

# Triage Of Fire Smoke Intoxicated Victims In A Disaster Situation

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## Abstract

Fire and disasters are often linked together. The smoke inhalation is one of the important pathologies found in fires and that could be lethal, lead to serious sequels or it could be of no importance, as well. In a disaster situation, the number of intoxicated victims could be large and their triage is of importance to select those who can benefit of treatment. We focus our attention on smoke inhalation cases, clinical presentation and importance of diagnostics even in a disaster situation. Measurement of breath carbon monoxide in the pre-hospital setting is interesting to diagnose poisoning and to help to find real smoke inhalation victims in a crowd of involved and stressed people.

## FIRE AND DISASTERS

Fire and disaster are linked together : every fire can become a disaster, for example a building fire, especially when it is a public building where potential victims are numerous as in dancing hall (Cocoanut Grove Night Club Fire in Boston, USA [1,2] in 1942 where 489 people died and 131 wounded were treated in the hospital) or an airport fire (fire of the airport Dusseldorf, Germany [3] where 62 people were intoxicated) or forest fire near residential zone ( Berkeley California forest fire [4] in 1991 with report of 25 fire-related deaths and 241 people with fire-linked health problems). A long list of disaster fires are listed by Favre [6] where one can find historical fires such as a circus fire in St. Petersburg, Russia in 1836 (800 dead), a theatre fire in Canton China in 1845 (1670 dead), a church fire in Santiago, Chile in 1848 (2500 dead) or more recent disasters as the fire of the MGM Hotel in Las Vegas, USA in 1980 (86 dead) or the stadium fire in Bradford, UK in 1985 (53 dead) or a forest fire in the North of China in 1987 (193 dead). Fire could be secondary to traffic, train or aeroplane accidents. Tunnel fire accidents are dominated by smoke inhalation, for example in a train fire in Zurich [5] with 140 passengers of the train trapped in a tunnel while the train was burning, resulting in 58 inhalation injuries or the Subway Fire in Baku in 1995 resulting in 289 dead and 256 poisonings and other casualties [16]. More classical major disasters as earthquake, volcano eruption, terrorist bombing, urban riots, classical or nuclear bombing,... are followed by fire.

## PATHOLOGICAL STATES OFTEN CAUSED BY THE FIRE

Some of the pathologies encountered during fire are highly specific and others nonspecific. The specific pathologies include burns and smoke intoxication and nonspecific ones are traumatic lesions, blast injuries and hyperthermia. The smoke intoxication is very frequent in the context of fire but it is frequently hidden by an other state more visible and better known, such as a burn. Emergency clinicians must keep in mind all the possible diagnoses in the context of the fire. Closed trauma and blast injuries have in common with smoke inhalation their hidden lethal potential : an apparently unharmed patient can collapse because of a major lung oedema [15] (in the smoke example), or intestinal perforation (in the blast example) and will thus escape the medical attention even more easily in a disaster context where rescue teams have other things to do than running after apparently unhurt victims.

## SMOKE

More than hundred toxic substances are known to be present in the fire smoke. Research in the chemistry and occupational hygiene [7, 8, 9, 10, 11] showing the presence of all these toxicants have to be validated by clinical research [12,13]. On the top of the list is the carbon monoxide which plays certainly a role, but other products could be as toxic like hydrocyanic acid [14], acrolein, hydrogen chloride, phosgene, sulphur and nitrogen dioxide among others. These

products are found in the smoke as gases, aerosol or are adsorbed on solid soot particles. Clinical effects of smoke could be divided into two categories : asphyxia and lung irritation or respiratory tract injuries.

Asphyxia by deprivation of oxygen in ambient air, by CO or by HCN intoxication is characterised by immediate death or coma with cardiovascular instability. Less heavy situation could be characterised by nonspecific symptoms, as vertigo, nausea and headache, disorientation and neurological symptoms. A trap for the physician is the possible grave subclinical intoxication. A 40 % HbCO carbon monoxide intoxication could be accompanied by no symptoms before coma, when the time to become intoxicated is very brief, as in all fires. For a decision to treat we have to remember that neuropsychological sequels, immediate or delayed touch up to 50% [17] of the victims regardless of the level of carboxyhemoglobin (from 15% upwards) or of the clinical initial picture.

Irritative effects of soots and different smoke gases and components are clinically evident as many of the victims complain of eye or skin itching, throat pain and cough. This irritation could be extremely severe up to chemical burns (which can mix with thermal burns in the upper respiratory tract). Victims can be immediately very symptomatic (heavy cough, dyspnea, obstructive respiratory failure) explained by a bronchospasm, soot obstruction or chemical oedema) or can only produce mild symptoms without the victim being protected against a possible sudden and delayed lung oedema [15].

### **DIAGNOSIS**

In the pre-hospital setting there will be no difference in the diagnostic approach between « every day case » and the disaster situation. However in the latter case the therapy is not available for everybody ; it means that accurate diagnosis is even more important. We suggest in table 1 diagnostic criteria ; they should still be validated by prospective clinical studies.

The history of the intoxication is important to the understanding of the real exposure : was the patient exposed to smoke in a closed area ? Could the patient find the exit alone or was he rescued by the fire fighters or was he prisoner of the fire and the smoke ? Did the patient faint ? We think that these three key-words are discriminant for diagnostic reasoning i.e., smoke inhalation in closed area, prisoner of the fire / smoke, trouble of conscious in the smoke. Presence or absence of headache, nausea and vertigo

are in our mind not so important because they are absolutely nonspecific and that their absence cannot exclude carbon monoxide intoxication. It is interesting to note the presence of coronary thoracic pain but we have to differentiate it from an irritative bronchopulmonary pain which is a retrosternal or suprasternal constant burning pain. Change in the voice or trouble to speak are also important to note.

The clinical examination begins with the primary survey (ABC). It is of vital importance and by no means specific. It doesn't matter to miss the specific diagnosis at this point because the therapy of intoxicated victims with ABC compromise is life supporting, only. Even in the absence of the toxicological diagnoses, high-dose oxygenotherapy is given, airway and breathing controlled and hemodynamic troubles corrected. It is the basis of emergency treatment for carbon monoxide or hydrocyanic acid intoxication and of smoke inhalation related respiratory failure. An early specific diagnosis will not lead to the use of antidote as hydroxocobalamin and hyperbaric oxygenotherapy because of their lack of availability in a disaster situation. We should just worry about dangers of intubation and general anesthesia in a smoke intoxicated patient (CO/HCN latent hypoxia and soot obstruction of trachea / bronchi).

During the secondary survey one can observe the symptoms and signs aiding in the positive diagnosis of inhalation. They are e.g. soot around the mouth, soot on the tongue or pharynx, burning of the face, of the vibrissae in the nostrils and foetor of smoke. The presence of smoke on clothes or face is not diagnostic. Complaints or clinical signs of irritation of eyes, throat, or bronchi just prove the exposure to smoke and not a clinically significant smoke inhalation.

Pre-hospital paraclinical investigations are not numerous. Pulse oxymetry cannot be used to exclude intoxication because the carbon monoxide is counted as oxyhemoglobin by the device. Low oxygen saturation is to be interpreted as a respiratory failure (gas exchange or mechanical compromise). Breath CO can be measured in the prehospital setting with an easy device (Bedfont's Microsmokerlyzer) where patient has to exhale after a 15 second apnea in a CO detector. Correlation between breath CO and HbCO level is easily done by the device. It is of good value to confirm or exclude the CO intoxication. Furthermore, we think that the presence of even a slight CO intoxication is an other diagnostic criterion for the smoke inhalation syndrome.

Table 1 : diagnostic criteria of smoke inhalation syndrome

History

- inhalation in closed area
- prisoner of the smoke / fire
- troubles of consciousness in the smoke

Clinical examination

- face burn
- vibrissae in the nostrils burn
- soot on the tongue and pharynx
- change of voice
- foetor of smoke

Breath CO If carboxyhemoglobin >5% (>10% by smokers)

**TRIAGE**

The context of fire brings to you a mix of smoke exposed and involved persons, all stressed, walking or lying, intoxicated or just involved. Triage in this situation is very important. The aim is to save lives in the different stages of the rescue : first we have to save lives of victims in coma and respiratory failure by major clinical manoeuvres; secondly to save lives of victims with potentially dangerous conditions or complications as myocardial infarction, throat oedema and CO intoxication, by emergency treatment, monitoring and rapid transport to hospital. Diagnostic and treatment of CO intoxication come at this place too.

We have then the task of determining who is smoke-intoxicated among the other victims or involved persons, and to organise medical monitoring over the next following two days (in a hospital or outpatient structure), to detect if lung oedema appears, saving thus a few additional lives. The use of oxygenotherapy is mandatory for all HCN and CO intoxication cases, but not for a « smoke » intoxication ; triage can thus save oxygen. Triage permits us to prevent disorganisation in hospital settings by retaining on the site of the accident patients with smoke inhalation who have no diagnostic or therapeutic reason to be transported to the hospital. This reasoning must be modified if there is no method to measure CO on site. It is therefore impossible to distinguish apparently slightly smoke intoxicated victim from significantly CO intoxicated ; we have to transfer these victims under oxygenotherapy to the next hospital which has

a co-oximeter.

Table 2 summarises our triage propositions. We use the international classification of triage where BLACK are hopeless patients, RED patients are with ABC compromise needing immediate resuscitation, YELLOW patients need urgent hospital treatment and the GREEN patients are those who can wait. Attention is focused on smoke intoxication pathologies : indeed, other pathologies are to be found in this situation such as polytrauma, blast, and burn which may modify the triage and treatment.

**Figure 1**

Table 2 : triage of smoke inhalation victims

Triage category	Clinical situation	treatment
BLACK	cardiac arrest	<ul style="list-style-type: none"> <li>• in routine conditions resuscitate as any other cardiac arrest and perhaps try hydroxocobalamin</li> <li>• in disaster situation, consider immediately as dead</li> </ul>
RED	unconscious respiratory failure hemodynamic failure	<ul style="list-style-type: none"> <li>• oxygenate at high doses <math>F_iO_2 = 1.0</math></li> <li>• iv line and volume infusion</li> <li>• consider intubation under general anesthesia</li> <li>• consider bronchodilator</li> <li>• consider hydroxocobalamin and HBO</li> </ul>
YELLOW	smoke inhalation with <ul style="list-style-type: none"> <li>• voice changes, stridor</li> <li>• cardiac arrhythmias</li> <li>• coronary thoracic pain</li> <li>• bronchospasm</li> </ul> CO intoxication with <ul style="list-style-type: none"> <li>• breath CO &gt; 20% HbCO</li> <li>• initial unconsciousness</li> <li>• neurological troubles</li> </ul>	<ul style="list-style-type: none"> <li>• high doses oxygenotherapy</li> <li>• iv line</li> <li>• vital sign monitoring</li> <li>• early transfer to hospital</li> <li>• consider nitroglycerine and morphine for coronary pain</li> <li>• consider bronchodilator</li> </ul>
GREEN	Inhalation syndrome : history, examination and breath CO > 5-10%	<ul style="list-style-type: none"> <li>• consider delayed transfer to hospital or other care structure</li> <li>• pulmonary auscultation every 6 to 24 hours for two days</li> </ul>

HBO = hyperbaric oxygenotherapy ; HbCO = carboxyhemoglobin

**CONCLUSION**

Physiological or anatomical triage systems developed for trauma patients must be profoundly adapted for toxicological situations. Fire smoke intoxication is an example of disaster where intoxication is predominant. We have proposed diagnostic criteria and categorisation of victims. The use of breath CO measurement is not yet widely applied and could be of importance in this situation.

**References**

1. C.S. Davidson ; The Cocoanut Grove disaster, The Journal of Infectious Diseases, 1972,125 :S58-S59.
2. M. Finland, C.S. Davidson, S.M. Levison ; Clinical and therapeutic aspects of the conflagration injuries to the respiratory tract sustained by victims of the Cocoanut Grove disaster ; Medicine 1946,25(3) :215-283 and The Journal of Infectious Diseases 1972,125 :S60-S73.
3. J. Schmitz-Beuting ; Die Brandkatastrophe am Flughafen Dörf ; Der Notarzt 1996,12 :108-111.
4. D. Shusterman, D. Kaplan, C. Canabarro ; Immediate health Effects of an Urban Wildfire; West J Med 1993,158 :133-138.
5. Wenker O, Wenker E, Train Fire in Zürich Switzerland ; The Internet Journal of Disaster Medicine 1997, Vol1N1.
6. R. Favre ; les Incendies Catastrophiques in :L'Homme et les Catastrophes, Edition France-Sition.
7. R.A. Orzel ; Toxicological aspects of firesmoke : polymer pyrolysis and combustion in Occupational Medicine : State of the Art Reviews, 1993,8(3) :414-429.
8. W.T.Lowry, L. Juarez, C.S. Petty, B. Roberts ; Studies of Toxic Gas Production During Actual Structural Fires in the Dallas Area ; Journal of Forensic Sciences, 1985,30(1) :59-72.
9. J. Jankovic, W. Jones, J. Burkhart, G. Noonan ; Environmental Study of Firefighters ; Ann occup Hyg, 1991,35(6) :581-602.
10. P.W. Brandt-Rauf, L.F. Fallon, T. Tarantini, C. Idema, L. Andrews ; Health hazards of fire fighters : exposure assessment ; British Journal of Industrial Medicine, 1988,45 :606-612.
11. B.C. Levin, The development of a new small-scale smoke toxicity test method and its comparison with real-scale fire tests. Toxicology Letters, 1992,64/65 :257-264.
12. D.J. Shusterman ; Clinical smoke inhalation injury : systemic effects in : Occupational Medicine : State of the Art Reviews 1993,8(3) :469-502.
13. W. Summer, E. Haponik ; Inhalation of irritant gases ; Clinics in Chest Medicine 1981,2(2) :273-287.
14. F.J. Baud, P. Barriot, V. Toffis, B. Riou, E. Vicaud, Y. Lecarpentier, R. Bourdon, A. Astier, C. Bismuth ; Elevated blood cyanide concentrations in victims of smoke inhalation, N Engl J Med 1991 ;325 :1761-6.
15. R.F. Dyer, V.H. Esch ; Polyvinyl chloride toxicity in fires : hydrogen chloride toxicity in fire fighters ; JAMA 1976,235 :393-397.
16. B. Wahlstrom (Stockholm Fire Department) ; The Baku Subway Fire ; unpublished data.
17. D.F. Gorman, D. Clayton, J.E. Gilligan, R.K. Webb ; A longitudinal study of 100 consecutive admissions for carbon monoxide poisoning to the Royal Adelaide Hospital ; Anesth Intens Care 1992, 20, 311-316.

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