.[32] This present study had been designed to analyse the organ changes & extent of burn injury in terms of percentage of Total Body Surface Area(TBSA) along with the time interval between the incident of burn and death & to follow the pattern of gross and microscopic changes in lung.

A very few numbers of systematic analytical studies of histo-pathological changes in lungs following deaths due to burn injuries have been carried out in India. So, the need of hour is that we should realize the importance of preventive measures to counter this problem & take adequate steps to put them into force. Thus, an attempt was undertaken to fill up this lacuna in regards to the deficit of knowledge about cause of death due to burns and its associated problems.

Aims and Objectives

Aim: To study the histopathological changes in lung specimens of deaths due to burn.

MATERIALS AND METHODS

This was a 2 years cross sectional study carried out at our tertiary care hospital, AGMC & GBP Hospital after approval from College Ethical Committee with **Ref. No.4(6-11)-AGMC/Medical Education/Ethics Com./2018** and Registration No. **ECR/937/Inst/TR/2017** issued under Rule **122DD of the Drugs & Cosmetics Rules 1945 under Govt of India, Dated 2 Dec 2019**. The study included all the lung specimens in death due to burn received over a period of 2 years i.e. December 2019 to November 2021. A total of 150 cases of lung in death due to burn were included in the study. All the cases were evaluated grossly and histopathologically.

Inclusion criteria: Fatal burn cases caused by flame, electricity & hot liquid, brought to AGMC & GBP Hospital for post mortem examination.

Exclusion criteria: Acid burn cases, lightning, charred bodies, burn skeletal remains, and decomposed burn cases.

Method of data collection

1. Consent was taken from the relatives of deceased for tissue (lung) preservation.
2. Detailed history was taken from inquest report and from deceased party.
3. During post mortem examination lungs were collected in the supervision of forensic and toxicology expert from the burn cases sent for examination in the Department of Forensic Medicine & Toxicology, Agartala Government Medical College & GB Pant Hospital.
4. Gross examination of the samples were done and various parameters like weight, colour, margins, any gross congestion, edema were noted down.
5. Samples were properly labelled and immediately put into a sterile container containing 10% neutral buffered formalin for storage and fixation.

Histological techniques

Grossing of the samples were done following the standard protocols- samples were taken from the apex of the upper lobes, base of the lower lobes and from the hilum of both the lungs. Tissue processing was done as per guidelines.[34]

Data analysis method

The data generated were entered in a master chart and then transferred to IBM SPSS (Version 21.0) software for WINDOWS (SPSS Inc., Chicago, IL, USA). Categorical data were analyzed in terms of rate, ratio, percentage & tested for significance by Pearson's chi-square (χ^2) test. Quantitative data were analyzed in terms of mean, standard deviation, coefficient of variation (if needed) and the significance of the outcome of analyzed data were tested by parametric/ non-parametric tests as appropriate. $P < 0.05$ was considered as significant.

RESULTS

The present study was conducted to find out the gross and microscopic features of lungs in 150 burn victims and to analyse the association of the changes in lungs with percentage of Total Body Surface Area (TBSA) of burn and duration of survival after

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burn. The most frequent age group in this study population affected by burn injuries were found to be in 21-30 years (34%), followed by the 11-20-year age group (22%). Almost half (49.3%) of the study population belonged to the age group of 21-40 years. The least number of patients were in the age group of 71-80 years (3.3%). It is seen that female burn victims were more frequent (71.3%) than the males (28.7%) in the study population. 76% of the study population were married while the rest (24%) were either unmarried, separated, divorced, widow or widower. Most of the study participants were from the rural areas (64.7%), whereas, 35.3% of the victims were from urban areas. 91.3% of the cases of burn in the study population were due to flame burns while 8.7% were scalds. In this study, 100(73%) burn victims had Kerosene oil as Source of fire, and in 32(23.40%) cases gas stove was the source of fire. Most of the specimens came from patients that underwent suicide (64.7%) followed by Accidental deaths (31.3%) while no cases of homicidal deaths. In 4% of the cases the manner of burn was unknown. In 97% of total study population the incidence of burn occurred at their own residence. The combined weight of the two lungs in most cases were between 502 and 600 gm. The most common category of combined left and right lung weight were 251-300 gm.

In this study most of the victims (24.7%) survived for 0-24 hours following burn injury. More than half (77 cases, 51.33%) of the patients were dead within 72 hours of the event. 10(6.7%) victims survived for 145-168 hours, another 11 victims survived for 169-336 hours. And 3(2%) victims survived for 337-504 hours. Most (40.7%) of the patients in the study population had ≥ 81% TBSA of burns, followed by 41-60% and 61-80% in 23.3% of the study population. Only 19 (12.7%) patients had burns less than 40% of TBSA.

The above table shows the association between survival time and TBSA% of burns. Survival time was higher in patients with lower body surface area affected by burns. The difference was statistically significant (P-value <0.001). [Table 1]

The commonest gross appearance of lung in victims of burn injury were congestion and edema seen in 40.66% of the specimens. The lungs were congested and on cut section showed areas of consolidation in 30% of the cases. Congested lung with pus formation were seen in 13.3% of the cases. And 6% cases showed pale but edematous lung. [Table 2]

Among patients with TBSA less than 40%, the most common gross appearance was congestion with oedema in 9(47.4%) cases followed by congestion with pus formation in 4(21.1%) cases.

Congestion and edema were the most common gross finding in 16(45.7%) cases of 41-60% TBSA buns followed by congestion with pus formation in 6(17.1%%) cases. Patients with 61-80% TBSA burns showed congestion and oedema as the most common (45.7%) gross lung finding. 12(34.3%) cases of 61-80% TBSA burnt victims showed congestion with areas of consolidation. Only 3 (8.6%) of the samples were pale with 41-60% TBSA burns. Among ≥ 81% TBSA involvement, most lungs were congested with areas of consolidation in 26(42.6%) cases, followed by congestion with edema in 20(32.7%) cases and pus formation in 7(11.5%) cases. The findings are statistically significant (p=0.030). [Table 3]

Among patients with survival time less than 72 hours the most common gross findings were congested and oedematous lung in 35(45.5%) cases followed by congestion with areas of consolidation in 25(32.5%) cases. Overall pus formation was seen in 10(13%) cases. Among patients with survival time more than 72 hours the most common gross features were congestion with oedema in 26(35.6%) cases followed by congestion with areas of consolidation in 20(27.4%) cases. Overall pus formation was seen in 18(24.6%) cases. However, association between gross findings of lungs and Survival time was not statistically significant (p=0.7500).

The commonest histopathological finding in victims of burn injury were presence of inflammatory cells and RBC's constituting 70.66% of the study population, followed by widening of septa and dilated blood vessels comprising of 40.66% of the cases, followed by 30% of cases showing alveolar fibrin strands. The least common histopathological findings were the presence of type II pneumocyte proliferation in 4% of the population. [Table 4]

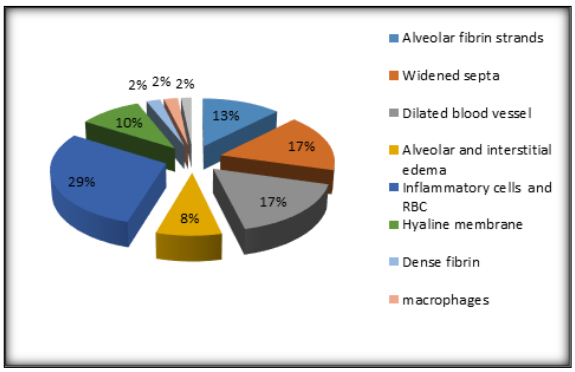

Chart 1: Distribution of histopathological features of lungs among study population

The association between histological features and survival time of the study population showed that among patients who died within 72 hours of burn injury, 54(70.12%) cases showed widening of septa and dilated blood vessels followed by presence of intra-alveolar and interstitial oedema with hyaline membrane formation in 16(20.77%) cases and 7(9.09%) cases showed presence of alveolar fibrin strands along with inflammatory cell infiltration and presence of RBC's. Among patients who died after 72 hours, 38(52.02%) cases showed presence of alveolar fibrin strands followed by histopathological features of intra-alveolar oedema with hyaline membrane formation in 14(19.17%) cases, and dense fibrin with macrophages were present in

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8(5.3%) cases. There are statistically significant differences (p<.05) between histopathological findings and survival time of the study population. [Table 5]

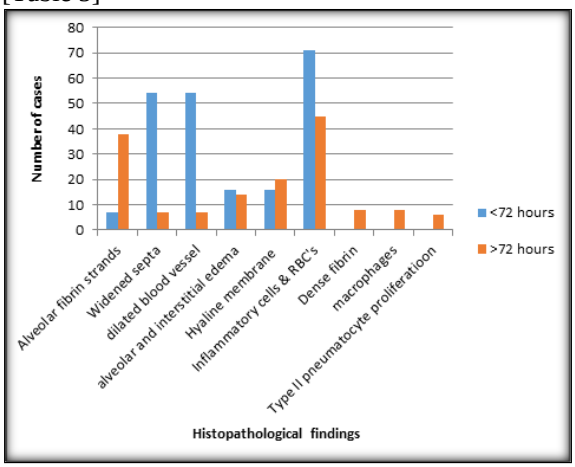

Chart 2: Association between survival time(hours) and histopathological findings of lungs

It is evident from the table that the most common finding in >81% TBSA burns were presence of inflammatory cells & RBC's (96.7%) followed by widening of septa and dilated blood vessel (63.9%). Dense fibrin and presence of macrophages (31.5%) were the most common findings in <40% TBSA burns. The histological findings show statistically significant differences (p<.001) in the present cohort study. [Table 6]

Figure 1: Gross appearance of pale and edematous lung from a 34 years woman with >80% TBSA burns and less than 72 hours of survival time

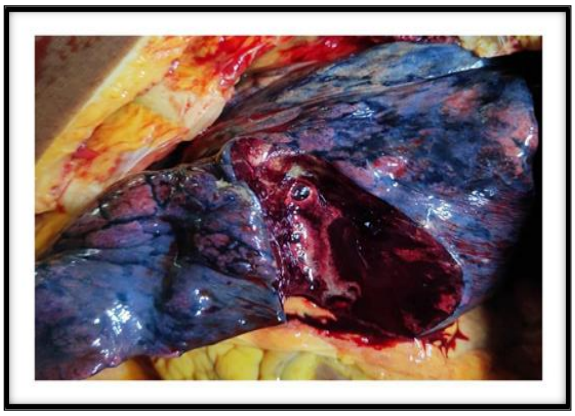

Figure 2: Gross appearance of congested lung from a 42 years old male with more than 81% of TBSA burns and less than 72 hours of survival time

Figure 3: Cut section of lung showing areas of consolidation(arrow) from a 72 years male with 61-80% of TBSA burns and more than 72 hours of survival time

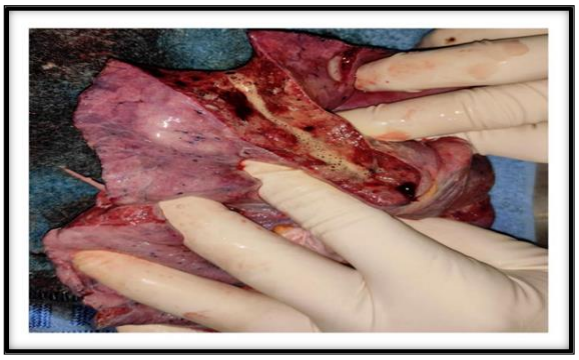

Figure 4: Gross appearance of lung showing pus mixed frothy fluid(arrow) on cut section from a 35 years old woman with 41-60% of TBSA burns and more than 72 hours of survival time

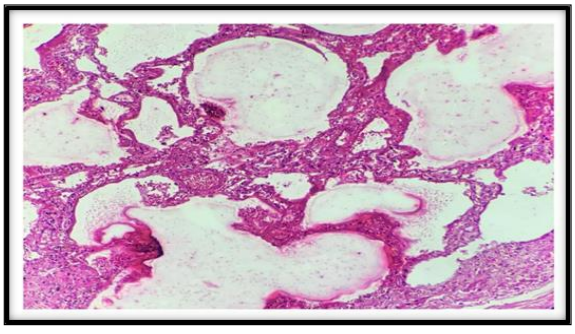

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Figure 5: Intra-alveolar edema with hyaline membrane formation(arrow) and inflammatory cell infiltration (H & E, 10X)

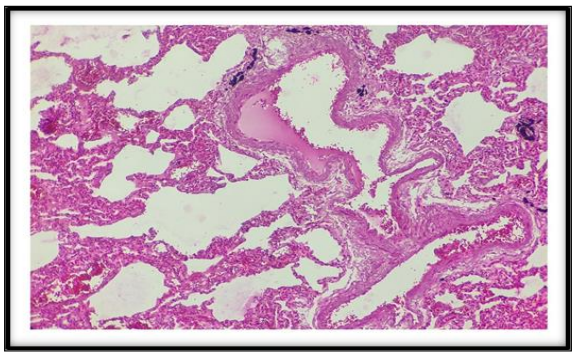

Figure 6: Widening of septa with dilated blood vessels and inflammatory cell infiltration (predominantly polymorphs) (H & E 10X),

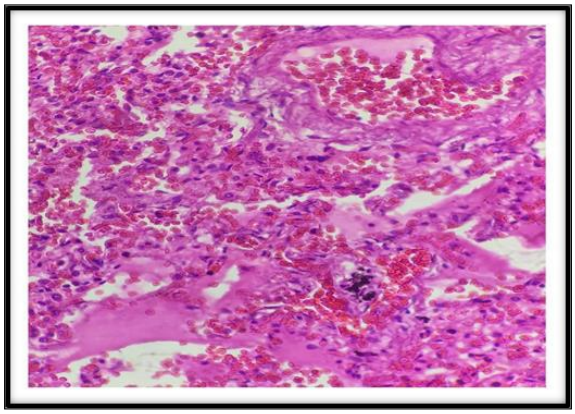

Figure 7: Alveolar fibrin strands with presence of intra-alveolar neutrophils & RBC's (H & E, 40X)

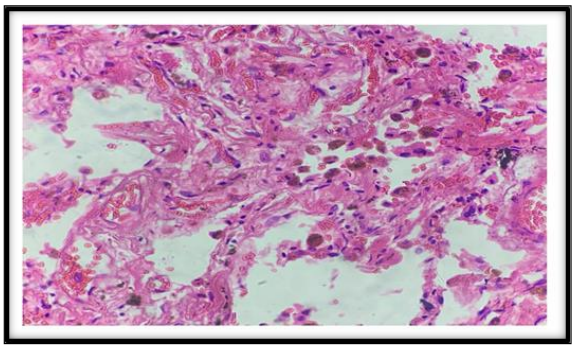

Figure 8: Dense fibrin with presence of hemosiderin laden macrophages(arrows) and inflammatory cells (H& E,40X)

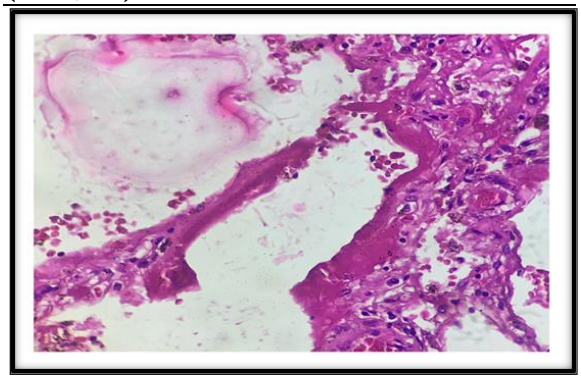

Figure 9: Presence of intra-alveolar fluid (black arrow) and hyaline membrane (blue arrow) (H & E, 40X)

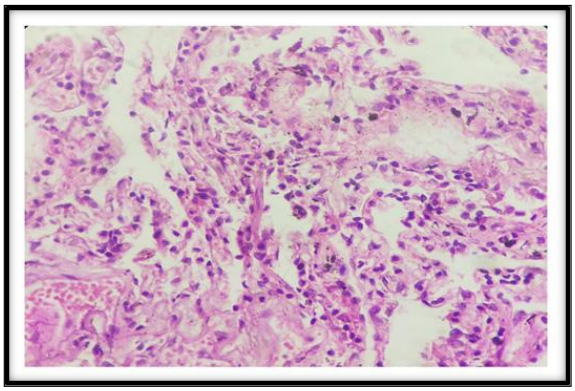

Figure 10- Type II pneumocyte proliferation (arrows) (H & E, 40X)

Table 1: Showing association between survival time and TBSA% involved

TBSA (%)	Survival time		Total	Chi square	p value
	<72 hours	≥72 hours			
≤40	3(3.9%)	16(21.9%)	19 (12.7%)	42.283	<0.001
41-60	10(12.9%)	25(34.2%)	35 (23.3%)		
61-80	27(35.1%)	8(11%)	35 (23.3%)		
≥ 81	37(48.1%)	24(32.9%)	61 (41.7%)		
Total	77(100%)	73(100%)	150 (100%)		

Table 2: Distribution by the gross appearance of the lungs among study population

Gross appearance of Lungs	Frequency	Percent
Congested & edematous	61	40.66%
Congested and pus formation	20	13.3%
Congested with areas of consolidation	45	30.0%
Pale and edematous	9	6.0%
Pale with pus formation	8	5.3%
Pale	7	4.7%
Total	150	100.0%

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Table 3: Table showing the association between gross appearances of the lungs and the TBSA in percentage (n=150)

Gross appearances of lungs	TBSA%				
	≤40	41-60	61-80	>81	TOTAL
congested & edematous	9 (47.4)	16 (45.7)	16 (45.7)	20 (32.7)	61 (40.7)
Congested and pus formation	4 (21.1)	6 (17.1)	3 (8.6)	7 (11.5)	20 (13.3)
Congested with areas of consolidation	3 (15.8)	4 (11.4)	12 (34.3)	26 (42.6)	45 (30.0)
Pale and edematous	1 (5.3)	4 (11.4)	1 (2.9)	3 (4.9)	9 (6.0)
Pale with pus formation	2 (10.5)	2 (5.7)	3 (8.60	1 (1.6)	8 (5.3)
Pale	0 (0)	3 (8.6)	0 (0)	4 (6.6)	7 (4.7)
TOTAL	19 (100)	35 (100)	35 (100)	61 (100)	150 (100)

Chi-square value: 22.1012; p-value: 0.030

Table 4: Association between gross appearances of lungs and Survival time

Gross appearances of lungs	Survival time		Total	Chi square	p value
	<72hours	>72 hours			
Congested & edematous	35(45.5)	26(35.6)	61(40.7)	4.3338	0.7500
Congested and pus formation	7(9.1)	13(17.8)	20(13.3)		
Congested with areas of consolidation	25(32.5)	20(27.4)	45(30.0)		
Pale and edematous	4(5.2)	5(6.8)	9(6.0)		
Pale with pus formation	3(3.9)	5(6.8)	8(5.3)		
Pale	3(3.9)	4(5.5)	7(4.7)		
Total	77(100)	73(100)	150(100)		

Table 5: Association between survival time and histopathological findings of lungs in victims of burn

Histopathological findings	Survival time ≤ 72 hours	Survival time ≥ 72 hours	Total	Chi square	P value
Alveolar fibrin strands	7(9.09)	38(52.05)	45 (30)	113.019	P<0.001
Widened septa	54(70.12)	7(9.6)	61 (40.6)		
Dilated blood vessels	54(70.12)	7(9.6)	61(40.6)		
Alveolar and interstitial edema	16(20.77)	14(19.17)	30(20)		
Hyaline membrane	16(20.77)	20(27.4)	36 (24)		
Inflammatory cells & RBCs	71(92.2)	45(61.64)	106(70.6)		
Dense fibrin	0(0)	8(10.9)	8 (5.3)		
Macrophages	0 (0)	8(10.9)	(5.3)		
Type II pneumocyte proliferation	0 (0)	6(8.21)	6(4)		
Total	77(100)	73(100)	150(100)		

*** numbers and percentages may add more than 150 (100%) because of the presence of more than one HPE finding in one sample.**

Table 6: Association of histopathological features of lungs with TBSA involved in burns

Histopathological findings	TBSA(%) involved				Total	Chi Square	P value
	≤40%	41-60%	61-80%	≥ 81%			
Alveolar fibrin strands	2(10.5)	9(25.71)	14(40)	20(32.7)	45(30)	217.182	<0.001
Widened septa	1(5.2)	11(31.42)	10(28.57)	39(63.9)	61(40.6)		
Dilated blood vessels	1(5.2)	11(31.42)	10(28.57)	39(63.9)	6140.6)		
Alveolar and interstitial edema	4 (21.05)	13(37.14)	11(31.42)	2(3.2)	30(20)		
Hyalin membrane	10(52.63)	13(37.14)	11(31.42)	2(3.2)	36(24)		
Inflammatory cells	3(15.7)	20(57.14)	24(68.57)	59(96.7)	106(70.6)		
Dense fibrin	6(31.5)	2(5.7)	0(0)	0(0)	8(5.33)		
Macrophages	6(31.5)	2(5.7)	0(0)	0(0)	8(5.33)		
Type II pneumocyte proliferation	6(31.5)	0(0)	0(0)	0(0)	6(4)		
Total	19(100)	35(100)	35(100)	61(100)	150(100)		

*** numbers and percentages may add upto more than 150 (100%) because of the presence of more than one HPE finding in one sample.**

DISCUSSION

Age distribution

Among all the victims of fatal burn injuries the peak incidence (34%) were found to be in the age group of 21-30 years. Almost half (49.3%) of the study population were in the age group of 21-40 years. The next most prevalent was 11-20 years age group (22%). The mean age was 34.42 ± 16.46 years with range from 14-75 years.

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Our study tallies with the study of Latif M et al.[36] (2016) who concluded as the predominant (53.33%) victims were in the age group of 18-30 years[36]. Similar result was found in the study by Batra (2003),[11] in North India in which the predominant age group was 21-40 years[11]. Akther JM et al,[37] in their study also concluded that majority (53.5%) of the patients were in 21-40 years age group.[37] Other studies like Das P et al,[38] in their study at Tertiary Hospital of Tripura, stated that maximum number of the victims (37.96%) belonged to the age group of 21-30 years,[38] and Shinde AB et al,[39] also found similar results with a peak incidence (45.45%) of burn deaths in the age group of 21-30 years.[39]

Gender distribution

The percentages of female and male population in our study were 71.3% and 28.7% respectively. The predominance of female deaths was observed by Lal S et al.[40] with a male to female ratio of 1:4.6.[40] Several other studies Das P et al,[38] Batra AK,[11] Shinde AB et al,[39] Akhter JM et al,[37] showed almost similar trend with female preponderance of the burn victims. However, the present study varies from Gupta M et al,[41] where majority (54%) of the burn victims were male and rest 46% were females.[41]

Age and gender wise distribution

Female preponderance is noted in almost every age group with a peak of 38.3% females and 23.3% males in the age group of 21-30 years. A similar proportion of females, more than half (53.33%) belonging to the 18–30 years age group, were seen in the retrospective study by Latif et al,[36] on 42 autopsy cases in Jammu and Kashmir. However, in this present study a male preponderance is seen in relatively older (61-70 years) age group and this finding tallies with the study by Lam NN et al.[42] where they found half of the patients were male and in the age group of >65 years.[42] Our findings also tally with the study by Jaiswal et al,[43] Khajuria et al,[44] Subrahmanyam,[45] and might be explained by the involvement of females in domestic activities and also to dowry deaths. Higher incidence among young adults both male and female may be explained by the fact that they are generally active and exposed to hazardous situations both at home and work. Due to our social structure, older individuals usually live within the family, thus decreasing their exposure to hazardous situations.[36] In contrast, study by Olaitan PB et al,[36] showed maximum number of cases in old aged male, probably due to different geographical region and environmental factors.[46]

Distribution based on marital status

Majority (76%) are married and rest 24% are either unmarried/separated/divorced/widow/widower in the present study. This observation is similar to the study of Batra (2003),[11] where 82.4% were married compared to 12.2% of the unmarried ones[11]. Ghaffar et al. (2009),[47] in their study also found almost similar result with 72.5% were married and 27.5% were unmarried.[47] Shinde et al,[39] showed that 81.91% of their study population were married.[39] The high incidence of fatal burn related deaths among married females are due to exposure to fire with much unsafe condition of kitchen and dowry related deaths.[11,56]

Distribution by Residence

64.7% victims of fatal burn injuries were the residents of rural area where as rest 35.3% were from the urban areas in this present study. Batra,[11] (2003) in his study pointed out that the process of fatal burn injury was more common in rural India than the urban population (rural deaths- 75%). The study of Ghaffar et al. (2009),[47] Shinde et al.[39] (2013) also showed almost similar result where majority of the affected victims were from rural area. The high incidence of victims among rural areas may be explained by the reason that majority of poor Indian population belongs to rural parts having limited and unsafe cooking measures.[47]

Distribution based on type of burn

Distribution of study population based on type of burn injury which shows majority of the cases (91.3%) were flame burns while 8.7% were scalds. However, no electrical burn cases were found in this study population. Similar findings were seen in the study by Akther JM et al. (2010),[37] Jaiswal AK et al. (2007),[43] Lal S et al. (2012),[40] Latif M et al. (2016),[36] where flame burns outnumbered scalds or electrical or other causes of burn.

Distribution by source of fire

In this study kerosene oil was the main (73%) accelerant accountant for burns followed by gas stove in 23.40% cases. This study reflects the outcome similar to the other studies of Das P et al. (2015),[38] Ghaffar et al,[47] Lal S et al. (2012),[40] where kerosene was the main source of burn injury. This is probably because kerosene is cheap and easily accessible and more use of kerosene stove and kerosene lamp by the people of rural India.[47]

Distribution by manner of burn

64.7% of the burn deaths were suicidal in nature followed by accidental (31.3%) deaths. The most common agent used were kerosene oil. These results are consistent with the study by Das P et al.[38]

Distribution of the study population by place of occurrence

It is evident from this study that 145(97%) cases of burn occurred in victim's own residences. Fire incidents inside residence are mainly due to its use for cooking and heating purposes.[37] Our study is consistent with that of Akhter JM et al,[37] Gupta et al. (1992),[48] Haik et al. (2007),[49] who concluded as majority of burns occurred at home.

Distribution by duration of survival after sustaining burn injuries

In this study population 24.7% died within first 24 hours, 12.7% died within 25-48 hours, 14% died within 49-72 hours, thus more than half (51.33%) of the patients died within 72 hours of the event. 20% of the victims died within 73-96 hours, 7.3% died within 97-120 hours, 5.3% died within 121-144 hours, 6.7% died within 145-168 hours, 7.3% died

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within 169-336 hours, and 3(2%) patients died within 337-504 hours (Table-10, chart-8).

Findings of Mukherjee JB (2011),[57] Reddy (2014),[50] are similar to our study. In a study by Swanson et al. (2013),[51] concluded that most of the deaths occurred within 72 hours of injury and follow a pattern of early rapid decline (58%).[51] Gadge et al. (2014),[52] studied that 43.4% victims died within 72 hours of burn injury.[52]

Shinde et al. (2013),[39] in their study found that 28.18% victims died within 24 hours, 10% within 24-48 hours, 3.64% died within 48-72 hours and 20% died within72-96 hours. Thus 41.18% died within 72 hours of the event. The result of our study closely matches with the findings of the study by Shinde and Keoliya.[39] Chakrabarti N et al. (2017),[53] observed that 43.4% victims died within 72 hours and 64.14% died within 96 hours of burn injury.[53] The victims who died within 72 hours, sustained extensive burn injuries involving wide body surface area and of more severe degrees. In 48.67% who died after 72 hours, even though they received reasonably good treatment and attention, the cause of death being several factors in addition to the direct effects of burn.

Percentage of Total Body Surface Area burn among the study population

40.7% of the study population had >81% total body surface area (TBSA) burns, 46.6%% patients had 41-80% TBSA burns and rest 12.7% had less than 40% TBSA burns in the present study. The study of Gadge et al. (2014),[52] concluded that 51.4% of the victims suffered from 80-100% TBSA burns, 27.9% had 60-79% TBSA burns, 18.1% had 40-69% TBSA burns and rest 9.4% had <40% TBSA burns[52]. Thus, the findings of our study tally with the study of Gedge et al,[52] with majority of the victims in the group of 80-100% TBSA burns. Similar findings were observed by the study of Latif M et al,[36] where out of total 42 cases, 27 (64.3%) had 90-100% TBSA of burns, followed by 5(11.9%) cases with 80-90% TBSA of burns and rest 10(23.8%) cases had <80% TBSA of burns.[36] Total body surface area of burn is a highly significant variable affecting mortality. Increased involvement by TBSA of burn leads to a profound hypermetabolic response, devastating muscle and protein catabolism, multi-organ dysfunction. Failure to attenuate these responses leads to irreparable damage and death.[21]

Association between duration of survival and TBSA (%) of burn involved

In this study, among 61 (41.7%) victims who had more than 80% TBSA burn 37 victims died within 72 hours, and 24 (16.0%) victims died after 72 hours. Among 35 cases (23.3%) who had 61-80% TBSA burns 27(18.0%) cases died within 72 hours, while 8 (5.3%) cases died after 72 hours. 35 (23.3%) cases with TBSA of 41-60% burn, among which 10 cases (6.66%) died within 72 hours and rest 25 (16.6%) cases died after 72 hours. Among 19(12.7%) victims with less than 40% TBSA 3 (2.0%) victims died within 72 hours and rest 16 (10.6%) died after 72 hours. So, it can be said that the rate of fatality decreases as time passes after sustaining the burn injuries and in extensive burn cases hospitalization certainly improves the chances of recovery. The association between duration of survival and percentage of TBSA burns. It is seen that duration of survival is statistically significant ($p<0.001$) with percentage of TBSA burns. It indicates that with increased percentage of TBSA burns, the time of survival of the victims decreases significantly. Olaitan et al. (2006),[46] in their study observed that survival time was decreased as percentage of burn surface areas increased. They also concluded 100% mortality with TBSA >80% of burn[46]. Study findings were similar with the findings by Olaitan et al.[46] A study by Haik et al,[49] found that the highest mortality rate (96.6%) were with the victims of burns >90% TBSA.[49]

Jeschke MG et al. (2007) in their study concluded that patients with more than 40% total body surface area burns were at high risk for morbidity and mortality.[61] Shanmugakrishnan et al. (2008),[54] in their study concluded that mortality rate was 57.33% following burn injury and the higher mortality was associated with burns involving more than 55% TBSA and nosocomial infections during hospital stay.[54]

Distribution of study population based on weight and colour of lungs

This study measured the weight of individual lungs at the time of autopsy. Weight of right lung were maximum in the range of 251-300g in 46(30.7%) cases followed by 301-350g in 41(27.3%) cases. Whereas, the weight of left lung was maximum in the range of 251-300g in 48(32%) cases, followed by 301-350g in 39(26%) cases. The combined weight of the two lungs (right 30.7%, and left 32%) in most of the cases were between 502 and 600 grams. As most of the lungs belonged to female victims, which are comparatively lighter than their male counterpart, that is why the values are less than the standard weights. The normal weight of the lungs, according to Reddy (2014),[50] is estimated as right lung (360-570g with a mean of 450g) and left lung (325-480g with a mean of 375g). The views expressed here are of healthy lungs, without differentiation of sex, social parameters or any other morbid conditions. The reported weight of the lungs in the present study was much lower than that reported by Hasleton,[55] from UK, who reported that all 68 victims in his study, the lungs were heavy, having a combined weight ranging from 820-1590 g (mean 1223 g).[55] The weight of lung is considered an approximately 1% of the total body weight and in proportion to body structure, the lungs are heavier in men than in women.[50] Considering the fact, that majority of the victims of our study were belonged to rural undernourished female population, the weight of the lungs in the present study were little below the reference weights mentioned by above authors. Moreover, weights of

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lungs are more in western countries considering their height and built.

Distribution of study population based on gross appearance of lungs and association of gross findings with survival time and TBSA (%) involved

In the present study out of 150 victims of burn injury, 61(40.66%) cases were found to be congested and odematous lung. Whereas, 45(30%) cases showed congestion and on cut section areas of consolidation were noted. Pus was detected in 28(18.6%) cases, and 24(16%) cases were pale. Congestion and oedema were the most common (47.4%) gross finding among the patients with less than 40% of TBSA burns and pus formation was seen in 31.6% cases. Congestion with areas of consolidation were the most common finding in patients with >80% TBSA burns.

It is evident that most common gross finding among patients with survival time less than 72 hours were congestion and oedema (45.5%) followed by congestion and on cut section areas of consolidation were noted in 32.5% cases. Victims who survived more than 72 hours also had most common gross finding as congestion and oedema in 26 (35.6%) cases followed by congestion and on cut section areas of consolidation in 27.4% cases. But both of the findings (congestion and oedema, congestion with areas of consolidation) were more predominant among victims who died within 72 hours of burn injury. Whereas pus formation was more common in patients who died after 72 hours.

Due to initial response to burn injury, there is vasodilatation and engorgement of oxygenated blood in pulmonary vasculature. Following stasis, there is increased vascular permeability. Within a short interval of sustaining burn injuries, the victims died as a result of shock and hence there is increased congestion in pulmonary vasculature. In long standing hospitalized cases of septicaemia, purulent material is present in lungs which ooze out on squeezing. There is, at times unaccounted overload of fluid loss, resulting in grossly oedematous lungs.

The study tallies with the study by Pujari et al,[32] where they found congestion of lung in all cases which died within 24 hours of sustaining burns, oedema was found in 42.30% cases.[32] Similar findings were seen in study by Rathod et al,[56] where they found oedema to be the most frequent change in lungs and explained as a result of protein imbalance in burned patient which may result in oedema of entire body.[56] Mukherjee,[57] opined that lungs were usually found congested and oedematous, the cut sections exuding frothy fluid blood in cases of burn. Occasionally the lungs are found shrunken and anaemic.[57] Bala S et al,[58] in their study revealed almost normal gross findings in lungs with mild focal congestion in some cases and few specimens showed outer surface patchy, whitish area and cut surface showed consolidated area.[58]

Distribution of the study population by histopathological findings of lungs and association with survival time and TBSA involved

In this study the commonest histopathological findings following burn injury were, widening of septa with dilated blood vessels along with presence of inflammatory cells (predominantly polymorphs) and RBC's, a feature of stage of congestion of lobar pneumonia were seen in 61(40.66%) of cases. Alveolar fibrin strands with intra-alvolar neutrophils and red cells, feature of red hepatization of pneumonia were present in 45(30%) of cases. Interstitial and intra-alveolar odema along with hyaline membrane formation, feature of exudative phase of diffuse alveolar damage were seen in 30(20%) cases. In 6(5.33%) cases we found dense fibrin and macrophages, a feature of gray hepatization of pneumonia. 6(4%) cases showed presence of hyaline membrane with lymphocytic infiltration and type II pneumocyte proliferation, feature of proliferative phase of diffuse alveolar damage. Among patients who died within 72 hours of burn injury 54(70.12%) cases showed stage of congestion of lobar pneumonia followed by 16(20.77%) cases of exudative phase of diffuse alveolar damage and 7(9.09%) cases of red hepatization of lobar pneumonia while no case of gray hepatization of pneumonia or proliferative phase of diffuse alveolar damage.

Patients who died after 72 hours showed 38(52.05%) cases of red hepatization of pneumonia followed by 14(19.7%) cases of exudative phase of diffuse alveolar damage (DAD), 8(10.9%) cases of gray hepatization of pneumonia, 7(9.6%) cases of stage of congestion of pneumonia and 6(8.21%) cases of proliferative phase of DAD. In this study, 3 patients died after 338 hours and among them 2 patients showed histopathological features of proliferative phase of DAD and one patient showed features suggestive of gray hepatization of pneumonia.

Among patients with <40% TBSA burns most common histopathological findings were presence of macrophages with dense fibrin in 6(31.5%) cases. Among patients with 41-60% TBSA burns most common finding was exudative phase of DAD in 13(37.14%) cases followed by stage of congestion in 11(31.42%) cases, and 2(5.7%) cases of gray hepatization of pneumonia. 14(40%) cases of red hepatization of pneumonia were seen in 61-80% TBSA burns followed by 11(31.42%) cases of exudative phase of DAD, 10(28.57) cases of stage of congestion of pneumonia while no cases of gray hepatization and proliferative phase of DAD. 39(63.9%) cases of stage of congestion of pneumonia were seen in patients among >81% TBSA burns followed by 20(32.7%) cases of red hepatization of pneumonia and 2(3.2%) cases of exudative phase of DAD.

Our findings tally with the study of Bala S et al,[58] where they observed 47.61% cases of congestion, 33.33% cases of red hepatization of pneumonia, 15.87% cases of DAD and 3.17% cases of gray

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hepatization of pneumonia.[58] Urer et al,[59] found that out of 20 fire related deaths 16(80%) cases of exudative phase of DAD and 4(20%) cases of proliferative phase of DAD.[59] Similar studies were seen with Pujari et al,[32] Khomazyak et al.[60]

CONCLUSION

As is said "Prevention is better than cure"- dimensions should be carved to cope with the incidence rather than the aftermath. It is evident from our study that domestic fire is the major cause of burns with maximum involvement of females. Dowry deaths, curse to our so-called modern society, are still prevalent, in spite of stringent laws and amendments in the acts.[56] It is necessary to implement programmes for health education relating to prevention of burn injuries by means of broadcast flashes on mass media like television or radio, showing risk situations and teaching self-care methods in workplaces and homes.

From this study it can be concluded that the main causes of death in burn patients are burn injury itself and sepsis related organ dysfunctions. In the present study it is observed that lung was affected in every deceased victim of fatal burn injury. Histopathological examination can support to estimate the extent of lung injury in response to severity and duration of survival in fatal burns.

Study correlating lung function tests with percentage of total body surface area of burn and duration of survival and study correlating between ante-mortem lung function tests and post-mortem histopathological alterations, may be done with larger sample size to evaluate the clinical justification of this study in future. The early detection of status of vital organ function and treatment of microbial infections can reduce the mortality among burn victims.

The results of this study further suggest that clinical strategies to improve burn care further should be focused on early interventions and optimization of fluid replacement during the first 24-48 hours after burn injury by goal-directed resuscitation to dampen the ischemia induced injury to vital organs and use of antibiotics in a proper and adequate manner to prevent sepsis related complications for a better outcome of patients.

Limitations

1. As this is a hospital-based study, therefore may not represent the actual incidence of burn injury in general population.
2. Though the sample size was calculated statistically, but because of feasibility criteria, the sample size was kept to a minimum.
3. The present study was undertaken to find out the gross and histopathological changes following burn injury in only one organ.

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