

## A Fire Extinguisher Death: The Macklin Effect

Blumenthal, Ryan, MBChB(Pret), MMed(MedForens)(Pret), Dip For Med(SA), FC For Path(SA), PhD(Wits);

Hänert-van der Zee, Brigitte, BSc(MedSci)(Pret), BSc Hons(MedCriminalistics)(Pret)

From the Department of Forensic Medicine, School of Medicine, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa.

The authors report no conflict of interest.

Reprints: Ryan Blumenthal, MBChB(Pret), MMed(Med Forens)(Pret), Dip For Med(SA), FC For Path(SA), PhD(Wits), Department of Forensic Medicine, University of Pretoria, Prinshof Campus, Pathology Building (Level 4), Pretoria, South Africa. E-mail: [Ryan.Blumenthal@up.ac.za](mailto:Ryan.Blumenthal@up.ac.za); [brigittehanert@yahoo.com](mailto:brigittehanert@yahoo.com).

### Abstract

We present the case of an adult white man found dead in a psychiatric institution with fine white powder (monoammonium phosphate) deposited over the entire face after he insufflated the contents of a dry chemical fire extinguisher. Fine white powder was present within the mouth and sinuses and lined the upper airways. On opening the thoracic cavity, approximately 500 g of fine white powder was present within the right thoracic cavity. The esophagus was ruptured. Traumatic emphysema of the posterior sternum wall was present (pneumomediastinum). The ethmoid bones were fractured by the barotrauma. On polarization of the lung tissue, birefringent material was noted deposited along the bronchovascular sheaths and in a subpleural distribution. Death was probably due to a combination of barotrauma and asphyxia.

This case study provides strong evidence in support of the etiology and pathophysiology of the Macklin effect. It also provides for the first visual evidence of the phenomenon.

**Keywords:** barotrauma; fire extinguisher; Macklin effect

We present the case of an adult white man found dead in a psychiatric institution with fine white powder (monoammonium phosphate) deposited over the entire face after he insufflated the contents of a dry chemical fire extinguisher.

On its last inspection, 13 days before the incident, the fire extinguisher had a working pressure of approximately 1400 kPa (203 psi). The powder was composed of monoammonium phosphate (34%–94%), ammonium sulphate (1%–58%), mica (<4%), magnesium aluminium silicate (1%–30%), methyl hydrogen polysiloxane (<1%), and amorphous silica (<2%).<sup>1</sup> The deceased had a known psychiatric history and was diagnosed with an underlying mood disorder.

## Scene Examination

The deceased was found dead in July 2017, at a private psychiatric hospital, in the back garden.

The brick wall behind the deceased showed a “shadow area” created by the fine white powder, where the deceased had been sprayed. The deceased was found to be lying on the ground, face up, covered with fine white powder. An empty fire extinguisher was present to the left of the deceased's body (Fig. 1). Fine white powder covered the deceased's face (Fig. 2). Fine white powder was also present within the concrete drainage area and on the grass. The label of the fire extinguisher showed it to contain 34% to 40% monoammonium phosphate base (Fig. 3). Examination of the scene suggested that the deceased was sitting at the time the fire extinguisher discharged.



FIGURE 1. Scene of death at psychiatric hospital, Pretoria, South Africa.



FIGURE 2. Close-up view of the face at the scene of death.



FIGURE 3. Close-up view of the label of the fire extinguisher recovered fully.<sup>8</sup>

Autopsy examination showed an adult white man with fine white powder (monoammonium phosphate) deposited over the entire face. Fine white powder was present within the mouth and sinuses and lined the upper airways. There was subcutaneous emphysema in the cheeks and congestion of the eyes. On opening the thoracic cavity, approximately 500 g of fine white powder was present within the right thoracic cavity (Fig. 4). The esophagus was ruptured (Fig. 5). Traumatic emphysema of the posterior sternum wall was present (pneumomediastinum). The ethmoid bones were fractured because of barotrauma (Fig. 6).

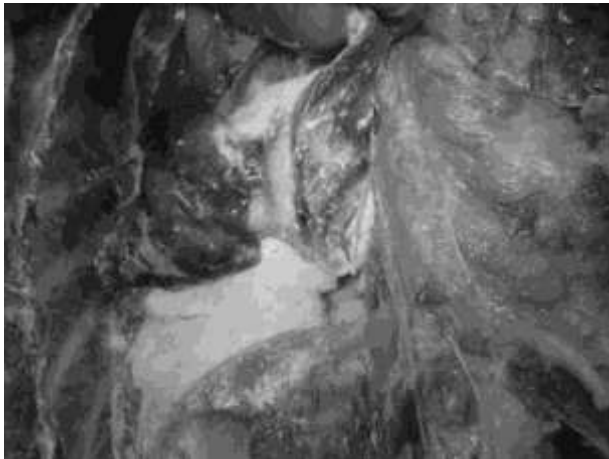


FIGURE 4. Approximately 500 g of fine white powder present in the thoracic cavity, on and between the lobes of the right lung, due to the esophageal rupture. Fine white powder in the thoracic cavity, beneath the lungs.



FIGURE 5. Figure showing the extensive rupture of the esophageal tract.

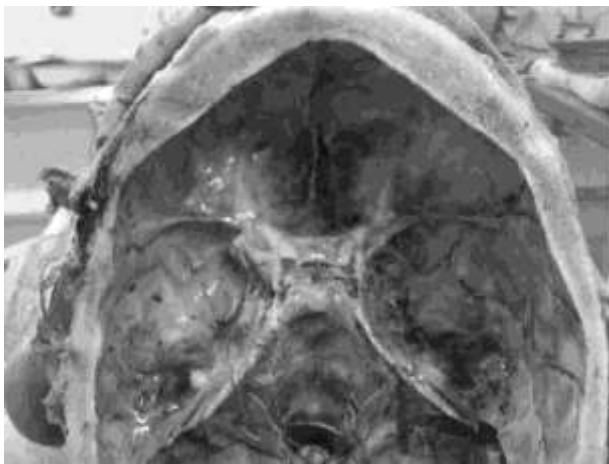


FIGURE 6. Fractures of the ethmoid bones, on the base of the skull.

### **Histological Examination**

Lung: Pulmonary edema and vascular congestion were present. Some of the alveoli were dilated, whereas some of the alveoli appeared ruptured. There was irregular distension of the alveoli in places. There was foreign substance (with a crystal-like lattice) present within some of the distal alveoli. In places, the lung tissue had the appearance of emphysema.

On polarization, birefringent material was noted in a bronchovascular distribution and within the subpleural membranes (Figs. 7–9). The distribution of the birefringent material provided the first real visual evidence in support of the Macklin effect.

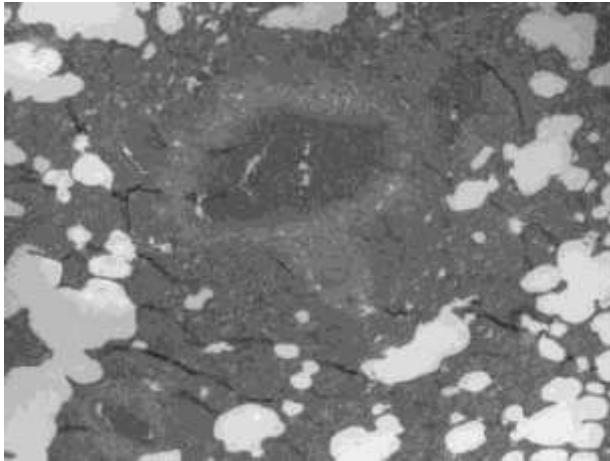


FIGURE 7. On polarization of the lung tissue, birefringent material is noted in a bronchovascular distribution.

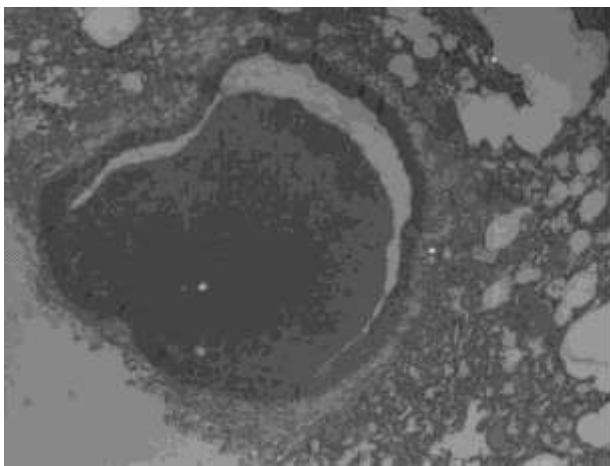


FIGURE 8. On polarization of the lung tissues, birefringent material is noted within the bronchovascular sheaths.

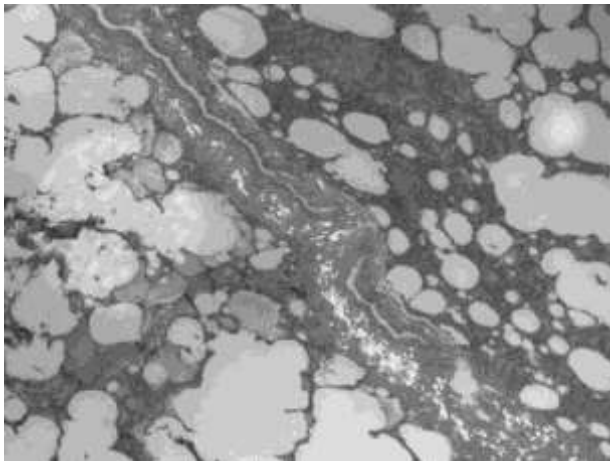


FIGURE 9. On polarization of the lung tissues, birefringent material is noted within the bronchovascular sheaths and subpleural.

## Literature Review

There is scant literature on fire extinguisher–related deaths, with only a handful of publications, which mostly encompass the toxicity of the contents after inhalation/ingestion.

From the case studies, most patients were admitted to hospitals before succumbing to the toxic effects. These cases included, inter alia, asystolia due to vagal reaction,<sup>2</sup> respiratory failure,<sup>3</sup> hyperphosphatemia, and subsequent ventricular tachycardia<sup>4</sup> and hypernatremia with metabolic alkalosis followed by respiratory and cardiac arrest.<sup>5</sup>

On autopsy, we found positive signs of barotrauma. There is a relatively large body of literature citing barotrauma within the oral cavity, which mostly includes the improper handling and opening of homemade drinks.<sup>6,7</sup> Only 1 case report involving barotrauma due to a fire extinguisher featured in the literature. Here, the trauma was not due to insufflation of the fire extinguisher but rather, the explosion of a small fire extinguisher near the gaping mouth of an engineer offloading it from a truck. He experienced a pneumatic rupture of the lower esophagus but was treated and recovered fully.<sup>8</sup>

## **DISCUSSION**

The fire extinguisher powder did not play a significant role in the death of the individual but rather, the air pressure that caused the powder to be distributed. These findings were appreciated on observing the fractured ethmoid bones as well as the extensive laceration of the esophagus.

## **SUMMARY**

This case study represents the unusual suicidal death of a psychiatric patient after the insufflation of a monoammonium phosphate–based powdered fire extinguisher, which in turn caused barotrauma and subsequent asphyxia.

The extent of the barotrauma was notable.

On polarization, birefringent material was noted along the bronchovascular sheaths and along the subpleural membranes. This finding supports the hypothesis of the Macklin effect. It also provided the first visual evidence of the phenomenon.

The Macklin effect relates to a 3-step pathophysiologic process, namely blunt traumatic alveolar ruptures, air dissection along bronchovascular sheaths, and spreading of this blunt pulmonary interstitial emphysema into the mediastinum.<sup>9,10</sup>

## **Ethical Consideration**

The necessary permissions have been obtained. All data have been treated confidentially, and no special identifying features have been presented. Consent has been obtained from the next of kin. Permission has been granted by the director of Public Prosecutions, Pretoria, South Africa. This matter has also served before the University of Pretoria's Ethics and Integrity Committee (Ethics Reference number 372/2017).

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