BASF Chemical Emergency Medical Guidelines

Sulfur dioxide (SO_2) C 1

Information and recommendations for doctors at hospitals/emergency departments

- **Patients exposed only to sulfur dioxide gas do not pose a significant risk of secondary contamination. Patients whose clothing or skin is contaminated with liquid sulfur dioxide (boiling point –10°C, 14°F, respectively) can secondarily contaminate rescue and medical personnel by direct contact or through off-gassing sulfur dioxide.**
- **Sulfur dioxide gas is rapidly corrosive when it comes in contact with moist tissue such as the eyes, skin, and upper respiratory tract causing eye irritation, coughing, chest pain, dyspnea, and bronchoconstriction. Laryngospasm and signs of pulmonary edema (shortness of breath, cyanosis, expectoration, cough) may occur.**
- **There is no antidote to be administered to counteract the effects of sulfur dioxide. Treatment consists of supportive measures.**

1. Substance information

Sulfur dioxide (SO_2), CAS 7446-09-5
Synonyms: sulfurous anhydride
Sulfur dioxide is, at room temperature, a colorless, nonflammable gas with a pungent, irritating, suffocating sulfur odor. Under pressure or at temperatures below –10°C (14°F), it is a clear liquid. Sulfur dioxide is soluble in water and forms sulfurous acid (H_2SO_3).
Sulfur dioxide is used in ore and metal refining, chemical manufacturing, wood pulp treatment in paper manufacturing, extracting lubricating oils, as a preservative, fumigant, disinfectant, reducing agent, antioxidant in magnesium processing, bleaching agent, fungicide, insecticide, and as a food additive or preservative.

2. Routes of exposure

Inhalation

Most exposures occur by inhalation. Sulfur dioxide's odor and irritant properties generally provide adequate warning of hazardous concentrations; however, olfactory fatigue may occur. Asthmatic subjects may respond to concentrations below the odor threshold. Prolonged low-level exposure may result in olfactory fatigue and tolerance of its irritant effects. Sulfur dioxide is heavier than air and may cause asphyxiation in poorly ventilated, low-lying, or enclosed spaces.

Skin/eye contact

Direct contact with liquid sulfur dioxide or gas on wet or moist skin causes severe chemical burns, leading to cell death and ulceration.

Ingestion

Ingestion of sulfur dioxide is unlikely because it is a gas at room temperature.

3. Acute health effects

Respiratory

Exposure to low concentrations of sulfur dioxide usually causes sore throat, coughing, and bronchoconstriction. Rapid development of respiratory distress, with chest pain, dyspnea, and laryngospasm and pulmonary edema may occur with inhalation of high concentrations of sulfur dioxide gas. Pulmonary injury may progress over several hours. After severe exposure, respiratory and cardiovascular failure may occur.

Dermal

Deep burns of the skin and mucous membranes may be caused by contact with concentrated sulfur dioxide; disfiguring scars may result. Contact with less concentrated sulfur dioxide gas can cause burning pain, redness, inflammation, and blisters. Contact with liquid sulfur dioxide under pressure can result in frostbite.

Ocular

Low gas concentrations cause burning discomfort, spasmodic blinking or involuntary closing of the eyelids, redness, and tearing. Corneal burns may occur at high concentrations.

Dose-effect relationships

Dose-effect relationships are as follows:

Sulfur dioxide concentration		Effect
0.5-2 ppm	-	Pulmonary function changes in exercising asthmatic subjects
3-5 ppm	-	Odor detection (some tolerance develops)
8-20 ppm	-	Throat and conjunctival irritation and lacrimation
50-100 ppm	-	Strong eye, throat, and lower respiratory tract irritation, tolerated for 30-60 minutes
400-500 ppm	-	Lethal after 1 minute

Potential sequelae

If the patient survives the initial 48 hours after exposure, recovery is likely. After acute exposure, pulmonary function usually returns to normal in 7 to 14 days. Complete recovery is usual; however, symptoms and pulmonary deficits may persist. Airways hyperreactivity to non-specific irritants may persist, resulting in bronchospasm and chronic inflammation of the bronchi; sulfur dioxide-induced reactive airways dysfunction syndrome has been reported to persist for years. Sequelae of the pulmonary tissue destruction and scarring may lead to bronchiolitis obliterans, chronic dilation of the bronchi and increased pulmonary susceptibility to infection. Chronic or prolonged exposure to sulfur dioxide has been associated with increased risk of chronic obstructive pulmonary disease.

4. Actions

Self-protection

Patients exposed only to sulfur dioxide gas do not pose a significant risk of secondary contamination. Patients whose clothing or skin is contaminated with liquid sulfur dioxide can secondarily contaminate other people by direct contact or through off-gassing sulfur dioxide.

Decontamination

Patients exposed only to sulfur dioxide gas who have no evidence of skin or eye irritation do not need decontamination. All others require decontamination.
Patients who are able and cooperative may assist with their own decontamination. If the exposure involved liquid sulfur dioxide and if clothing is contaminated, remove and double-bag the clothing.
Assure that exposed or irritated eyes have been irrigated with plain water or saline for at least 20 minutes. If not, continue eye irrigation during other basic care.
Remove contact lenses if present and easily removable without additional trauma to the eye.
Assure that exposed skin and hair have been flushed with plain water for at least 15 minutes. If not, continue flushing during other basic care. Protect eyes during flushing of skin and hair.

Initial treatment

Therapy will be empiric; there is no antidote to be administered to counteract the effects of sulfur dioxide.
The following measures are recommended if the exposure dose is 8-20 ppm or greater (depending on time exposed), if symptoms, e. g. eye irritation or pulmonary symptoms have developed, or if no exposure dose can be estimated but exposure has possibly occurred:

- **Administration of oxygen**
- **Administration of 8 puffs of beclomethasone (800 µg beclomethasone dipropionate) from a metered dose inhaler.**

Patients with severe clinical respiratory symptoms (e.g. bronchospasms, stridor) should be treated as follows:
a) Nebulization of adrenaline (epinephrine): 2 mg adrenaline (2 ml) with 3 ml NaCl 0.9% and inhale through a nebulizer mask.

b) Administration of a ß2-selective adrenoceptor agonist, e.g., four strokes of terbutaline or salbutamol or fenoterol (one stroke usually contains 0.25 mg of terbutaline sulfate; or 0.1 mg of salbutamol; or 0.2 mg of fenoterol); this may be repeated once after 10 minutes. Alternatively, 2.5 mg salbutamol and 0.5 mg atrovent may be administered by nebulizer mask.
If inhalation is not possible, administration of terbutaline sulfate (0.25 mg to 0.5 mg) subcutaneously or salbutamol (0.2 mg to 0.4 mg over 15 minutes) intravenously.

c) Intravenous administration of 250 mg methylprednisolone (or equivalent steroid dose).

Patients with clinical signs of a toxic lung edema (e.g. foamy sputum, wet crackles) should be treated as follows:

a) Start CPAP-therapy (Continuous Positive Airway Pressure Ventilation).
b) Intravenous administration of 1000 mg methylprednisolone (or an equivalent steroid dose) is recommended.

Intubation of the trachea or an alternative airway management should be considered in cases of respiratory compromise. When the patient's condition precludes this, consider cricothyrotomy if equipped and trained to do so.

Note: Efficacy of corticosteroid administration has not yet been proven in controlled clinical studies.

If sulfur dioxide has been in contact with the moist skin, chemical burns may result; treat as thermal burns: adequate fluid resuscitation and administration of analgesics, maintenance of the body temperature, covering of the burn with a sterile pad or clean sheet. Contact with liquid sulfur dioxide under pressure can result in frostbite.
After eye exposure chemical burns may result; treat as thermal burns. Immediately consult an ophthalmologist.
Note: Any facial exposure to liquid sulfur dioxide should be considered as a serious exposure.

Further evaluation and treatment

To the standard intake history, physical examination, and vital signs add pulse oximetry monitoring and a PA chest X-ray.
Spirometry should be performed. Routine laboratory studies should include a complete blood count, blood glucose and electrolyte determinations.
Evidence of pulmonary edema - hilar enlargement and ill-defined, central-patch infiltrates on chest radiography - **is a late finding that may occur 6 to 8 hours or later after exposure. The chest X-ray is typically normal on first presentation to the emergency department even with severe exposures.**
Patients who have possible exposure or who develop serious signs or symptoms should be observed for a minimum of 24 hours and reexamined frequently before confirming the absence of toxic effects. Delayed effects are unlikely in patients who have minor upper respiratory symptoms (mild burning or a slight cough) that resolve quickly.
If oxygen saturation is less than 93 % or if it appears to drop, immediately check arterial blood gasses and repeat the chest X-ray.
If blood gasses begin to show deterioration and/or if the chest X-ray begins to show pulmonary edema start oxygen supplementation.
In case of worsening clinical signs (especially tachypnea >30/min with a simultaneous decrease of the partial pressure of carbon dioxide) CPAP-

therapy (Continuous Positive Airway Pressure Ventilation) should be started within the first 24 hours after exposure.
In case of a pulmonary edema fluid intake/output and electrolytes should be monitored closely. Avoid net positive fluid balance. Central line or Swan-Ganz catheterization might be considered, to optimize fluid management.
As long as signs of pulmonary edema are present, intravenous administration of methylprednisolone (or an equivalent steroid) should be continued in intervals of 8-12 hours.

Prophylactic antibiotics are not routinely recommended but may be used based on the results of sputum cultures. Pneumonia can complicate severe pulmonary edema.

Patient release/ follow-up instructions

Asymptomatic patients exposed to a concentration of **less than 8-20 ppm** (depending on the period of time exposed) **as well as patients who have a normal clinical examination and no signs or symptoms of toxicity may be discharged after an appropriate observation period in the following circumstances:**

a) The evaluating physician is experienced in the evaluation of individuals with sulfur dioxide exposure.
b) Information and recommendations for patients with follow-up instructions are provided verbally and in writing. Patients are advised to seek medical care promptly if symptoms develop or recur.
c) The physician is comfortable that the patient understands the health effects of sulfur dioxide.
d) Site medical is notified, so that the patient may be contacted at regular intervals in the 24-hour period following release from the emergency department.
e) Heavy physical work should be precluded for 24 hours.
f) Exposure to cigarette smoke should be avoided for 72 hours; the smoke may worsen the condition of the lungs.

Patients who have serious skin or eye injuries should be reexamined in 24 hours.
Post discharge spirometry should be repeated until values return to the patient's baseline values.

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