Pharmacological treatment of inhalation injury after nuclear or radiological incidents: The Chinese and German approach[1]

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The complexity of fire smoke

Inhalation injury is often associated with burns and significantly increases morbidity and mortality. The composition of fire smoke is very complex and depends on the burning material, the availability of oxygen, the temperature and chemical reactions between the constituents. Moreover, fire smoke composition varies over time. The main toxic components of fire smoke are **carbon monoxide**, **hydrogen cyanide** and **irritants**. In the case of an incident in a nuclear power plant or recycling facility associated with fire, smoke may also contain **radioactive material**.
Medical treatment may vary in different countries. We examined and compared the therapeutic approaches and the drugs/antidotes available and mainly used in treating inhalation injury victims in China and Germany. The treatment of burns or acute radiation sickness by external irradiation was not considered.

Smoke compounds

Carbon monoxide (CO)

CO is formed by incomplete oxidation of carbon. It has a high affinity for hemoglobin and binds Hb 200-300 times stronger than O_2 (Hb-O_2 + CO -> Hb-CO + O_2). Hb-CO cannot bind and transport O_2. The O_2 transport capacity of blood is reduced leading to cellular asphyxia.

Therapy

Immediate supply of O_2 and speeding up the elimination of Hb-CO is essential (administration of 100 % O_2 at ambient pressure, 1 bar, 760 mmHg). If available, hyperbaric oxygenation can be conducted.

Hydrogen cyanide (HCN)

HCN is formed by combustion of nitrogen-containing coumpounds. CN^- inhibits the mitochondrial respiratory chain leading to cellular asphyxia.

Therapy

Therapy of CN^- intoxication consists of 3 components (see figure 1):

1. Administration of 100 %O_2
2. Binding CN^- and releaving the respiratory chain (Met-Hb-forming agents or hydroxocobalamine for direct binding)
3. Speeding up CN^- metabolism (sodium thiosulfate)

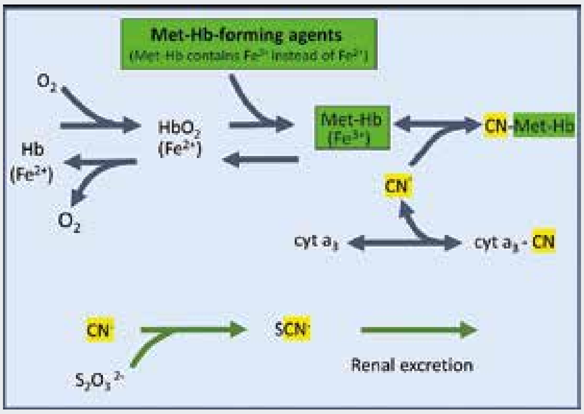

Fig. 1: Action mechanisms of Met-Hb-forming agents and thiosulfate in cyanide intoxications

Irritants

Various combustion products may be produced with differing penetration capacities depending mainly on solubility, but also on their concentration.
By dissolving in water, these products form corrosive acids or alkalis that will damage the cell linings of the airway.

Therapy

Therapy of airway irritations by smoke compounds is conducted symptomaticaly:

- Inhalative or systemic steroids are not used systematicaly for the prevention of toxic lung edema (negative effect on the outcome in burn patients)
- Steroids may however be given e.g. in case of laryngeal edema, bronchospasm, etc.
- Fiberoptic diagnosis of airway injury at hospital admission and bronchial hygiene (at the same time removal of radioactive particulates) may be required.
- Respiratory support is given as needed: Oxygen, invasive or non-invasive ventilation.
- Adjunct drug therapy as used for respiratory insufficiency (e.g. antibiotics in case of infections, etc.) may be required.

[1]For full article see:
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Radionuclide(s)
The incorporated nuclides depend on the facility damaged and/or the kind of accident. In most cases the radiological dose by radionuclide incorporation is not suited to cause an acute radiation sickness, but long term stochastic health effects must be expected.

Therapy
Goal of each therapy is the decorporation of the radionuclide(s). Efficacy decreases if treatment initiation is delayed.

The time slot for a highly efficacious decorporation treatment depends on the nuclide, the physicho-chemical properties of the compounds involved and the invasion pathway and lies in a range of hours to several days (see figure 2).

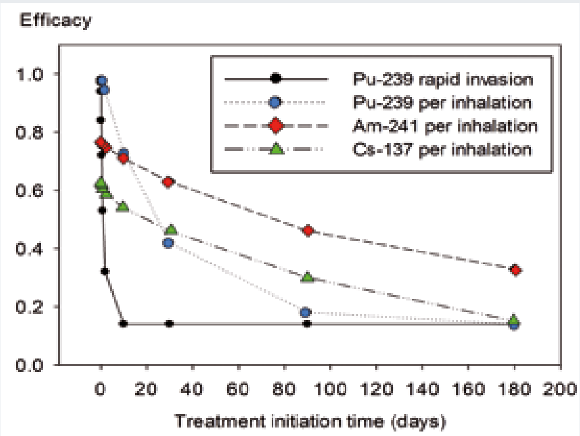

Fig. 2: Efficacy of decorporation treatment is depending on the time from incorporation to treatment.

Table 1: Antidotes used in China and Germany against toxic compounds of fire smoke including radioactivity

Poison	Antidotes	
		
Carbon monoxide	100 % O_2 Hyperbaric oxygenation (if possible)	100 % O2 Hyperbaric oxygenation (if possible)
Cyanide	Sodium nitrite Sodium thiosulfate	Dimethylaminophenol / Hydroxocobalamine Sodium thiosulfate
Irritans	No systematic steroid administration	No systematic steroid administration
Radionucilde(s)	Stable iodine Ca(DTPA) (lower dosage) Prussian Blue	Stable iodine Ca(DTPA) Prussian Blue

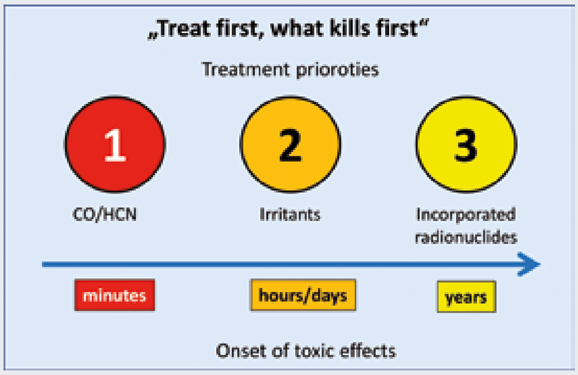

Fig. 3: Treatment priorities are the same in China as in Germany.

Treatment in China and Germany

„Treat first, what kills first“ is the principle of each therapy. Treatment priorities depending on the onset time of toxic effects of different smoke compounds are shown in figure 3.

Conclusion

General therapeutic strategies for treatment of victims from inhalation injury are very similar in China and Germany. The choice of antidotes for the treatment of cyanide intoxication shows the main differences: DMAP as methemoglobin-generating compound in Germany vs. sodium nitrite in China and no use of hydroxocobalamine in China (Table 1).

In case of a contamination of fire smoke with radionuclide(s), dosage of Ca(DTPA) for decorporation treatment in China is lower (Germany: 1 g/day; China: initially 0.1-0.5 g/day followed by 0.1 g/day).

Manuscript data

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