Original Paper

Lung Pathology and Presence of Carboxyhaemoglobin in Burn Mortality

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ABSTRACT

Severe burn injury is among the most devastating injuries that a person can sustain and yet hope to survive. The only regions/body fluids of the body, which yield reliable proof of life of the deceased at the time when the fire occurred are the air passages and the blood. If the deceased had inhaled very hot gases or actual flame, the mucosa of the tongue and larynx may be blistered or shredded and the larynx is often oedematous. The presence of carbon particles/soot in terminal bronchioles on histological examination is usually taken as sufficient proof of life when the fire broke out.

The presence of carbon particles and elevated carbon monoxide saturation together generally constitute absolute proof that the victim was alive when the fire occurred.

Key Words: Burn injury; Carbon monoxide; Carbon particles; Soot.

INTRODUCTION

Burns constitute a major cause of death and morbidity whatever the reason may be, around the world, and in this country as well. As everywhere else, the modes of sustaining burn injuries in India are the same, i.e., flames, boiling fluids, electrical source and other thermal sources. The most common manner of sustaining flame burns is accidental.[1]

Severe burn injury is among the most devastating injuries that a person can sustain and yet hope to survive. In the US, approximately 2 million thermal injuries occur every year and 1,30,000 of them necessitate hospital admission.[2] Approximately 10,000–12,000 of these individuals die as a result of thermal injury annually.

The majority of fatal dry burns in civilian practice occur in conflagration of buildings, rather than in vehicles or aircraft. In many of these tragedies death is not caused by burns, but due to inhalation of fumes produced by the combustion of the building structure and contents. Indeed, most burns seen by forensic pathologists are postmortem, either because the victim was already dead from smoke inhalation or because severe postmortem burning obliterates the lesser degrees of burns present up to the moment of death.[3]

The only body regions/body, fluids which yield reliable proof of life of the deceased at the time when the fire commenced are the air passages and the blood. In most of the victims of fires in buildings, where there is considerable production of smoke, the tongue, fauces, larynx and trachea are inflamed and covered by a layer of soot embedded in a layer of mucus. If the deceased had inhaled very hot gases or actual flames, the mucosa over the tongue and larynx may be blistered or shredded and the larynx is often oedematous. Not uncommonly, the

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victim who inhaled also vomits and inhales some vomitus presumably due to bouts of coughing, and plugs of regurgitated stomach contents mixed with soot may be found in the bronchi in the depths of the lungs.[4]

The presence of carbon particles in the terminal bronchioles on histological examination is generally taken as sufficient proof of life during the fire. The soot is better seen by thin film of mucus on a clean sheet of white paper. The amount of soot in the air passages depends on the type of fire, the amount of smoke produced and the duration of survival in the smoke-contaminated atmosphere.[5] The smoke that contains much carbon monoxide is absorbed by the blood, and gets reflected as carboxyhaemoglobin in the form of bright pink hue of the blood, muscles and even cut surface of organs.[4] The presence of smoke or soot particles in the air passages, evidence of thermal injury/inhalational injury of the respiratory tract by hot fumes and gases, elevated blood carboxyhaemoglobin levels due to carbon monoxide poisoning and presence of other toxic gases in the blood, and cutaneous reactions, have been used either alone or in conjunction to arrive at the cause of death.[6]

In death due to burns, carbon monoxide levels in blood generally rise to more than 10%, and may reach up to 70–80%, though children and old persons die at levels of 30–40%. The level of carbon monoxide saturation is dependent on concentration in the inhaled air, the duration of exposure, the rate and depth of respiration, the haemoglobin concentration and the activity of the victim. Carbon monoxide may be absent in blood due to various reasons such as rapid death, convection currents, low production of carbon monoxide flash fire as in conflagration of a chemical plant, inhalation of super-heated air resulting in death by suffocation, in warfare, or in an explosion when death is instantaneous.[5]

While saturations of 30–50% carboxyhaemoglobin are common, a blood level of more than 10% carbon monoxide in a non-smoker may be considered as evidence of inhalation and consequently that the victim was alive after the fire started.[7]

The presence of carbon particles and elevated carbon monoxide saturation together are an absolute proof that the victim was alive when the fire occurred. In the absence of carbon monoxide in blood and soot in the airways, death may have resulted possibly due to poisoning with carbon dioxide or oxygen deficiency. Poisonous gases like cyanide and oxides of nitrogen are also produced due to burning of plastic and synthetic material. In the case of flame or super-heated air inhalation, death may occur due to shock or acute respiratory insufficiency. If the victim survives for a few days, inflammatory changes occur in the larynx, with sloughing of mucosa, ulcerations and secondary infection.[5]

Duttra, in 1949, had first reported that in some cases where death had occurred after the onset of fire, there would be deposits of soot in the larynx and trachea.[8] He went on to suggest that the best evidence that a person was alive during a conflagration was the presence of excessive quantities of carbon monoxide in his blood. In a subsequent article in 1950, he reported that the most important gaseous toxic by-product of burning is carbon monoxide, and usually the victim's blood would contain a high percentage of this gas.[9] The presence of carbon monoxide and other toxic gases would depend on the materials being burned and also on the condition of combustion.

MATERIALS AND METHODS

The present study was carried out in 50 cases alleged to have died of burns and brought to the mortuary attached to the Department of Forensic Medicine and Toxicology, Government Medical College, Amritsar from May 2004 to July 2005. Relevant information was collected from accompanying relatives, hospital records and police papers to ascertain the incidence, manner and circumstances of burns. The external and internal findings of burns at autopsy were noted, along with the examination of clothes, respiratory tract, tests for carboxyhaemoglobin and demonstration of soot particles in the trachea.

Demonstration of Soot Particles: Soot particles were detected by taking a swab from the mucus in the respiratory passages and spreading it over a glass slide and examining under light microscope for carbon particles.[3]

Tests for Carboxyhaemoglobin[10]: The following tests were performed:

1. Kunkel's Test: In this test, a sample of blood was diluted with four times its volume of water and a few drops of 3% aqueous tannic acid solution was added to it and shaken well. In cases with more than 10% carbon monoxide, a pinkish white precipitate would form.
2. Hoppe-Seyler Test: In this test, a suspected blood sample was diluted with about 20 times the volume of water and 10% caustic soda was added to it. Normal

blood would turn reddish brown, but blood containing more than 10% carbon monoxide would remain bright red in colour as no methaemoglobin is formed.

3. Potassium Ferrocyanide Test: In this test, 15 cc of blood is mixed with an equal amount of 20% potassium ferrocyanide solution and 2 cc of dilute acetic acid and shaken gently; a bright red coagulum would form in cases of normal blood.

RESULTS

Soot particles in trachea were present in 40% cases and absent in 60% cases. Congestion and desquamation were present in 96% cases and absent in 4% cases. Pulmonary oedema was present in 80% cases and absent in 20% cases. Pleural effusion was present in 40% cases and absent in 60% cases. Blood stained froth was present in 44% cases and absent in 56% cases (**Table 1** & **Fig 1**).

Table 1 Incidence and Distribution of Burn Lung Pathology

Changes	Present		Absent	
	No.	%	No.	%
Soot particles in trachea	20	40	30	60
Congestion and desquamation	48	96	2	4
Pulmonary oedema	40	80	10	20
Pleural effusion	20	40	30	60
Blood stained froth	22	44	28	56

Table 2 Incidence and Distribution of Soot Particles in Stomach

Changes	Present		Absent	
	No.	%	No.	%
Soot particles in stomach	6	12	44	88

Soot particles were present in stomach in 12% cases and absent in 88% cases (**Table 2**). Kunkel's test was positive in 88% cases, Hoppe-Seyler test in 38% cases and potassium ferrocyanide test in 24% cases (**Table 3** & **Fig 2**).

Table 3 Tests for the Presence of Carboxyhaemoglobin in Blood in Burn Cases

Test	Positive	%
Kunkel's test	44	88
Hoppe-Seyler test	19	38
Potassium Ferrocyanide test	12	24

DISCUSSION

Burnt Lung Pathology: In the present study, soot particles within the trachea were seen in 40% cases (**Table 1** and **Fig 1**). Betz et al[11] observed soot particles in the airways in 86% cases. Aggarwal and Chandra[12] observed this in 4 out of 100 study cases. Betz et al detected soot even when the deceased showed very low carbon monoxide blood saturation. In the present study, in 60% cases,

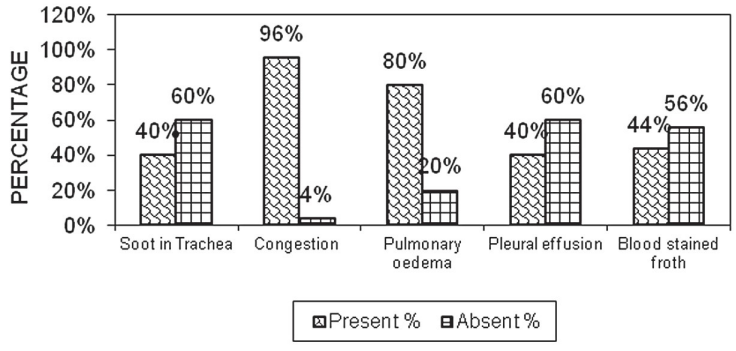

Fig 1 Burn Lung Pathology

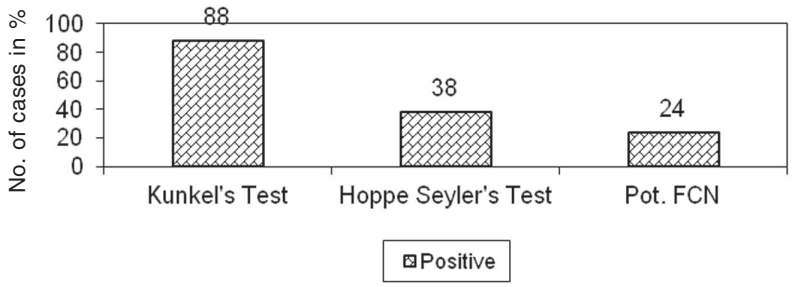

Fig 2 Incidence and Distribution of Tests for Presence of Carboxyhaemoglobin in Blood in Burn Cases

soot examination was negative. Of 60% cases, 4% cases were of postmortem burns and in the remaining 56% cases, the deceased were hospitalized for long durations, so soot examination was negative in them. Suarez-Penarando et al[13] studied two cases of homicidal ligature strangulation with extensive burning of bodies in which histopathological examination of distal airways for soot particles was negative. It is well known that soot particles in the airways constitute good evidence of antemortem burns in cases that do not survive for a long time.

In our study, congestion and desquamation were present in 96% cases, pulmonary oedema in 80% cases, pleural effusion in 40% cases and blood-stained froth in 44% cases. Aggarwal and Chandra[12] observed generalized visceral congestion in the majority of the cases examined by them, along with a common finding of lung oedema.

Soot Particles in Stomach: In the present study, soot particles were seen in the stomach in 12% cases (**Table 2**). Napier[14] described the presence of soot in the oesophagus and stomach, which implied that it had been swallowed, and also indicated life at the start of the fire. As the study was on hospitalized living cases, and the current study is an autopsy study, there is a difference in the observations.

Tests for the Presence of Carboxyhaemoglobin in Blood: In the present study, only qualitative analysis for carboxyhaemoglobin has carried out done using Kunkel's test, Hoppe-Seyler test and potassium ferrocyanide test.[10] Carboxyhaemoglobin was demonstrated with the help of Kunkel's test in 88% cases, Hoppe-Seyler test in 38% cases and potassium ferrocyanide test in 24% cases. (**Table 3** and **Fig 2**). The studies conducted earlier by various authors have involved quantitative estimation of carboxyhaemoglobin. All the three tests and presence of soot particles were positive in 22% cases, and only three tests were positive in 24% cases. No comparative study was available to discuss this issue. Suarez-Penarando[13] studied two cases of homicidal ligature strangulation with extensive burning of bodies in which carboxyhaemoglobin levels were very low along with negative histopathological examination of distal airways for soot particles. Kunkel's test for qualitative estimation was found to be the most sensitive test. In our study, 22% cases were both smokers and alcoholics, and 4% cases were only smokers.

CONCLUSION

Burnt lung pathology showed the presence of soot particles in trachea in 40% cases, congestion and desquamation in 96% cases, pulmonary oedema in 80% cases, pleural effusion in 40% cases and blood stained froth in 44% cases.

Stomach showed the presence of soot particles in 12% cases. Kunkel's test was the most sensitive test for detection of carboxyhaemoglobin qualitatively in blood, with positivity in 88% cases, Hoppe-Seyler test in 38% cases and potassium Ferrocyanide test in 24% cases. All the three tests, as well as presence of soot were positive in 22% cases, and the three tests alone were positive in 24% cases.

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