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Original Research Article

SMOKE TOXICITY AS A SPECIAL DEVELOPING CONDITION IN A MASS FIRE EVENT

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Abstract

We present the case of a mass fire event into enclosed space in Bucharest, generating a smoke explosion. We analyzed patient's lesions and evolution, aiming to appreciate the keystones, key points to learn, and golden standards to establish for fire management, highlighting by molecular docking technique the toxicity of gas resulting from combustion of polymers. Several important lessons were clearly learned from the case, being now constitutive parts of a new concept of intervention, designing and realizing exercises for responders, and ministries with responsibilities to preplan emergency support and evacuation for victims resulting from close space fire events with smoke inhalation, severe poisoning, and extensive burns.

Keywords: smoke inhalation, fire event, burns, poisoning, cyanide, carbon monoxide.

Introduction:

Emergency medicine involves pre-planning and preparedness for unpredictable and unexpected events.

Various emergencies whether intentional or accidental can result in massive burn casualties. Regardless of their nature, all emergencies share common features of collective accidents and a large number of burn victims whose management requires an efficient, integrated workforce and prompt involvement of highly specialized medical centers [1]. However, several different circumstances trigger the manifestation of fire in inhabited spaces, and various associated factors lead to variability among these events. These factors include sex, age, physical capabilities, and individual and collective behaviors of at-risk persons occupying the space in response to the effects of fire, smoke, and collapsing structures such as panic, vital space limitations, disorientation, confusion, and poisoning related to burning of chemical materials [2]. Moreover, scene-specific structural aspects such as the nature and characteristics of materials, especially those used for insulation spaces; alarms and

automatic fire extinguishing systems; support system for self-evacuation in case of emergency, and electronic systems for continuous recording of the number of persons in the space have an overwhelming impact on the functioning of air currents, wave propagation of light, heat, and smoke responsible for victim injuries, and also the reaction of people trapped inside [3]. Specialists from the Polytechnical University of Bucharest presented on November 3, 2015, the results of analyzes of gases inhaled by victims. The burning of the sponge used for sound insulation in the collective club resulted in carbon monoxide, hydrogen cyanide, hydrochloric acid, nitrogen monoxide, but also nitrogen dioxide. The highest share in the resulting gas mixture was held by carbon monoxide, which has a very high affinity for hemoglobin from erythrocytes, together with which it forms a very stable compound - carboxy-hemoglobin and produces death by asphyxiation. In addition to carbon monoxide, hydrogen cyanide has been identified, a highly toxic and corrosive acid to the mucous membrane of the respiratory tract, hydrochloric acid with the same aggressive action against mucous membranes, nitrogen monoxide, and nitrogen dioxide, which are also extremely toxic to the body [4].

Despite some common basic elements, each fire event in populated areas is unique in manifestation and consequences, and each intervention should be customized according to the specificities of the event.

For the emergency medical teams, statistically, a few important elements correlate with severity, prognosis, and anticipation of the lesion profile of patients, and requiring special approach for pre-hospital intervention and hospital preparedness.

Materials and Methods

We present a case of a fire event in a nightclub in Bucharest that occurred on October 30, 2015. During the event, 400–500 individuals were in the club. At approximately 10:30 pm.a fire began as a result of pyrotechnic games.

We aimed to appreciate the intervention keystones, key points to learn, and golden standards to establish, for the each, technical or medical, echelons of intervention in special circumstances. At the same time, we targeted to identify the all necessary changes to implement at operational, tactical and strategic levels of intervention management.

In total, 11 fire trucks and 57 ambulances (including 17 mobile resuscitation units) were deployed.

Our theoretical study with the help of Autodock 4.2 software helps us to understand the disastrous balance of the fire after exposure to high concentrations of toxic gases [5].

Results and Discussion

Fire events in enclosed spaces are associated with significantly low survival with many patients dying at the scene. Fire burns and smoke poisoning are common in these cases. If it is a highly crowded space, disorientation and panic are expected to result in a large number of victims with not only burns but also trauma and smoke inhalation injuries [6].

In this case, the fire was initiated by the ignition of sound insulation foam, generating initially combustion (Figure 1)

Figure 1 – Overcrowded nightclub. The moment of fire initiation

The consequences are resulting in the reproduction of the basic condition of the backdraft: closed space where the fire can start to smolder and produce large quantities of carbon monoxide and unburned hydrocarbons from incomplete combustion, significant quantity alcohol present into space, accelerating the combustion, pressurizing the compartment, and generating important heat.

Gases resulting from the combustion of plastics generate compounds that bind to human hemoglobin (Figure 2) and form complexes with stability comparable to that of the Hb-oxygen complex (Table 1).

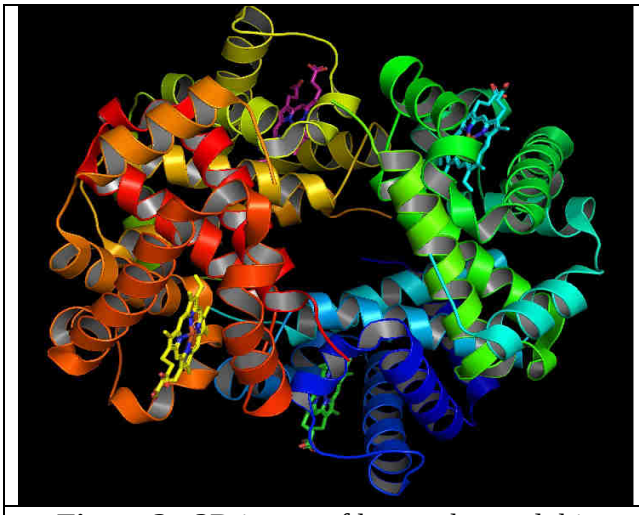

Figure 2 - 3D image of human hemoglobin

Table 1:- stability of smoke compounds that bind to human hemoglobin compared to oxyhemoglobin

Parameter	0xygen	Carbon monoxide	Hydrochloric acid	Hydrogen cyanide	Nitrogen monoxide	Nitrogen dioxide
Binding energy (kcal/mol)	-2.02	-1.94	-1.47	-1.43	-2.00	-2.8

We observe that binding energy of toxic compounds to hemoglobin are favorable then oxyhemoglobin and that led to severe cytotoxic anemia syndrome that, and in the conditions of endotoxinic shock caused by massive tissue destruction (burns), hypovolemia, drug toxicity, and hypoxia, all these have led to the dramatic impact of survival chance.

The second effect was compounded by the only exit door opening, by the victims, in an attempt to escape, generating the smoke explosion by active oxidation reaction of unburned particles, at the moment of oxygen penetration when a rapidly developing flame front spreads through the enclosure burning the available materials, and culminating in a large fireball outside the opening [7]. This association has led to the combined effect of heat, light and smoke production, and, on the other side, of shock waves and blowing effect quickly propagated.

Table 2: – Patients medical needs distribution

Consequences	**Number**
Injured peoples	186
Victims admitted to hospitals	147
Intubated on scene	88
Transferred (abroad burns centers)	43
Declared dead at the scene	26
Declared dead in abroad hospitals	12
Total number of fatalities	65

The present case underscores the need for proactive planning and also provides a coherent working base and consistency [8].

The red plan release decision. The creation and management of stocks of useful materials for burn patients and with related injuries, to assist a minimum of 50 patients simultaneously, immediately deployed on the scene was a crucial planning element. In addition, the regional collective unit for accidents and disasters provided equipment, supplies, and medication for at least another 50–75 patients at a time as part of *the red plan release decision.* [9].

Scene command and control. A succession of command. The unitary command and command succession [10] was onset instantly and started the medical chain (triage, treatment, and discharge – Table 2). Thus, triage inside smoke flooded or unstable structures was assumed, by the firefighters and, their first aid crews. The initial missions were too the rapid localization of victims, extraction, and achieving rapid START triage over a short time (11'from the first fire department team arrival, space was completely evacuated), providing immediate life-saving techniques and rapid evacuation to the medical centers. Structural impediments due to fire and explosion were a potential risk and posed difficulties such as the localization, access, and retrieval of the patient.

Based on the several considerations, the medical scene director (MSDS) decided to not use the Advanced Medical Care Point [11] but only there medical resources: flooded scene by smoke, the expected time to set up the system self-evacuation of victims were already in progress, 6 emergency university hospitals were located approximately 5–18 'from scene, the insufficient space, and an expected large influx of ambulances.

Considering the MSD tactical decision, the resuscitation teams (including 38 emergency medicine physicians) acted directly in the field to provide advanced medical care and stabilize before evacuation (eight patients received cardiopulmonary resuscitation on the field, and 88 patients in critical conditions were tracheal intubated before their arrival at the hospitals), and secondary to transfer patients.

Advanced airway management was also a strategic decision to make before evacuation [12], and, both, adapting the type of oxygenation or ventilation support to patient needs [13], could be considered life-saving [14] for some victims with critical airway condition, smoke inhalation, or intoxication, those without critical burns, and those who were probably pronounced dead upon hospital arrival in case of lower-level management.

Taking into consideration the high number of patients with high plasmatic levels of carbon monoxide and cyanide detected (n= 169), it is possible that a large number of available cyanokit for emergency pre-hospital teams could optimize survival chance for some victims with limited others lesions. [15]

The evacuation decision. The strategy of MSDs for primary medical evacuation was to evacuate to the closest appropriate emergency university hospital around the scene, for evaluation and immediate management of vital lesions and primary surgery for burn lesions, but, to avoid an uncontrolled influx of victims to a unique hospital. [16]. However, approximately 100 critical victims who required the emergent use of operating rooms, help from surgical and anesthetic teams, and advanced life support devices, arriving simultaneously in 11 hospitals, were a source of an extreme challenge for the medical system. This clearly explains why the hospitals were rapidly overcrowded with critical patients who needed surgical attention, ICU and technical facilities over a long period.

Subsequently, the smoke toxicity causes itself acute systemic and pulmonary life-threatening injuries. It is well known acute adult respiratory distress (ARDS) as part of multiple organ dysfunctions in prolonged endotoxic and hypovolemic shock [17]. When smoke inhalation occurs, the direct irritative pulmonary injury and systemic asphyxia injury are associated with burns. The complex effects of cyanide and carbon monoxide on cellular respiration resulting in hypoxia (binds to the ferric ion in cytochrome oxidase a3 within the mitochondria, blocking the reduction of oxygen to water, and respectively binds hemoglobin strongly than oxygen and blocking oxygen transport and delivery to the tissues) generates medical demands such as extracorporeal oxygenation [18], and antidotes techniques and tactics which have to be accomplished in the same time with the regular treatment for burns lesions.

In the second stage of the evacuation, selected patients (from the event but with minor injuries or from the clinical hospital without urgent special needs but risky to discharge) were transferred to the backup centers.

Tertiary evacuation. Since the start, tertiary support from multiple highly specialized centers for burns appeared mandatory. In the following few days, 43 patients were evacuated abroad.

Conclusion

Fire in overcrowded enclosed spaces is always a peculiar event with a huge

potential to develop into a mass casualty, which may become the most challenging test of the intervention safety and emergency medical systems resilience.

Immediate attempts of self-evacuation, various trauma-related chaos, smoke inhalation and poisoning in burned or unburned victims are common. That explains the huge number of fatalities (over one-third of them in the scene) even to the very young and healthy peoples, long period of mandatory ventilation, needs for extracorporeal oxygenation and other advanced life support techniques, which may become restraint capabilities for long-term management.

In this situation, the gold standard of such intervention is not easy to define and prioritize.

All the aforementioned aspects are lessons learned, and all the conclusions based on the event and intervention analyses are now constitutive parts of checklists of operational, tactical and strategic responders.

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