Case Study

Chemical Pneumonitis Following Exposure to Organophosphate Pesticide in Insecticide Spraying Job Task

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ABSTRACT: *The clinical spectrum of respiratory illness in organophosphate poisoning varies from being asymptomatic to chemical pneumonitis and its complications. Large data on clinical features, imaging findings, appropriate management and outcome of this condition is lacking. Chemical pneumonitis is a well-known complication which occurs after inhalation of toxic fumes or gases. Therefore, workers exposed to risk of inhalation to organophosphate pesticides should undergo medical surveillance as required by Occupational Safety and Health (Use and Standard of Exposure of Chemicals Hazardous to Health) Regulations, 2000. This article highlights the grey areas that need to be improved from occupational safety and health perspective. Failure to go through Fitness to Work (FTW) assessment will breach the safety at workplace that can possibly end up in fatalities. Hence, we urge Pest Control Officer to be aware of the health effect of pesticide exposure and employers need to provide necessary framework of monitoring.*

Keywords: *Chemical, Exposure, Inhalation, Organophosphate, Pneumonitis*

1.0 INTRODUCTION

Pesticides are ubiquitous in the environment and most are synthetic in origin. Due to their availability, pesticides present a continuing health hazard as they are used in agriculture, public health eradication programmes and even as chemical warfare agents. Every year World Health Organization estimated that there are 3 million cases of pesticide poisoning resulting in more than 250,000 deaths. From that number, one million were serious unintentional poisonings and the additional two million people were hospitalized for suicide attempts (Kamanyire & Karalliedde, 2004). In Malaysia, the National Poison Centre reported that 16.4 percent of all admissions to government health facilities from the year 1999 to 2001 were due to accidental exposure caused by pesticides (Ministry of Health, 2004).

Organophosphorus compounds type of pesticides are usually esters, amides or thiol derivatives of phosphoric acid. They form a large family of more than 50,000 chemical agents with biological properties that have important and sometimes unique implications for man (Manoranjan, 2017). Organophosphate insecticides compounds inhibit both acetylcholinesterase and pseudocholinesterase activities (Čolović, Krstić, Lazarević-Pašti, Bondžić, & Vasić, 2013). Acetylcholine is hydrolysed by the enzyme acetyl cholinesterase (AChE) to choline and acetate. Choline is actively taken up by the axonal membrane by a sodium dependant mechanism. Organophosphates inhibit the AChE found in synaptic junction and red blood cells, and butyl cholinesterase (also known as pseudocholinesterase or plasma cholinesterase) in the blood. Blockade of AChE leads to the

accumulation of excessive acetylcholine at muscarinic receptors (cholinergic effector cells), at nicotinic receptors (skeletal neuromuscular junctions and autonomic ganglia), and in the central nervous system (Robb & Baker, 2019).

The clinical spectrum of respiratory illness varies from being asymptomatic to chemical pneumonitis and its complications. Large data on clinical features, imaging findings, appropriate management and outcome of this condition is lacking. No treatment-based randomized control trials have been performed as the number of cases is small. Data on precise incidence of chemical pneumonitis from Malaysia is also lacking mirroring the lack of global data. This article reviews and elaborates a case linked to occupational exposure to organophosphate pesticide in insecticide spraying job task. It also highlights the grey areas that need to be improved from occupational safety and health perspective. The literature on this clinical condition is also reviewed.

2.0 MATERIALS AND METHODS

This is a retrospective review of occupational organophosphate poisoning which relate to pesticide working process involving exposure to organophosphate and compliance failure to Personal Protective Equipment (PPE) usage in a Vector-Borne Disease Control Programme. The review involves secondary data analysis and utilizing data extracted from medical record from hospital and duty records from the District Health Office, in the state of Johor. Accordingly, as the State Health Officers in charge of Occupational and Environmental Health Unit are involved in this study, investigators have the authority and permission to converge and generate data belonging to the case. Subsequently, mixed method approach combining key information interviews, document analysis, secondary data analyses and interpretation conducted by an occupational health expert committee was utilised.

3.0 CASE PRESENTATION

A 28-year-old male worker was brought to the Hospital Emergency Department with complaints of a few hours of difficulty in breathing and chest discomfort. He was having non-productive cough which was progressively worsening over four days' period. He had similar symptoms of cough and flu for past 5 months and visited multiple clinics. However, there was no workplace history taken to relate his symptoms with working activity and his symptoms resolved after taking medicine. Tuberculosis screening revealed negative result.

Upon physical examination, he was tachypneic with respiratory rate of 60 per minute. He's only able to talk in short sentences. His Body Mass Index was 21.8 kg/m^2. His blood pressure was 105/58 mmHg with pulse rate of 116 beats per minute. Pulse volume was good. He was afebrile and lung auscultation revealed reduced air entry at the left lower zone.

4.0 OCCUPATIONAL HISTORY

This worker's placement was at a vector-borne disease control unit in a District Health Office for the past nine months. A Vector-Borne Disease Control Unit is responsible in preventing further spread of vector-borne diseases to human as part of public health control measure. This was his first working experience with the unit and he had no previous history of exposure to pesticide. Job rotation for him was performed in order to give him and other workers opportunity to gain various experience and knowledge in public health disease control and prevention measure.

His job comprised of a typical vector control programme activities such as performing insecticide spraying, insect breeding site search-and-destroy and also performing spray-larvaciding (Fig. 1). Additionally, he was also involved in preparing pesticide mixture to be used in spraying (Fig. 2). According to Malaysian Occupational Safety and Health (Use and Standard of Exposure of Chemicals Hazardous to Health) Regulations, 2000 (Department of Occupational Safety and Health - USECHH Regulations, 2000), workers exposed to

organophosphate insecticide should undergo periodic medical surveillance which include Blood Cholinesterase Test, Audiometry and Spirometry.

He was supplied with PPE namely half face respirator with cartridges, goggles and coverall to be worn at the field. His other tasks during insecticide spraying or fogging was to guide and assist the fogger in safe direction and give instruction if there is any potential hazard in front that can't be seen in. In this role, although he was not operating the fogging machine directly, he would accompany his designated worker/fogger within 10m radius and hence exposed to pesticide about 2-3 hours each time of the activity. In addition, he was assigned for fogging activity every alternate day for about 2-3 hours each time. He is new in the Unit and he diligently obeyed any tasks given to him in order to avoid any conflict with his supervisor.

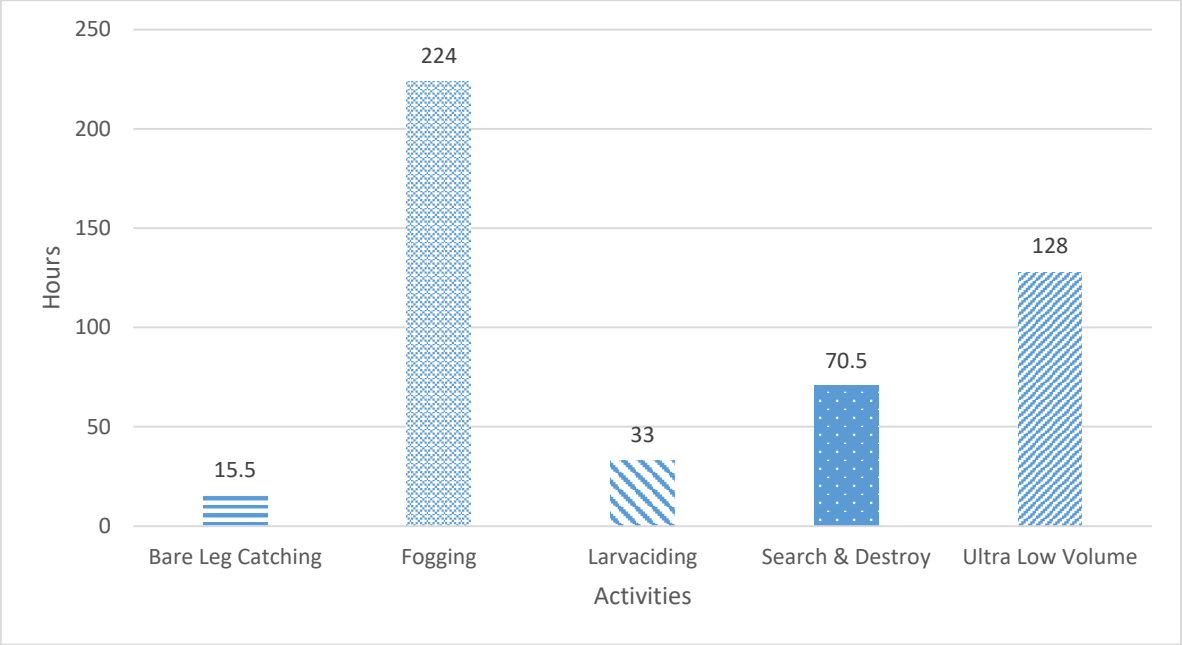

Figure 1 Job Task Analysis of a Public Health Assisstant Over Four Months Period

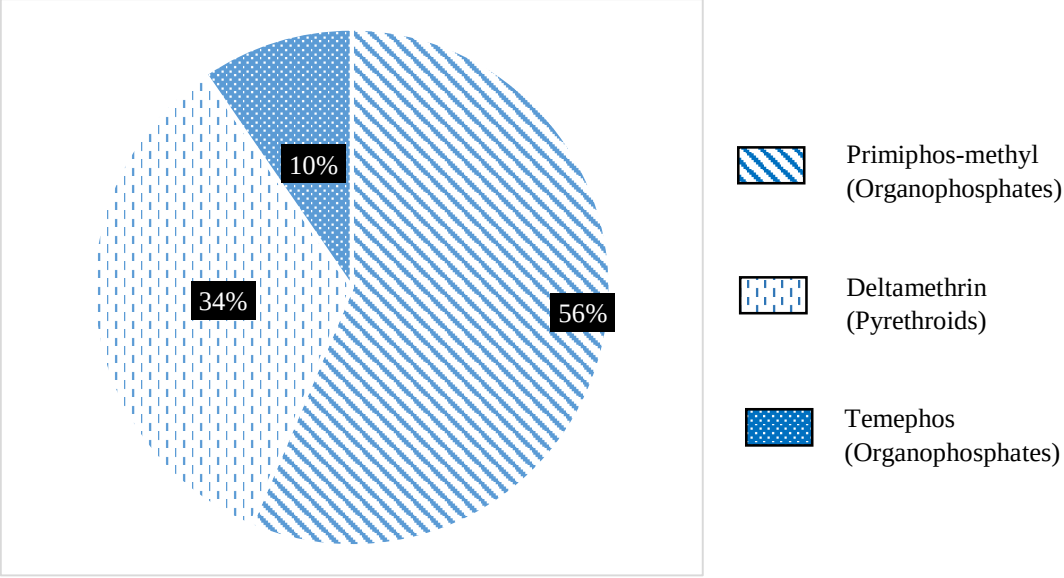

Figure 2 Percentage of Chemical Used Daily by a Public Health Assistant during Work Period of Four Months

5.0 SOCIAL HISTORY

He is single and he stays with friends at a rented house. His family is staying in a different state and he visits them during holidays and weekend.

6.0 RESULTS

On admission his blood pressure was 105/58 mmHg and he was tachycardic (116 beats per minute). Oxygen saturation was 95 per cent under High Flow Mask of 15 litres per minute. Auscultation of the lung revealed reduced air entry at the left lower zone. Chest X-ray showed alveolar infiltration at the left lower lobe and consolidation at right lower lobe (Fig. 3). Arterial blood gases showed Respiratory Failure Type 1 and he was intubated for seven days.

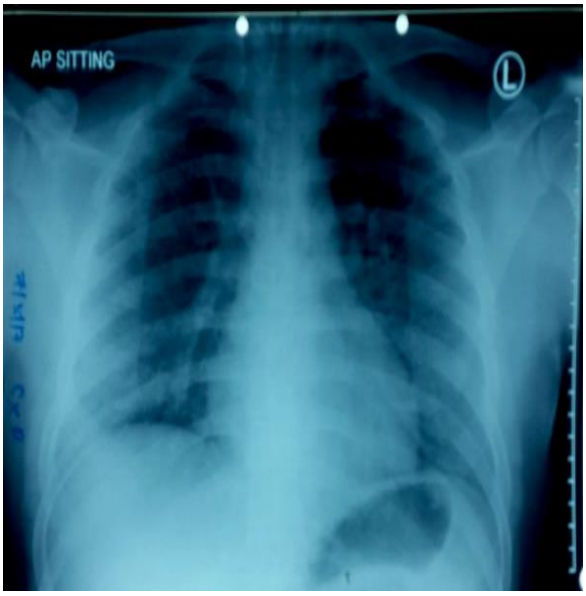

Figure 3 Chest X-Ray on Day 1 of Admission Showing Alveolar Infiltration at The Left Lower Lobe and Consolidation at Right Lower Lobe

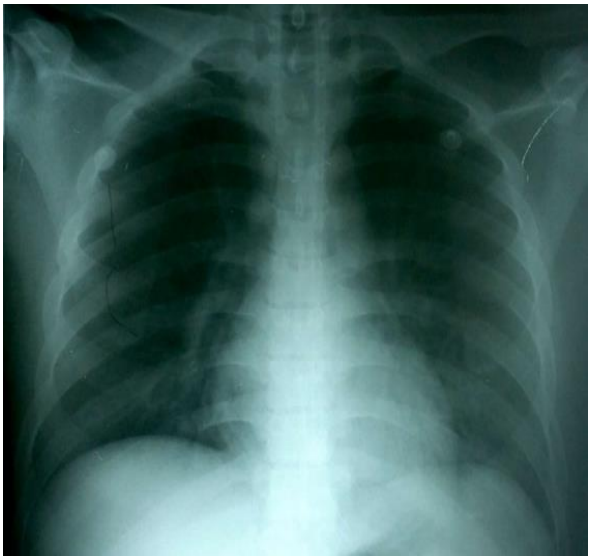

Figure 4 Chest X-Ray on Day 11 of Admission Showing Improvement after Treatment

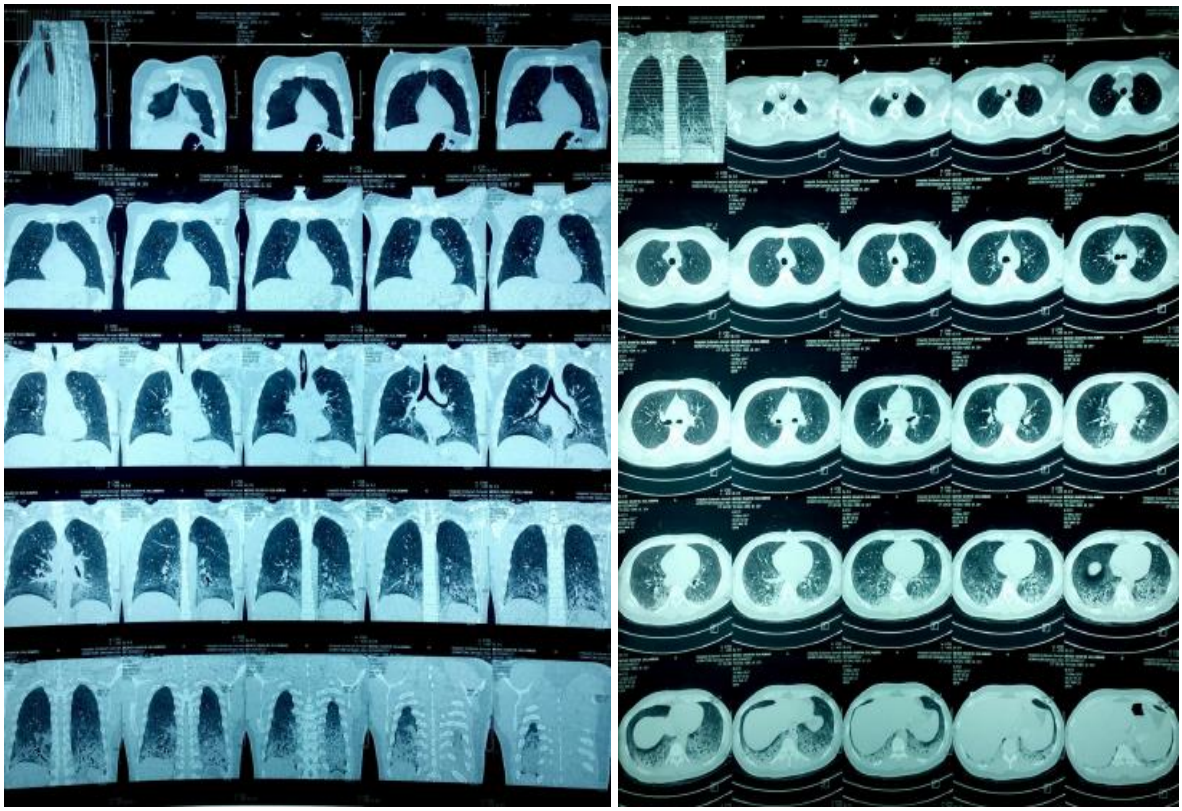

Figure 5 Lung High Resolution CT (LHRCT) on Day 7 of Admission Showing Generalised Ground Glass Pattern in a Mosaic Distribution Bilaterally, with Crazy Paving Pattern and Bronchiectatic Changes in The Lower Lobe Bilaterally

Lung High Resolution Computerised Tomography (LHRCT) (Fig. 5) showed generalised ground glass pattern in a mosaic distribution bilaterally, with crazy paving pattern and bronchiectatic changes in the lower lobe bilaterally. There were multiple ill-defined nodular consolidations scattered in both lungs, mostly in the peripheral compartment, largest was in the lingular segment of the left upper lobe, 0.4 cm in size. Consequent chest x-ray showed progressive improvement by Day 11 after treatment (Fig. 4). He was discharged after 11 days of stay in hospital. Repeated LHRCT after four months showed complete resolution (Fig. 6).

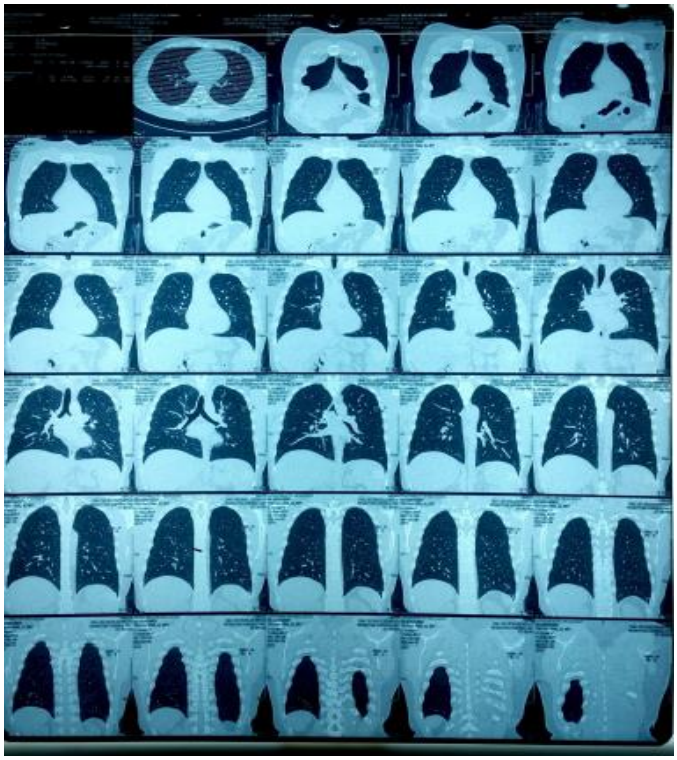

Figure 6 LHRCT Showed Complete Resolution after Four Months

Spirometry showed restrictive changes which gradually improved over time (Table 1, Fig. 7-8). Lung gas transfer as measured for diffusion capacity to carbon monoxide (DLCo) was also reduced indicating presence of parenchymal lung disease. In this case highly suggestive due to inhalation of organophosphate.

Table 1 Spirometry Results During Follow-Up Visits

Date/LFT	Predicted Value	Measured	Predicted Value	Measured	Predicted Value	Measured
Day	Day 11		Day 29		Day 72	
FEV1	3.23	1.79	3.23	2.15	3.23	2.33
FVC	3.77	2.03	3.77	2.31	3.77	2.58
FEV1/FVC	86%	88%	86%	93%	86%	90%
DLCo (mL/mmHg/min)	Not done		25.60	8.90	Not done	
PEF (L/min)	633	235	633	358	633	421

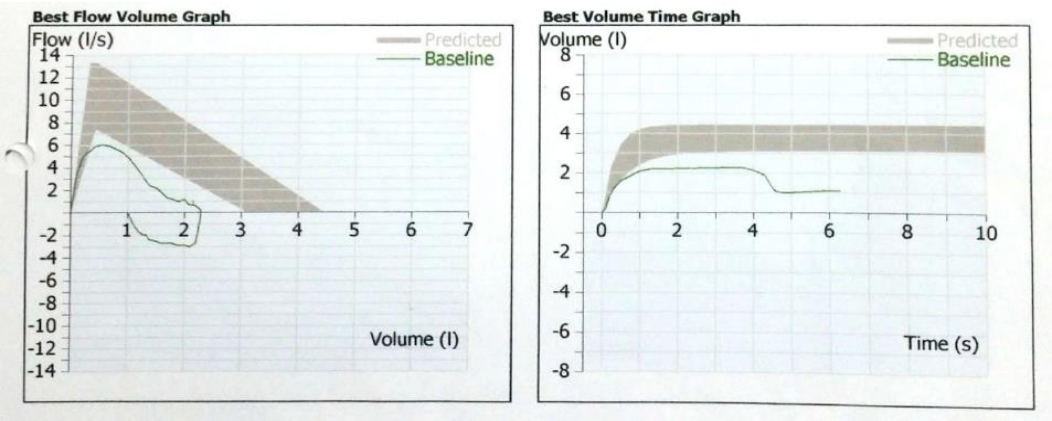

Figure 7 Flow Volume Graph & Volume Time Graph at The Day 29 Of First Month

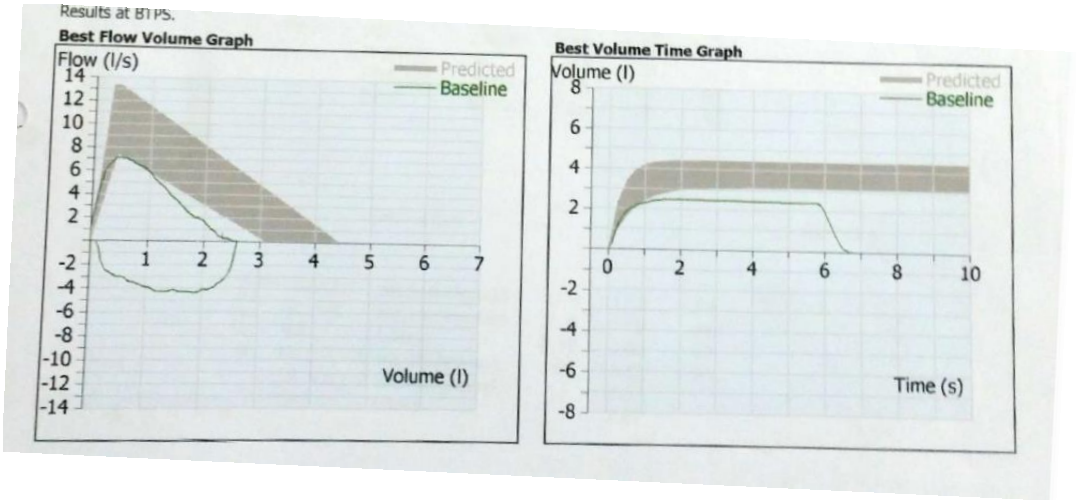

Figure 8 Flow Volume Graph & Volume Time Graph at The Day 72 of Second Month

During interview, it was noted that there was a lack of knowledge and awareness among the worker's supervisors about health impact due to exposure to organophosphate. Fitness for work assessment was not planned well to be conducted prior to the job task. Due to constraint of manpower and packed timetable, his baseline blood cholinesterase test was not done, establishing no data to be compared. There was also no evidence of any respiratory fit testing or training given on effective and efficient usage of PPE. Our interview with his buddy and performance of walk through survey at his work station found poor occupational safety compliance and he was likely to be exposed to pesticide during fogging activities.

7.0 DISCUSSION

The pesticide groups he was exposed to are organophospates and pyrethroids. Primiphos-methyl and temephos are organophosphate pesticides that inactivate AChE, so the irreversible blockage of this enzyme, which causes acetylcholine accumulation, results in muscle overstimulation (Fig. 9). Meanwhile deltamethrin, a member of pryrethroid pesticides, acts on cellular sodium channel (Fig. 10) and causes nervous system dysfunction such as facial paraesthesia, which can be described as feeling many different abnormal sensations, including burning, partial numbness, "pins and needles" and skin crawling.

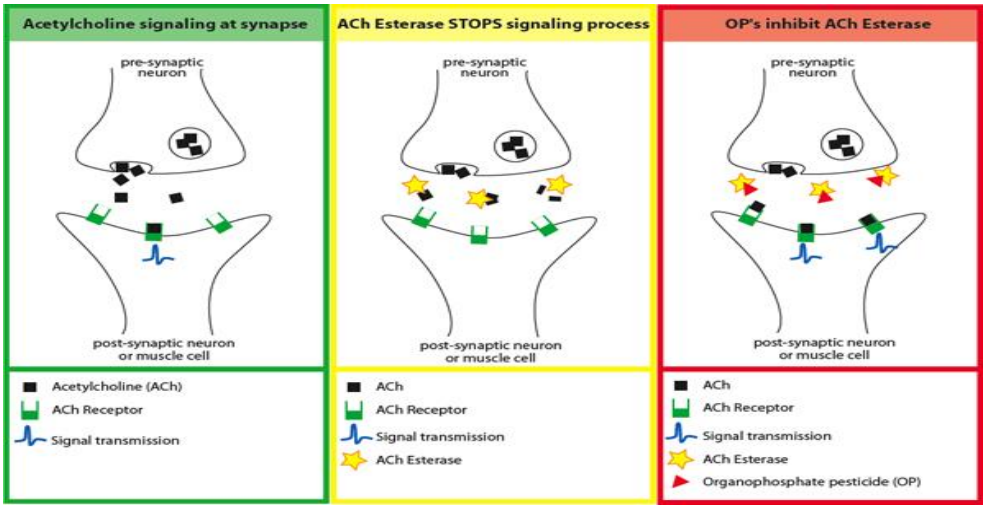

Figure 9 Mechanism of Action of Organophosphate Poisoning (University of Washington, 2007)

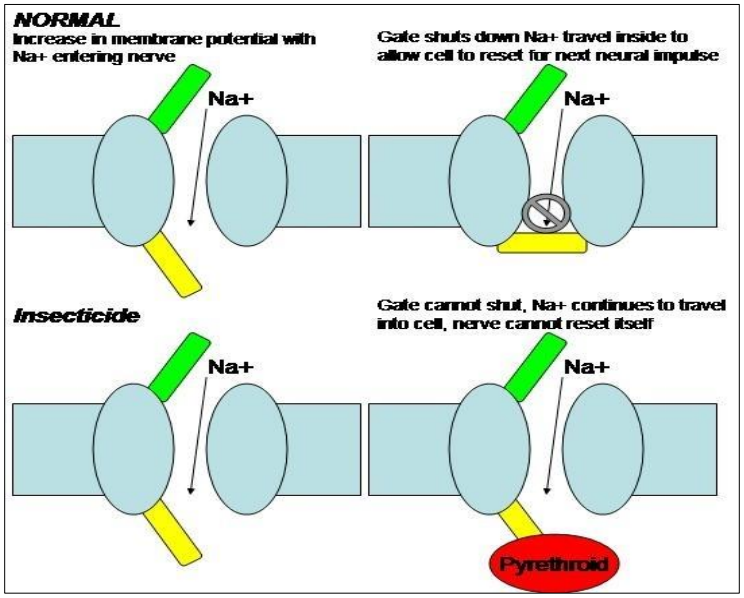

Figure 10 Mechanism of Action of Pyrethroids Poisoning (Manorajan, 2017)

The concentration of organophosphates contained in the form of primiphos-methyl and temephos used by the worker were 49% ww and 44.6% ww respectively. Meanwhile, the concentration of deltamethrin used was 25% ww (Malaysia Ministry of Health, 2005). All three pesticides used during past 3 months prior to the illness were registered with the Pesticide Board Malaysia to be used in public health activities. In this case, primiphos-methyl is used for mosquito adulticide in the form of thermal fogging while temephos was used in the form of liquid spray in residual mosquito adulticide function. Deltamethrin was used for larvicidal activities. The authors were in the opinion that the worker was mostly exposed to primiphos-methyl since primiphos-methyl was the most commonly used pesticide (Fig. 2) and thermal fogging produced a much smaller droplet size that can be easily inhaled and absorbed via respiration (World Health Organization, 2003).

Organophosphates can be absorbed through the skin, respiratory system and the gastrointestinal tract. In this case, the route of exposure is more likely via inhalation thus giving a direct effect to the respiratory system. Bronchospasm and bronchorrhea can occur due to the muscarinic effects of organophosphates and involvement of respiratory muscles may lead to respiratory depression (Elspeth J. Hulse, James O. J. Davies, A. John Simpson, Alfred M. Sciuto, and Michael Eddleston, 2014). Meanwhile, deltamethrin is used in liquid form, mixed with water and sprayed to stagnant water surfaces as a larvacide in this case. In view of improper use of PPE by the worker, exposure to deltametrin was most likely via inhalation and skin absorption. Toxicity-wise, deltamethrin is considered low in toxicity by inhalation when compared to organophosphates with a 4-hour LC_{50} of 2.2 mg/L and a 1-hour LC_{50} of greater than 4.6 mg/L in rats (Gowrinath, Shanthi, Sujatha, & Murali Mohan, 2012).

It is difficult to assess dose-response effect of the pesticide to the worker as exposure assessment was not done. It is partly due to the mobility of the worker while at work and the open space involved. Another aspect to be considered is the proper hazard control is not adequate and it is indirectly due to poor adherence to safe working procedure. The employer has published two relevant documents that can help in establishing safe working procedure in the form of a guideline for storage and handling of insecticides (Ministry of Health, 2004) and another for prevention of workplace accident (Ministry of Health, 2009*)*. The former has information on step by steps of "do and don't" in handling insecticides while the latter explained the how to prevent occupational accidents and diseases by framing the responsibilities of employer and employees in accordance to Malaysian occupational safety and health legal framework. However, with regard to chemical hazard that is relevant in this case (pesticide), the latter document only touches on superficial principles of hazard control.

As stated in Occupational Safety and Health Act 1994 Part IV Section 15 (2) (b), employer is responsible in ensuring, so far as is practicable, safety and absence of risks to health in connection with the use or operation, handling, storage and transport of plant and substances. Hence, Ministry of Health had drafted a Cholinesterase Screening Program for Foggers in 2016. Plasma cholinesterase screening test was highlighted in the Use and Standard of Exposure of Chemicals Hazardous to Health Regulations, 2000 (USECHH) (Department of Occupational Safety and Health, 2000) whilst Red Blood Cell Cholinesterase level was recommended for diagnostic purpose. The tests were carried out by designated laboratory officers at Public Health Laboratory. The officers are trained to conduct the tests. The procedure manual is available at the laboratory for reference. This are case, the test was run using Olympus-D/P/01-002 analyzer which was calibrated daily by the officer and maintenance performed by the appointed third party once every six months.

The most challenging part is to ensure foggers are rested for one month duration from the last exposure to organophosphate to establish a baseline serum cholinesterase as there is manpower shortage to carry out vector control activities during that period. Fogging activities, need to be performed as soon as vector-borne infectious disease cases were reported and in this case, there was a surge of cases. Two samples of worker's blood were taken to get an average value of baseline serum cholinesterase and it will be periodically compared with post exposure values. The first sample was taken after the rest meanwhile second sample was taken between day four and day fourteen of the first sample (Fig. 11). Due to the effect of ageing on cholinesterase level, baseline serum cholinesterase need to be reviewed once every two years (Roberts, 2007.).

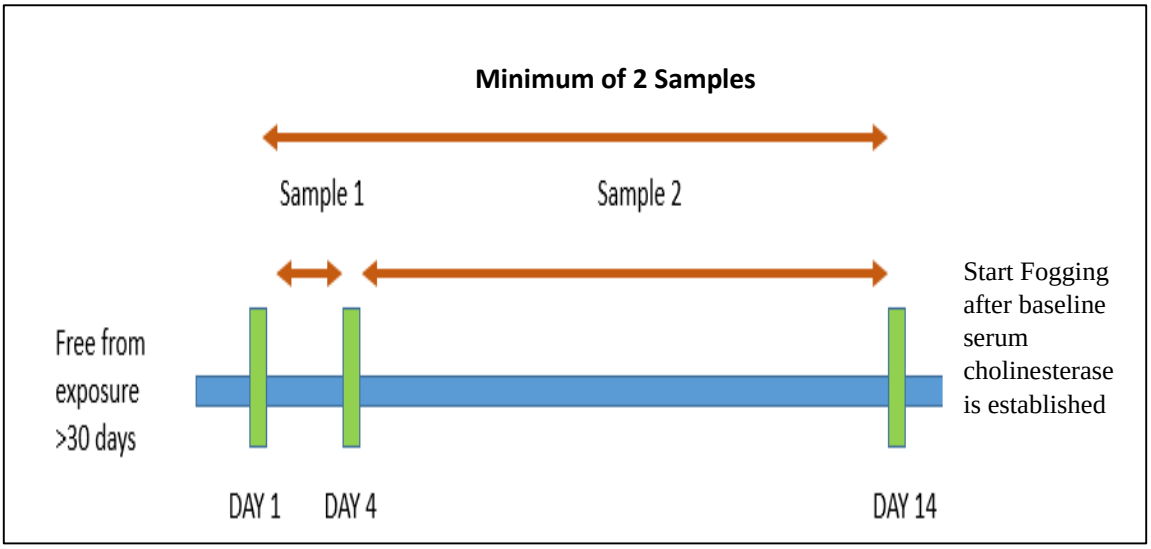

Figure 11 Timeline to Establish Baseline Serum Cholinesterase Level

The challenges in establishing baseline cholinesterase level in this setting could arise due to the following factors:

1) Coordination among workers (on annual leave, day off, medical leave, etc).

2) Workers need to rest for one month in order to establish baseline serum cholinesterase level, thus depriving available manpower for pesticide spraying activities.

3) Serum cholinesterase can only be done at one laboratory in the city of Johor Bahru, the state capital of Johor. Therefore, supervisor need to pre-plan between workers and despatch team to send the sample in timely manner to the laboratory. Time constraint is an issue for districts far away from Johor Bahru.

4) Reassessment of baseline serum cholinesterase once every two years. The existing workers might have been transferred to other unit and there is a need to establish new baseline for new workers.

5) Lack of awareness among supervisors and workers on the importance of serum cholinesterase as the indicator of organophosphate poisoning.

We noticed there were grey areas in conducting medical surveillance and we would recommend the following measures for the workers in Vector Borne Disease Control unit:

1) Improve and strengthen awareness among the supervisors that it is compulsory for them to send their workers for fitness to work assessment at the Occupational Health Clinic.

2) Develop script related to Occupational Safety and Health for supervisors to inform and brief their workers at each roll call session.

3) Improve collaboration between supervisors and Occupational Health Unit to conduct courses to ensure effective and efficient use of Personal Protective Equipment (PPE) by the workers.

4) Establish integrated discussion with higher management to strengthen safety and health at workplace which include periodic monitoring and auditing.

5) Develop a logbook with specific training pertaining to the hazards encountered during working process.

6) Gazette the Ministry of Health document for Cholinesterase Screening Program for foggers to make it a legally binding document to be followed as a guide and reference for the supervisors and medical officers to conduct medical surveillance.

8.0 CONCLUSION

Chemical pneumonitis is a well-known complication following inhalation of toxic fumes, toxic gases or pesticides. The spectrum varies from asymptomatic focal inflammatory reaction to life threatening condition. Workers exposed to organophosphate pesticides should undergo medical surveillance which includes spirometry and cholinesterase blood screening as required by the Occupational Safety and Health (Use and Standard of Exposure of Chemicals Hazardous to Health) Regulations, 2000. Failure to go through Fitness to Work (FTW) assessment will breach the safety at workplace that can possibly end up in fatality. Hence, we urge Pest Control Officers to be aware of the health effect of pesticide exposure and employers need to provide necessary framework of monitoring.

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