AMMONIA GASSING DEATHS - A REPORT ON TWO CASES

T C Chao, D S T Lo

ABSTRACT

The gross postmortem features of two victims (a 17-year-old and a 33-year-old male, both of Chinese descent) who died shortly after an ammonia-gassing exposure, are presented. The findings of extensive thermal burns on the body surfaces and on the lips, conjunctivitis and opaque cornea on both eyes, oedematous and congested lungs with large areas of haemorrhages, etc, were consistent with injuries inflicted by a corrosive gas such as ammonia.

The postmortem toxicological findings of elevated blood ammonia levels supported the postmortem findings. The pulmonary and femoral blood ammonia levels (0.26 mg/mL and 0.65 mg/mL) of decedent one were at least 371 times and 928 times respectively higher than normal. Similarly, the pulmonary and femoral blood ammonia levels (0.51 mg/mL and 0.43 mg/mL) of decedent two were at least 728 times and 614 times respectively higher than normal.

Keywords: *ammonia gassing deaths, postmortem blood ammonia levels*

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INTRODUCTION

Ammonia is a colourless gas with an extremely pungent smell. This chemical is a starting material for the manufacture of nitric acid and an ingredient for a number of explosives, synthetic fibres and fertilisers. Its endothermic nature in going from liquid to gaseous state found application as a refrigerant[1].

Alkaline ammonium hydroxide is produced when ammonia is dissolved in water. The high solubility of ammonia gas in water means that exposure to a sufficient amount of this gas would probably cause thermal injury similar to those caused by other alkalis. The parts of the body most susceptible to the insult are the skin, the eyes and the lungs[2-10].

The deaths of two foreign nationals arising from gassing by ammonia gas on board a foreign-owned trawler, came to our attention. The trawler called on Singapore after the accident, and the Institute was asked to perform the autopsy and postmortem toxicology of these two cases.

This paper records our findings. We believe we are the first to report the blood ammonia levels in fatal ammonia gassing cases.

CASE REPORTS

The main valve of a below-deck liquid-ammonia tank on board a foreign fishing trawler suddenly gave way and shattered, resulting in an explosive release of ammonia gas. The gas spread rapidly into the engine room and crews' cabin nearby. At the time of the accident which was about 4.30 in the morning, most the crew were asleep in the cabins. However, alerted by the noise and the pungent smell, they scrambled to the main deck to safety. A head-count showed two members missing. Their bodies were found about 40 minutes later, one in the cabin, presumably not woken up from his sleep, and the other at the landing of a staircase leading to the main deck. The first decedent was identified as a 17-year-old male and the second decedent, a 33-year-old male. Both were of Chinese descent. The cadavers were promptly refrigerated in an auxiliary refrigerator for 5 days before being transported to the Institute for postmortem examinations.

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Gross Pathology: First Decedent

External examination

The body, weighing 49.5kg and measuring 1.65m, showed extensive chemical burns covering about 80% of the body surface. At the burnt areas, notably the face and limbs, the skin was peeled off exposing red and raw underlying tissues. The unpeeled surfaces were cyanotic in colour. The lips were red and raw due to the peeling of superficial layer of mucosa. Both eyes showed conjunctivitis and opaque cornea. No other injuries were observed.

Respiratory system

Both lungs were oedematous, heavy and congested with large areas of haemorrhages. The trachea and bronchi were congested with mucus. The glottis was oedematous. The right lung weighed 800 g and the left lung 760 g.

Central nervous system

The brain weighing 1360 g, was congested, oedematous and cyanotic in colour.

Other observations

The genito-urinary system was normal except that the kidneys were congested. The reticuloendothelial system was not particular except for congested spleen. The cardiovascular and the alimentary systems were not unusual.

Gross Pathology: Second Decedent

The body was found to weigh 48.5 kg and measure 1.65 m. The pathological findings of this decedent were similar to those of the first decedent except that only 40% of the body surfaces, in particular the right side of the face, the upper half of the back, both thighs and legs and both upper arms and hands, showed chemical burns.

Toxicological investigation

Two blood specimens, one femoral and the other pulmonary, were obtained from each deceased, for toxicological investigations. The specimens were stored at 4°C for about 7 days before toxicological analyses were carried out.

MATERIALS AND METHODS

Chemicals

The following chemicals were purchased from the sources as indicated:

Ammonium chloride, 99.8% pro-analyst grade, (Merck); Potassium carbonate, 99.5% analytical reagent grade, (Ajax Chemical); Potassium iodide, 99.8% analytical reagent grade, (M & B); Mercuric chloride, 99.5% analytical reagent grade, (Ajax Chemicals); Sodium hydroxide, 99.0% pro-analyst grade, (Merck); and conc. sulphuric acid, 95-97% (w/w) pro-analyst grade, (Merck).

Reagents

The following reagents were prepared:

Aqueous ammonia chloride solution containing 0.10 g of ammonia per mL solution. Ammonia chloride (0.3147 g) was transferred to a 10 mL volumetric flask. Upon dissolving it in a minimum of water, the content was brought up to 10 mL with H_2O.

2.0 M aqueous sulphuric acid: To a 500 mL H_2O in a 1000 mL volumetric flask was slowly added 104 g of conc. sulphuric acid (caution: exothermic reaction). Upon cooling, the volume was brought up to 1,000 mL with H_2O.

0.01 M aqueous sulphuric acid: A 5 mL 2.0M aqueous sulphuric acid was diluted to 1,000 mL with H_2O.

Nessler's reagent: To an aqueous solution containing 1.25 g of mercuric chloride and 3.5 g of potassium iodide in 80 mL of H_2O was added a cold saturated solution of mercury chloride in H_2O with stirring, until a red precipitate was found. To the mixture was added 12 g of sodium hydroxide and a sufficient amount of H_2O to make up to 100 mL. The mixture was allowed to stand overnight and the clear liquid decanted, ready for use.

Blank blood

A plain sample of alcohol-free autopsy blood from a decedent who died of cardiac failure, was used as blank blood.

Blood standards containing various amount of ammonia

Blood standards containing 0.25 mg, 0.50 mg and 1.0 mg of ammonia per mL of blood were prepared by diluting respectively a 25 µL, 50 µL and 100 µL of aqueous ammonia chloride solution (0.1 g per mL) in a 10 mL volume with the blank blood.

Microdiffusion and analysis

To the centre well of a large Conway microdiffusion cell was added 1 mL of 0.01 M H_2SO_4. To the outer well was added 2 mL of blank blood, blood standard or blood specimen followed by 1 mL of saturated aqueous K_2CO_3. The cell was then sealed with a glass plate previously greased with a silicone grease. The trapping of the liberated ammonia gas by H_2SO_4 was allowed to proceed for 1 hour.

A 20 µL portion of the acid was withdrawn. To it was added 3 mL of 0.01 M H_2SO_4 and 0.5 mL of Nessler's reagent. The presence of ammonia would result in a yellow solution. The absorbance of the solutions were read at 370 nm against the Nessler's solution blank (3 mL of 0.001 M H_2SO_4 plus 0.5 mL of Nessler's reagent) using a Zhimadzu UV-160 spectrophotometer.

RESULTS

The absorbance at 370 nm of the resultant Nessler's solutions of blank blood and blood standards, read against the Nessler's solution blank are as follows:

Blank blood, 0.003; 0.25 mg/mL NH_3, 0.279; 0.50 mg/mL, 0.50 and 1.0 mg/mL NH_3, 0.92. The blank blood, kept a 4°C for 14 days, showed no discernable change in the background ammonia concentration.

The ammonia concentrations of the two decedents' blood specimens, determined using the calibration data above, are given in Table I.

Table I – Blood ammonia levels of the two decedents

Description	Blood ammonia level
Decedent one: 17-year old male Chinese	
Blood (pulmonary)	0.26 mg/mL
Blood (femoral)	0.65 mg/mL
Decedent two: 33-year old male Chinese	
Blood (pulmonary)	0.51 mg/mL
Blood (femoral)	0.43 mg/mL

The blood specimens of the two decedents were found to be negative for volatiles such as ethanol and methanol by headspace gas chromatography and negative for common drugs by gas chromatographic/mass spectrometry.

DISCUSSION

The corrosive nature of ammonia gas is well-known[1-10]. The postmortem findings of the two decedents, which showed extensive thermal burns of body surfaces with peeled stains, thermal burns on the lips with peeled superficial layer of mucosa, conjunctivitis and opaque cornea of the eyes, congested and oedematous lungs with extensive haemorrhages, congested trachea and bronchi with mucosa and oedematous glottis, are consistent with having been fatally exposed to this gas. The immediate consequences of being assaulted by the corrosive gas leading to death observed by us were also reported elsewhere[7].

The involvement of ammonia gas was demonstrated in its levels in the blood specimens of the two decedents given in Table I. Given the normal blood ammonia levels of up to 0.7 µg/mL in healthy subjects[11], the pulmonary and femoral blood ammonia levels of decedent one was at least 371 times and 928 times respectively higher than normal. Similarly, the pulmonary and femoral blood ammonia levels of decedent two were at least 728 times and 614 times respectively higher than normal. We believe that these blood ammonia levels are the first reported in fatal cases.

The transient survival of the two victims after the initial exposure was strongly suggested by the elevated levels of femoral blood ammonia, due to circulation distribution of this toxic agent to the peripherals. The transient survival of Victim One was further demonstrated in his histological findings of the widening of sinusoids with necrosis of hepatocytes in the liver and the eosinophilic mass of lysed red blood cells in the spleen, indicative of ammonia toxicity. However, judging from the massive direct injuries inflicted and the circumstantial evidence at hand, survival for more than 40 minutes, especially without prompt medical attention and life-support facilities needed, was considered highly unlikely.

Unlike the postmortem findings described above, the salient postmortem features of those who died 36 hours or longer after being exposed to ammonia gas were bronchopneumonia, cystic bronchiectasis, tracheobronchitis, bronchial ulceration, etc., indicating after-exposure complications[2-10].

CONCLUSION

The gross postmortem features supported by elevated blood ammonia levels confirmed the two fatal ammonia gassing deaths.

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