Occupational contact dermatitis in manual cloud seeding operations

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ABSTRACT

This is a case report on irritant contact dermatitis secondary to calcium oxide exposure during manual cloud seeding operations. A less hazardous substitute such as sodium chloride should be considered wherever possible. Cloud seeding operations are briefly discussed in this report, and the impact of calcium oxide exposure as an occupational hazard is elaborated.

Keywords: calcium oxide, cloud seeding, contact dermatitis, occupational hazards

Singapore Med J 2011;52(5):e85-e87

INTRODUCTION

Airborne manual cloud seeding is one of the methods used to alter the weather. This method requires a crew of personnel operating on board a transport aircraft and has the advantage of being able to deploy large amounts of seeding agent over a wide area. This report describes a case of occupational contact dermatitis resulting from chemical exposure during such operations.

CASE REPORT

A 20-year-old man presented at the medical centre with a rash on both cheeks. The rash had appeared the day before, following his first flight as part of a manual cloud seeding crew. He first noticed the rash after the flight but proceeded home, assuming that the rash would resolve overnight. However, it persisted and by the next morning, he noticed superficial flaking of the skin. This was the first time the patient had experienced this kind of rash. He described it as mildly painful and itchy. No sign of fever, gastrointestinal symptoms, chest or joint pains was observed. He had no history of atopy, asthma or skin conditions. The patient was a non-smoker, infrequent social alcohol drinker and was not on any regular medication. He had no other medical history, and his prior consults at the medical centre were for upper respiratory tract infections, the most recent being six months ago. There was also no family history of atopy or skin disorders.

On examination, the rash was pinkish-red, with scaling and mild superficial sloughing of the epidermis. There were no vesicles or bullae, and the distribution was limited to the cheeks. It was noted to be symmetrical bilaterally and sharply demarcated superiorly, 2 cm below the orbit, medially and inferiorly along the nasolabial fold. However, the lateral edge was not as well defined. A diagnosis of acute contact dermatitis, likely caused by an irritant, was made. No laboratory investigations were ordered and no patch testing was done. Hydrocortisone 1% cream was prescribed and the case was subsequently referred to the occupational medicine service for further investigation.

The patient was seen by an occupational medicine physician within 24 hours. Detailed history-taking elucidated the following salient points: (a) The patient had just completed his first flight as part of a manual cloud seeding crew; although he had previously flown, this was his first flight in which an actual agent was dispensed; (b) The agent used was different from that previously used. Further investigations revealed that the meteorological engineers had requested for calcium oxide (CaO) instead of the usual sodium chloride (NaCl) agent; (c) Throughout the operation, he was wearing his normal long sleeve coveralls with safety boots, additional fabric gloves, goggles and an N95 mask; (d) His role as part of the team was as a dispenser, half of a two-man team that physically dispensed the agent down the dispensing chute.

The Material Safety Data Sheet for CaO was consulted, and it was noted that upon contact with water or sweat, CaO converts to calcium hydroxide ($Ca(OH)_2$), an alkali. The other members of the cloud seeding team were examined, and two other members of the 11-member crew were also found to have a mild erythematous rash along the same distribution as the index case. However, it had not caused any discomfort and they had not sought medical attention. The occupational medicine physician concluded that the rash was an irritant contact dermatitis secondary to CaO exposure. During dispensation of the agent, CaO dust had accumulated along the area between the goggles and the N95 mask, resulting in a local build-up of the concentration of the agent. CaO, on contact with the personnel's sweat, was converted to its alkaline hydroxide form, thus causing local irritation and the resultant dermatitis. All three cases of dermatitis resolved quickly, with no further sequelae.

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New operating guidelines for the use of CaO as a dispensing agent were issued. The final guidelines required all dispensing personnel to be issued with impermeable disposable overalls and full-face N95 respirators. Furthermore, the use of CaO was advocated only if the operational requirements precluded the use of NaCl. Lastly, an additional safety brief was made mandatory for all sorties involving the use of CaO.

DISCUSSION

In 1994, 27 countries worldwide reported their involvement with weather modification activities.[1] Cloud seeding is a method used to alter the weather; it is used to create increased precipitation, which can manifest as rain or snow, as well as to reduce the size of hailstones and clear fog. The principle behind cloud seeding is broadly divided into three hypotheses:[1] static seeding, dynamic seeding and hygroscopic seeding.

Static seeding involves the introduction of a crystalline agent into clouds with the intent of forming a nucleus to encourage further freezing. The nucleus grows in size as existing water droplets in the clouds freeze around it, thus increasing the particle size. When the particle reaches a certain size, it then falls as snow or rain. In dynamic seeding as well, a crystalline agent is introduced into the clouds to encourage the freezing of super-cooled liquid water. However, it is postulated that the latent heat released by the freezing process increases the buoyancy, depth and vigour of the cloud mass, which results in increased precipitation. In hygroscopic seeding, clouds are seeded with agents that act as hygroscopic nuclei. These nuclei encourage the collision and coalescence of small water droplets, resulting in the formation of larger droplets that will precipitate.[1]

Various agents have been used for cloud seeding, with the more commonly used chemicals being silver iodide, dry ice, liquid propane, CaO and NaCl. The potential of using ice-nucleating bacteria or bio-precipitation has also been described.[2] There are several ways to disperse these agents. Ground-based dispersal is achieved through the use of special generators or through artillery rounds calibrated to detonate within the target clouds. Airborne dispersal can be carried out in specially modified crop dusters through the release of exploding flares, and manually, from a custom-configured transport aircraft such as the Boeing C-130.

Manual cloud seeding is the dispersal of cloud seeding agents, as described above, through specially configured aircrafts. The following description is typical for operations from a Boeing C-130 or a similar aircraft. There are typically three sets of personnel aboard the aircraft: the aircrew whose primary responsibility lies with the aircraft functioning and navigation; the seeding crew whose job is to dispense the agent; and the meteorological engineers who will identify the correct cloud formations for dispensation. There are typically three to four aircrew in the flight deck and 12 seeding crew in the rear cabin. The meteorological engineers are usually in the rear cabin during transit to the dispensing area, after which they are deployed on the flight deck during actual operations. A typical flight sortie lasts for two to three hours, depending on the distance from the airfield to the dispensing area. The actual dispensing is usually conducted over 60–90 minutes.

There are two main modifications to the transport aircraft. Firstly, customised attachments with dispensing chutes must be fitted behind the standard side doors of the aircraft (there are two side doors in a C-130). This is the primary mechanism through which the agent is released. The presence of these chutes prevents cabin pressurisation during agent dispensation, and hence, the aircraft must be capable of flying with an unpressurised cabin. Secondly, the storage and dispensing area within the aircraft must be segregated from the flight deck so as to prevent agent dust from interfering with the aircrew and function of the aircraft.

Manual cloud seeding is conducted based on hygroscopic hypotheses. The agents of choice are CaO or NaCl. On a typical sortie, a total of 4,000 kg of agents, divided into 200 20-kg sacks, are transported. Upon arrival at the dispensing area, the seeding crews are divided into two six-man teams, one for each dispensing chute. Two men carry a bag from the storage area to the cutter who is positioned near the chute. The cutter cuts open the sack using a knife, after which the two men stationed at the chute dispense the open bag into the chute. The sixth man is the overall operations and safety supervisor for the team.

The opening and dispensing of 4,000 kg of powdered agents generate a large amount of atmospheric dust. High concentrations of dust are irritants to the respiratory tract and the eyes. Within the confined space of the rear cabin, the dust build-up in the air during the operation results in reduced visibility. In a moving aircraft, the dust particles remain in constant Brownian motion, resulting in deposition on all exposed surfaces in the rear cabin by the end of the flight. Both man and aircraft require protection from the effects of the dust. Sensitive electronic controls in the rear cabin are sealed using plastic sheets, and all dispensing crew are required to wear full face respirators with N95 filtration. The rear cabin is also sealed with heavy plastic sheeting from the

flight deck so as to prevent the dust from affecting the flight crew and aircraft controls.

The NaCl utilised is a coarse form of table salt. It is inert and does not react adversely with human skin or membranes. However, NaCl dust that settles on the face may dissolve with perspiration, thus increasing the mucosal irritation when the sweat comes into contact with the eyes. CaO, also known as quicklime or unslaked lime, forms $Ca(OH)_2$ upon contact with water or sweat. $Ca(OH)_2$, an alkali, is an irritant to skin and a severe irritant to eye tissue (causing blurred vision, tearing and pain). It is also corrosive to both the respiratory tree and oesophagus if inhaled and ingested, respectively. If CaO is chosen as the agent of choice, apart from the full face N95 respirators mentioned above, impervious protective clothing is required.[3]

Cloud seeding is a strategy used in various parts of the world to create rainfall. Due to limitations in terrain, distances and other resources, seeding via artillery or automated aircraft may not be possible. Manual cloud seeding has the advantage of being able to dispense a large amount of agents over a wide area. However, these operations expose workers to a variety of hazards, one of which is occupational contact dermatitis. Understanding this hazard and implementing appropriate mitigation measures is important to the safe conduct of these operations.

REFERENCES

1. Bruintjes RT. A Review of Cloud Seeding Experiments to Enhance Precipitation and some new prospects. B Am Meteorol Soc 1999; 80:805-20.
2. Christner BC, Morris CE, Foreman CM, Cai R, Sands DC. Ubiquity of biological ice nucleators in snowfall. Science 2008; 319:1214.
3. Material Safety Data Sheet, Calcium Oxide, CAS No. 1305-78-8, Mallinckrodt Chemicals.