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A Homicide Case of a North Korean: The Use of Nerve Agent VX

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Abstract

The potential for chemical weapons to be used in terrorism is a real possibility as they are actually inexpensive chemicals found in many places. O-Ethyl S-2-diisopropylaminoethyl methyl phosphonothioate or better known as VX is one of the nerve agent designated as chemical warfare agent, listed in Schedule I of the Chemical Weapons Convention (CWC). This paper highlights a case of a North Korean whom was assassinated using a poisonous fluid, believed to be VX in the Kuala Lumpur International Airport 2, Malaysia. Chronology of the incident is narrated until the victim was brought into the National Institute of Forensic Medicine (NIFM), Hospital Kuala Lumpur. Before the commencement of the postmortem examination, Postmortem Computed Tomography (PMCT) was performed by a forensic radiologist followed by fingerprint comparison. The fingerprint showed a match with the deceased's name as stated in the passport. However, forensic odontology examination and DNA analysis could not reveal the identity of the deceased as disputed by the media as ante mortem data were not made available. A total of 122 specimens were taken from the deceased and were sent to various laboratories in different agencies to be analyzed. Subsequently, the laboratory results are presented covering the spectrum of analysis ranging from chemical weapon and poison, toxicology to the biochemical analysis including cholinesterase level. Finally, challenges faced by the team in the case management are discussed and a few recommendations are given to relevant authorities to equip their buildings with the special detector for chemical weapons, as well as to enhance both hospitals and mortuaries decontamination facilities and Personal Protective Equipment (PPE) for the personnel.

Keywords: Chemical Weapons; VX; Nerve Agents; OPCW

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Introduction

Since a century ago, the development, production and use of biological and chemical weapons are prohibited by international treaties to which most states of the world have subscribed to. They are the 1925 Geneva Protocol for the prohibition of the use in war of asphyxiating, poisonous or other gases, and of bacteriological methods of warfare, the 1972 Biological and Toxin Weapons Convention for the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and toxin weapons and the 1997 chemical weapons convention [1]. The Organization for the Prohibition of Chemical Weapons (OPCW), which is the international authority for the 1997 chemical weapons convention, is putting practical arrangements into place for such assistance in regard to chemical weapons. As yet, there is no similar organization for biological weapons like the OPCW. O-Ethyl S-2- diisopropylaminoethyl methylphosphonothioate or better known as VX is one of the nerve agent designated as chemical warfare agent, listed in schedule I of the convention on the prohibition of the development, production, stockpiling and use of chemical weapons and on their destruction [2]. VX which can be manufactured by relatively simple chemical techniques with inexpensive and readily available raw materials have made VX a feared second 'nuclear weapon' of poor countries [3]. Previously, nerve agents have been designated as chemical warfare agents used in war against countries. Nevertheless, chemical warfare agents such as Sarin and Soman have been a popular choice for terrorism not long ago. A case of a North Korean whom was assassinated using a poisonous fluid, believed to be VX is reported in this paper.

Chronology of Incident

A 46-year-old North Korean man had been allegedly applied with a fluid by two females on the morning of 13 February 2017 in Kuala Lumpur International Airport (KLIA) 2, Malaysia. The victim then walked albeit with a wide based gait into an outpatient clinic KLIA2 at around 9.15 am after the attack to seek medical assistance. The medical officer attended to the victim said that

Table 1: Summary of the types of specimens taken for various laboratory analyses.

Types of Specimens taken			
Department of Chemistry Malaysia			**Pathology Department, Hospital Kuala Lumpur**
Centre of Chemical Weapon Analysis	**Toxicology Unit**	***DNA Unit***	
Chemical weapon & poison analysis	Toxicology Analysis	DNA Analysis/Profiling	Biochemical Analysis
· Eye mucosal swabs · Facial swabs · Nasal swabs · Blood · Plasma · Urine · T-shirt · Underwear · Blazer · Bag with brand name *Tumi* · Bandage	· Blood · Urine · Liver tissue · Brain tissue · Lung tissue · Kidney tissue · Vitreous humor · Stomach contents · Bile	· Blood on FTA card	· Blood for Cholinesterase level

both of his eyes appeared to be teary whilst sweating profusely and had an unpleasant smell near him. He complained of severe pain of both eyes and his vital signs showed high blood pressure with fast heart rate. Shortly afterwards, he collapsed in the clinic with loss of consciousness and developed convulsions with generalized twitching of the muscles as well as drooling of secretions from his mouth. He was immediately intubated and manually Ambu bagged and was given 1 ampoule of adrenalin and atropine each intravenously. At this time, his vital signs showed low blood pressure with fast heart rate and he was arranged for transfer to Hospital Putrajaya *via* the KLIA2 ambulance accompanied by the paramedics. On arrival at the Emergency Department, Hospital Putrajaya at 11 am on the same day, he showed no signs of life. Cardio Pulmonary Resuscitation (CPR) was instituted by cardiac compressions together with several ampoules of adrenaline given intravenously. The attending medical officer at the emergency department noted the victim's pupils to be constricted and he was pronounced dead after failed resuscitation. As the victim was a foreign national and died under suspicious circumstances, the case is categorized as high complexity involving an unknown agent, where an intense discussion was held between the forensic medicine consultants with the Royal Malaysia Police (RMP) to decide on the next course of management of the case on the 14 February 2017. Meanwhile, the body of the deceased was securely kept in cold body storage in the Forensic Unit, Hospital Putrajaya. The deceased body was then transferred to the National Institute of Forensic Medicine (NIFM), Hospital Kuala Lumpur for postmortem examination.

Postmortem Examination

The deceased was brought in to the NIFM and registered at 11.30 am on the 15 February 2017. Before the commencement of the autopsy, Postmortem Computed Tomography (PMCT) was performed by a forensic radiologist on the deceased at 11.56 am in the same NIFM building.

Subsequently, autopsy was carried out at 12.45 pm by two forensic medicine consultants. The postmortem examination took approximately 6 h and was completed on the same day at 6.45 pm.

Fingerprint analysis

Following completion of the autopsy, the fingerprint expert from the Royal Malaysia Police had taken the finger print of the deceased for the purpose of identification. The fingerprint showed a match with the deceased's passport.

External examination

The deceased body was in a good state of preservation. The body was of a large built adult male of Asian appearance with a height of 173 cm and weighed 96 kg. The face and neck of the deceased were congested while the lips were cyanosed and both eyes appeared mildly congested. There were numerous moles seen all over the face including the chin and the pinna of both ears. Besides these, there were also black-colored and multi-colored tattoos in various regions of the deceased body. In addition, various medical intervention marks were found on the body. A few minor injuries were noted on the left upper lip, left lower lip and left angle of mouth.

Internal examination

The scalp was mildly congested and there was a minimal patchy area of congestion over the vertex and left frontal lobe of the brain. Rib cage showed several CPR related rib fractures and the trachea and bronchi contained some blood tinged fluid. The lungs were moderately oedematous and congested. The heart was mildly enlarged but of normal shape. The left anterior descending coronary artery showed moderate luminal narrowing by atherosclerotic plaque proximally. The right coronary artery and left circumflex artery showed minimal luminal narrowing by atheromatous plaques. On sectioning, the myocardium showed no gross infarcts or fibrosis, and there was no evidence of pulmonary thromboembolism. The liver was enlarged but grossly intact. Similarly, the spleen was externally intact and showed congestion of its cut surfaces on serial sectioning. Both kidneys were intact but showed uniform granularity of the cortical surfaces.

Odontology examination

A dental examination was performed by a forensic odontologist on 17 February 2017. Dental charting, photographs and video were taken to capture the facial profile of the deceased for further analysis. Fifteen periapical radiographs were taken for record. Dental impressions of the deceased were also performed for comparison and record keeping purposes. Upon examination, an upper removable partial denture was found in position inside the oral cavity. It was also noted that whitish lesions were present on the right and left buccal mucosa.

Specimens

There were more than 10 different types of specimens taken from the deceased for various laboratory analyses. These samples were taken and placed in appropriate containers and sealed. Subsequently, they were handed over to the Investigating Officer (IO) to be sent to the assigned laboratories on the same day immediately after the

Table 2: Summary of the chemical weapons analyses.

No.	Specimen	Analysis / Result
1.	Swabs of eye mucosa	VX nerve agent (Ethyl *S*-2-diisopropylaminoethyl methyl phosphonothioate) VX degradation product Ethyl Methyl Phosphonic Acid (EMPA) VX degradation product N,N-Di methyl amino ethanol
2.	Swabs of face	VX nerve agent (Ethyl *S*-2-diisopropylaminoethyl methyl phosphonothioate) VX degradation product Ethyl Methyl Phosphonic Acid(EMPA)
3.	Blood	VX nerve agent VX degradation product Ethyl Methyl Phosphonic Acid(EMPA)
4.	Plasma	VX nerve agent VX degradation product Ethyl Methyl Phosphonic Acid(EMPA)
5.	Urine	VX nerve agent VX degradation product Ethyl Methyl Phosphonic Acid(EMPA)
6.	T-shirt	VX degradation product Ethyl Methyl Phosphonic Acid(EMPA) VX precursor 2-(N,N-Diisopropylamino)ethyl chloride
7.	Blazer	VX nerve agent (Ethyl *S*-2-diisopropylaminoethyl methyl phosphonothioate) VX degradation product Ethyl methyl phosphonic acid VX degradation product Bis(2-N,N-Diisopropylaminoethyl)sulphide VX degradation product Bis(2-N,N-Diisopropylaminoethyl)disulphide VX precursor 2-(N,N-Diisopropylamino) ethanethiol VX precursor 2-(N,N-Diisopropylamino)ethyl chloride VX precursor O-Ethyl methyl phosphonothioic acid
8.	Brown bag with brand '*Tumi*'	VX degradation product Ethyl Methyl Phosphonic Acid(EMPA)

Table 3: The comparison of nerve agents' properties.

Agents	Category	Properties	Volatility (mg/mm^3 at 77°F or 25°C)	LD_{50} on Skin (mg)
Tabun (GA)	G	Clear, odorless	440	1,000
Sarin (GB)	G	Clear, odorless	22,000	1,700
Soman (GD)	G	Clear, odorless	3,900	50
Cyclosarin (GF)	G	Clear, odorless	581	30
VX	V	Faint amber color, odorless	10.5	10

completion of postmortem examination. Table 1 below summarized the types of specimens taken for various laboratory analyses.

Laboratory Analysis

Chemical weapon & poison analysis

Analysis for the chemical weapons yielded positive detection of VX nerve agent and its degradation product, Ethyl Methylphosphonic Acid (EMPA) on the swabs of the eye mucosa and face as well as in the blood, plasma and urine. The VX nerve agent contains the alkyl methylphosphono moiety in its chemical structure and it is readily hydrolyzed to EMPA [3]. The precursor of VX and its degradation product were also detected on the T-shirt of the deceased. Further analysis also found the presence of VX, various degradation products and its precursors on the deceased's blazer as well as the presence of VX degradation product, EMPA on the deceased's brown Tumi bag. VX is listed as nerve agent under Schedule 1.A.03 of the Chemical Weapons Convention Act Malaysia 2005 and 1997 Chemical Weapons Convention.

The Ethyl Methylphosphonic Acid (EMPA) or also known as the VX acid is listed as degradation product of VX under Schedule 2.B.04 of the chemical weapons convention act Malaysia 2005 and 1997 chemical weapons convention. Other degradation products of VX found on various specimens such as Bis(2-N,N-Diisopropylaminoethyl) sulphide and the Bis(2- N,N-Diisopropylaminoethyl)disulphide are listed under non-schedule reportable chemical (NSRC) QDOC/LAB/WI/PT04 under the OPCW proficiency test. On the other hand, the 2-(N,N-Diisopropylamino)ethyl chloride is listed as precursor of VX under Schedule 2.B.10 of the chemical weapons convention act Malaysia 2005 and 1997 chemical weapons convention. Table 2 summarizes the analysis of the chemical weapons. Other precursors of VX, 2-(N,N-Diisopropylamino)ethanethiol and O-Ethyl methyl phosphonothioic acid are listed under Schedule 2.B.12 and Schedule 2.B.04 respectively of the chemical weapons convention act Malaysia 2005 and 1997 chemical weapons convention.

Toxicology analysis

Toxicology result showed evidence of therapeutic drugs for diabetes, hypertension and gout in the blood, urine and tissues. These drugs were consistent with the medical history of the deceased. There are no common pesticides detected in the blood, urine and tissues.

DNA analysis/profiling

DNA analysis was performed on the deceased blood taken during autopsy. Deceased DNA profile was successfully obtained.

Biochemical analysis

Cholinesterase level detected by the Biochemical laboratory was 344 U/L. The normal range of the cholinesterase level is 5320 to 12920 U/L. The clinical toxicologist was in opinion that there was a very significant drop in blood cholinesterase enzyme level, where the low cholinesterase level could be due to conditions such as intoxication with organophosphorus compounds (cholinesterase inhibitors) and impaired cholinesterase production due to liver diseases. The result was in accordance with the United States Army Medical Research Institute of Chemical Defense, nerve agents are organophosphates [4].

Discussion/Challenges

The deceased was carrying a North Korea passport with him at the KLIA2. Identity of the deceased was known as the person stated in the passport as a result of the matched fingerprint. However, the forensic odontology examination and DNA analysis could not reveal the identity of the deceased as disputed by the media as ante mortem data were not made available.

Postmortem examination showed no significant marks of trauma apart from the marks of medical intervention. Internal examination revealed non-specific congestion of the internal organs, associated

signs of lung oedema with congestion and evidence of hypertensive with diabetic changes in the kidneys. The significant drop in blood cholinesterase enzyme level was suggestive of an acute exposure to toxic substance that inhibits cholinesterase. Tsuchihashi et al. [3] mentioned that VX strongly and readily binds to acetyl cholinesterase and thereby inhibits the vital enzyme's normal biological activity in the cholinergic nervous system [5]. With the positive detection of VX, VX degradation products and VX precursors on the specimens sent to the centre of chemical weapon analysis have strengthen and corroborated the clinical history. Thus, the cause of death for the deceased was given as VX (Nerve Agent) poisoning following the rapid onset of exposure.

There are two categories of nerve agents which are the G agents and the V agents. The G agents are non-persistent agents and the V agents are persistent agents. Nerve agents are organophosphates [4] and many commercially available insecticides are organophosphates but they are much less potent than nerve agents which are specifically developed as weapons [5]. Table 3 below showed the comparative volatility among the nerve agents [4,5]. From the table, it is obvious that Sarin is the most volatile whereas VX is the least volatile nerve agent. Comparative LD50 of the nerve agents also showed clearly that VX is the most toxic among all nerve agents [5]. Nerve agents are so powerful because they can be absorbed orally, by inhalation, or through the mucosa or skin. Since pure VX is available in fluid form and odor less, these properties have made VX easy to be transported without being detected. Thus, it is recommended that all airports and highly secured buildings should be equipped with the special detector for chemical weapons as a preventive measure.

In this case, the victim collapsed and died within 2 h after the attacked. The toxicity level of VX depends on the route of exposure as well as the duration of exposure. The route of exposure is known to be through the eye mucosa, facial skin, mouth and inhalation. Due to the fact that the contact was confined directly to the victim and the nature of VX, people moving at close vicinity to the victim were not affected. Having said that, VX has a high viscosity and remain in fluid form at room temperature. Only when VX is subjected to a high boiling temperature, will it transform into gaseous state and could have caused more casualties or fatalities to the surrounding public.

Hospital facilities should be equipped with well-trained medical personnel as well as decontamination facility under a comprehensive hospital disaster plan. Decontamination is a critical part of the medical response to a toxic chemical incident. Early decontamination protects patients from further exposure. Simple removal of clothing results in decontamination of 80% of a liquid nerve agent [6]. Decontamination showers should be part of the standard equipment available in the event of nerve agent attack. Appropriate Personal Protective Equipment (PPE) should be made available to all health care personnel in the decontamination zone. The personnel should be trained in donning the PPE while attending to patients. Similarly, all the personnel in the hospital mortuaries or the forensic medicine facilities should also be equipped with proper decontamination facility as well as PPE to protect the personnel whom will be working with the dead exposed to these toxic chemicals.

Conclusion

The case of the assassination of a North Korean with nerve agent has shown the possibility and potential for chemical weapons to be used in terrorism. There are very minimal publication and cases reported on the use of VX on human. The metabolism of VX in the human body is still unclear. Besides the nerve agents, there are actually other simple yet conventional chemicals found in industries that can also be potential chemical weapons. The statement by the World Health Assembly in May 1967 that "scientific achievements, and particularly in the field of biology and medicine - the most humane science - should be used only for mankind's benefit, but never to do it any harm" remains as valid today as it was then [7]. It is hoped that the OPCW and the Chemical Weapons Convention can remain strong as to uphold the international treaty in order to prevent the non-conventional weapon attack resulting in mass casualty and fatality events.

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