CANADIAN TACTICAL OFFICER'S ASSOCIATION NEWSLETTER

Handling Novichok and the 4th Generation Nerve Agents

CTOA Bulletin

3/17/2019

4th Generation Agents - Novichok

Threatwatch first introduced the topic of Novichok in 2011. At the time there was little or no information available online, but a small collection of documents were available from the deep web; there was a great deal of skepticism about the article at the time from people outside of CBRNE circles, saying there was no such agent in existence.

On 4 March 2018, Sergei Skripal, a former Russian military officer and double agent for the UK's intelligence services, and his daughter Yulia Skripal were poisoned in Salisbury, England, with a Novichok nerve agent known as A-234, according to official UK sources and the Organisation for the Prohibition of Chemical Weapons (OPCW). After three weeks in a critical condition, Yulia regained consciousness and was discharged on 9 April 2018. Sergei was also in a critical condition until he regained consciousness one month after the attack. He was discharged from hospital on 18 May 2018. A police officer was also taken into intensive care after apparent exposure to the remnants of the toxic agent at Sergei Skripal's residence. By 22 March he had recovered enough to leave the hospital.

On 30 June 2018 a similar poisoning of two British nationals in Amesbury, seven miles from Salisbury, involved the same nerve agent. A man found the nerve agent in a perfume bottle and gave it to a woman who sprayed it on her wrist. The woman fell ill within 15 minutes and died on 8 July, but the man who also came into contact with the poison survived. British police believe this incident was not a targeted attack, but a result of the way the nerve agent was disposed of after the poisoning in Salisbury.

Later the British government accused Russia of attempted murder and announced a series of punitive measures against Russia, including the expulsion of diplomats. British authorities identified three Russian nationals as suspects in the Skripals' poisoning, and alleged that they were active officers in Russian military intelligence. The UK's official assessment of the incident was supported by 28 other countries which responded similarly. Altogether, an unprecedented 153 Russian diplomats were expelled. Russia denied the accusations and responded similarly to the expulsions and accused Britain of the poisoning.

So now that there seems to be no doubt that Novichok exists, safety awareness bulletins have been released by various domestic and global agencies as part of ongoing preparedness to inform decisions, protect emergency responders, and support response operations if an incident ever occurs involving a fourth generation agent (FGA, also known as A-series or Novichok nerve agents).

History and Development of FGA's

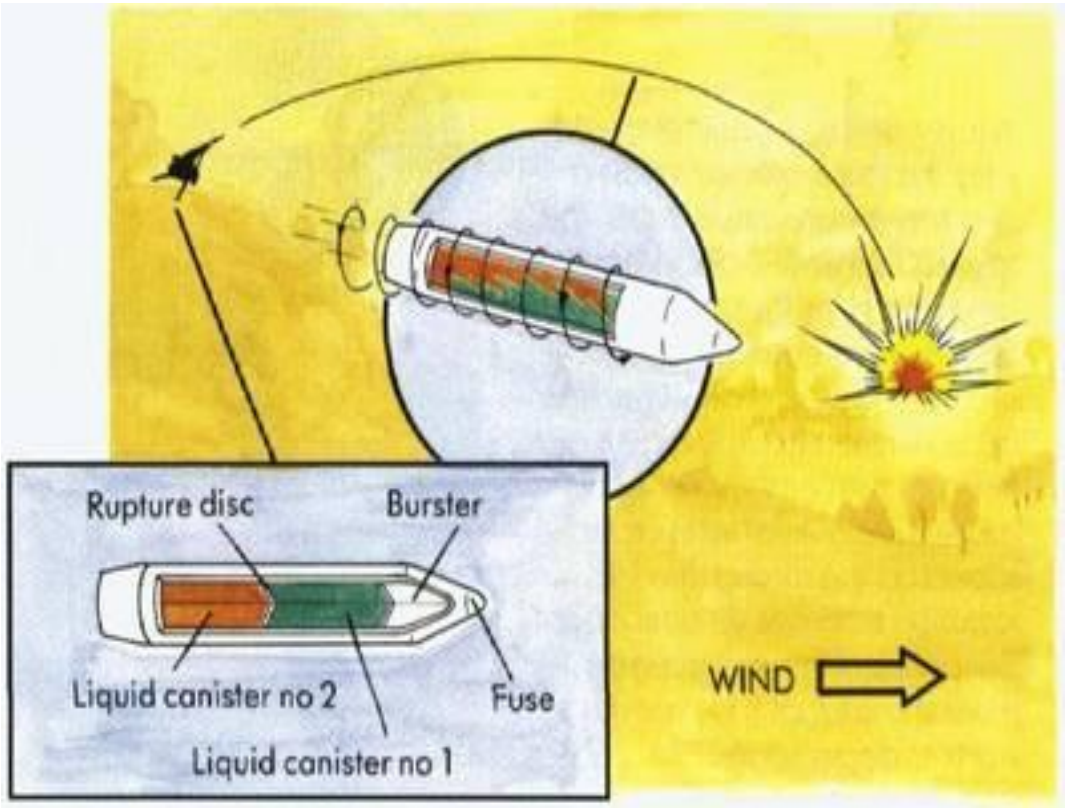
The Soviet war machine placed a high priority on the use of chemical warfare agents. As much as 30 percent of the USSR’s arsenal was related to chemical warfare. Due to the secrecy of the former government, very little information was available about the direction and progress of their chemical weapons programs until the latest decade.

In 1991 and 1992, Russian chemists Vil Mirzayanov and Lev Fedorov published articles in the Moscow News revealing illegal chemical weapons experimentation in Russia. According to Mirzayanov, when the United States and the Soviet Union signed a bilateral agreement in 1990 to reduce their chemical weapons stockpiles, Moscow was in fact developing secret chemical weapons of its own. Mirzayanov was imprisoned several times for revealing this information, but was eventually released and relocated to the US.

Russia developed several highly toxic agents during this period; The only unclassified information is that they are known in the open literature as "Foliants" and by various code designations, such as A-230 and A-232. Called the Novichok series (after the Russian word for "New Kid", or newcomer), they were included in Mirzayanov's reports, and were designed to achieve multiple objectives:

- To be undetectable using standard NATO chemical detection equipment
- To defeat NATO chemical protective gear
- To be safer to handle
- To be effectively untreatable

To meet these objectives, the Soviets developed binary weapons. In binary chemical munitions, the toxic agent is not contained in its active state, but is in the form of two chemical precursors, physically separated within the weapon. The chemical reaction takes place while in flight. Firing the munition ruptures the capsules. The munition spins rapidly in flight, thoroughly mixing the two precursors, so they can react with one another. Finally, a bursting charge aerosolizes and distributes the chemical agent.



Because the precursors are significantly less hazardous than the agents themselves, this technique makes handling and transporting the munitions simpler. Additionally, precursors are easier to stabilize than the binary agents themselves, which significantly increased their shelf life. Finally, the individual precursor chemicals were not on any prohibited Chemical Weapon Convention lists, avoiding attention from international treaty inspectors.

Mirzayanov claims that under the Foliant program, the Soviet military secretly developed and tested three unitary agents that were the basis for the development of the Novichok series of binary weapons. The first was Substance 33, a compound similar to the persistent nerve agent VX, of which 15,000 tons were produced in the early 1980s. The two other unitary nerve agents were A-230, which

was officially approved by the military in 1988, and A-232, which was effective in cold weather (unlike most nerve agents) and would not freeze on the battlefield.

The first Soviet binary agent, Novichok-5, was derived from the unitary nerve agent A-232. A test batch of 10 metric tons of Novichok-5 was produced at a plant in Volgograd and field-tested in 1989 and 1990. Novichok-5 is five to eight times more lethal than VX and practically defies medical treatment. One of the chemical engineers involved in its development was exposed to the agent in a laboratory accident, and became an invalid for life. The USSR also developed a binary form of Substance 33 that has no established name but that Mirzayanov calls "Novichok-X", which is undetectable by standard NATO chemical weapon detectors.

Another example of the Novichok family is the third-generation nerve variant A-234, which is a simple unitary agent derived from acetonitrile (used in photographic film industry and pharmaceuticals) and a common organophosphate pesticide precursor. Dispersed in an ultra-fine powder as opposed to a gas or a vapor, it can bypass much of the chemical protective gear used by modern armies, where it can be absorbed directly through the skin and can break through a NATO standard gas filter canister in minutes. Mirzayanov also reports that the military had another binary agent called Novichok-7, which had a similar volatility to the nerve agent soman but is approximately 10 times more effective.

Agent	LCt_{50} Inhalation mg/min/m³ (Lethal Concentration)	LD_{50} Skin mg/individual Lethal Dose)
Tabun	200	4000
Sarin	100	1700
Soman	100	300
VX	50	10
Novichok	1 (Estimate)	3 (Estimate)

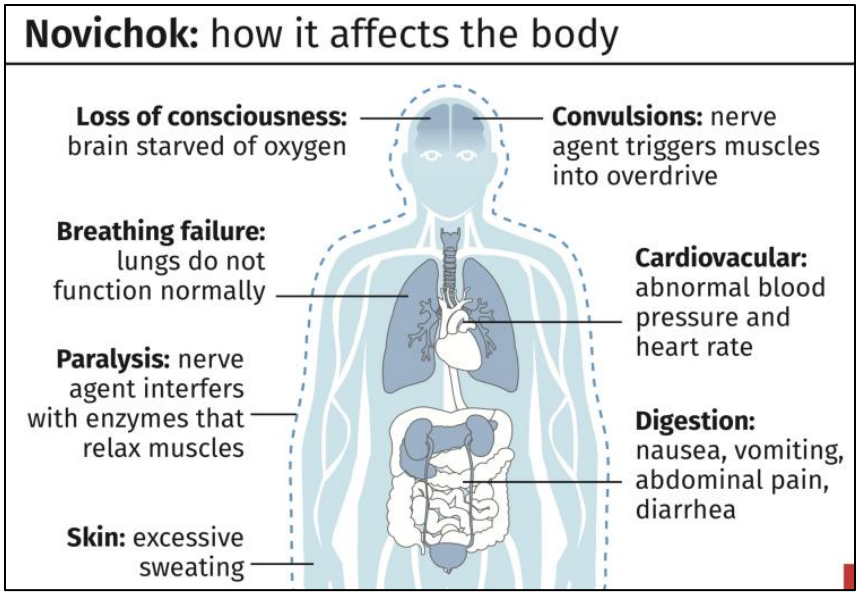
LD_{50} Skin is the amount of product on skin in mg that will kill 50% of those exposed.
LCt_{50} Inhalation is the concentration (C) over time (t), measured in mg per minute per cubic meter of lung tissue that will kill 50% of those exposed.

Clinical Features of FGA's

FGAs are low volatility nerve agents, like VX, and therefore most likely to be encountered as a liquid.

In general, the latent period between dermal exposure and symptom onset may be longer for FGAs than for VX and can be up to 3 days. Inhalational, ingestion, or large dermal exposures will have shorter latent periods.

FGAs are persistent; if not decontaminated, they can remain on environmental surfaces for days or even many months. Physical surfaces must be decontaminated to prevent additional exposures. Decontamination of skin and hair is crucial and may provide clinical benefit even when performed hours to days after exposure to liquid agent, although the earlier the decontamination, the better. Bronchoconstriction is a prominent feature of FGA toxicity in animal studies but has not been observed in the very limited number of human cases. If it occurs, bronchoconstriction may be difficult to manage clinically.



Seizure activity has been a prominent feature of FGA toxicity in animal studies but has not been observed in the very limited number of human cases. FGAs may cause severe metabolic acidosis with markedly elevated serum lactate. Patients poisoned by FGAs may need medication and intensive supportive care over an extended duration. Multiple casualties may strain local resources at the point of care.

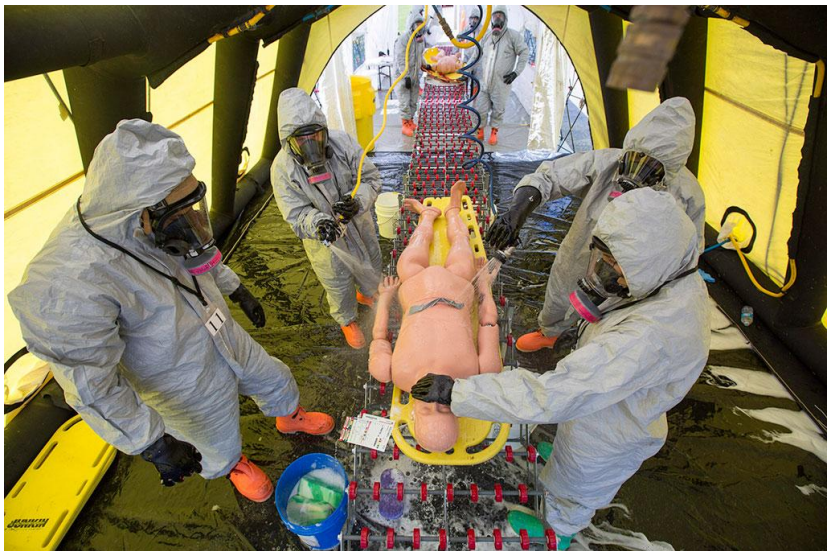
PPE

The all hazards approach is usually the safest, unless immediate life saving is required. Level A is the safest for an unknown agent, for full respiratory and splash protection. Level B is a more efficient method when patient extrication is required, when combined with correctly applied butyl boots and 15 mil nitrile or 14 mil butyl rubber gloves. Single-use coveralls should be constructed of fabric that provides protection against VX, such as TyChem® F, Microchem®4000, or Zytron® 300 fabric with taped seams. Level C is not recommended for the initial approach, as canisters only provide limited protection against FGA's in gaseous form. As always, follow local guidelines and protocols.

Patient Decontamination

After FGA exposure, the first and most effective decon procedure is removal and containment of exterior clothing. This is a vital step to reduce ongoing and secondary exposure and can remove

significant amounts of chemical contamination. Pay particular attention to how clothing is removed in order to minimize the spread of contamination.
Decontaminating patients' skin and hair is essential. Decontamination is a medical intervention and should be performed as soon as possible to prevent absorption of agent. However, even after a delay of hours or days, decontamination may still reduce harm to the patient and the risk of secondary exposure to other people.



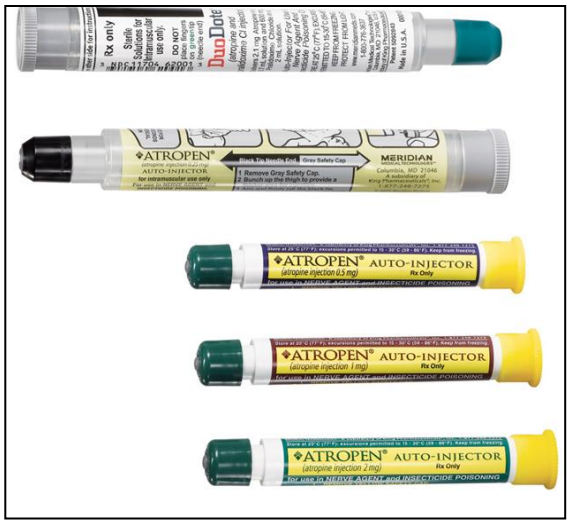
Blotting skin with a paper towel, dry wipe, or other dry cloth will also contribute to effective decontamination. Primary Response Incident Scene Management (PRISM) guidance recommends 10 seconds of blotting followed by 10 seconds of rubbing the contaminated area of skin. This dry decontamination step can be performed by patients themselves and, along with clothing removal, should be done as early as possible. Disrobing and blotting skin with a paper towel, dry wipe, or other dry cloth can remove significant amounts of chemical contamination.

If Reactive Skin Decontamination Lotion (RSDL) is available, it is recommended for spot decontamination. Water should be utilized per established decontamination protocols after disrobing, ideally with a high-volume, low-pressure shower, including soap if available, gentle rubbing with a soft cloth or sponge, and active drying with a clean towel after the shower. Do not delay decontamination awaiting specialized products such as soap or RSDL. Avoid using hand sanitizer or other products containing alcohol, as they may enhance absorption of FGAs. Do not use bleach to decontaminate skin. FGAs are not readily degraded by water; thus, avoid direct contact with runoff.

Responders and hospital personnel should report any potential exposure and be medically evaluated immediately per your department or agency's procedures. Symptoms may occur up to 3 days post exposure.

Treatment
Meticulous attention to supportive and symptomatic care is the key to patient management. FGA exposures may be resistant to initial and typically recommended medication doses, requiring significantly higher doses and a longer duration of repeated dosing than other nerve agent exposures. Along with supportive care and decontamination, anticholinergics (e.g., atropine), oximeAChE reactivators (e.g., 2-PAM), and anticonvulsants (e.g., the benzodiazepines - diazepam, midazolam, and lorazepam) are the mainstays of the management of nerve agent toxicity. Supportive care can be

remembered using the acronym **ABCDD**. The **ABC**s, or airway breathing circulation ensures preservation of vital functions before and during decontamination and administration of medications.



Decontamination (**D**) is a medical intervention designed to minimize the conversion of an external dose (on the skin) to an internal dose (inside the body). It is as important as supportive care and medication can be lifesaving. Decontamination should be performed as soon as possible but with FGAs may still be effective even hours or days after exposure.
Drugs (**D**) include atropine, 2-PAM, and diazepam. Anticholinergics are given until secretions diminish and airway resistance (difficulty breathing, resistance to ventilation) resolves. 2-PAM is given as long as nicotinic effects such as muscle weakness (effects not treated by atropine) are present. Anticonvulsants are given initially in severe cases even in the absence of convulsions because of a positive interaction of anticonvulsants with the other medications.

Auto-injectors (AI) have typically been used for administering drugs intramuscularly (IM) to treat nerve agent exposures in a military setting and are available for civilian use. They may be particularly expedient in the pre-hospital setting. However, if resources permit, intravenous (IV) or intraosseous (IO) administration would be preferred, especially in critically ill patients. Lorazepam is also available for intranasal (IN) administration. Atropine and 2-PAM are available together in the same as DuoDote, packaged together (Mark 1 kit) and as individual AIs.

Waste Management
Once lifesaving efforts are under control, the incident command should develop a comprehensive waste management plan along with a site-specific health and safety plan. The incident-specific comprehensive waste management plan should address the following:
Consideration must be given early on, in an exposure or suspected exposure event, of the need to preserve certain materials and samples as required for investigation and chain of custody purposes. Consultation with the local law enforcement CBRNE or other law enforcement may be necessary to ensure proper materials (and quantities) are preserved.
Materials and samples needed for investigation and chain of custody should be secured and isolated from the waste collection activities. Once designated as "evidence" the materials are no longer treated as "waste."
FGAs can persist for extremely long periods of time on materials and effluent liquids such as water. Personnel handling these materials and liquids must be made aware of the potential hazard they present and provided with appropriate PPE.

The plan must identify specific collection and decontamination methods and personnel. Personnel must be knowledgeable of the FGA hazards, effective decontamination methods, and have appropriate PPE.
Waste must be decontaminated before it is handled by the facility's regular waste management staff.
Incineration may be identified in the Comprehensive Waste Management Plan as the best decontamination method for some of the contaminated materials. Consult with experts for disposal recommendations.

Downgrading PPE
In order to determine when it is appropriate to downgrade PPE, employers are encouraged to perform a risk and hazard assessment, taking into account patient status.
General recommendations for handling PPE include:

- PPE should be inspected prior to donning for any defects and those that are punctured, torn, or otherwise damaged should be discarded and replaced.
- PPE should be taken off in a dedicated area when exiting the patient room to prevent cross-contamination.
- PPE, linens, and other waste that have come into contact with the patient should be segregated from other waste and disposed of properly. Consult with experts for disposal recommendations.

Field Detection and Sampling
Detecting FGAs is more challenging than detecting other chemical agents. There is a limited field capability within hazardous materials teams to detect, characterize, and identify FGAs. M8 paper may be useful in detecting liquid FGAs. Upon exposure to a liquid, a yellow/green or green/blue color is indicative of an FGA, and may shift to a more yellow color over time (up to 10 minutes). This color change is further indicative of an FGA versus VX. Failure to detect does not mean that FGAs are not present.
Monitoring, sampling, and analysis by specialized assets may be the only way to determine if FGAs are present. Initial field detection of FGAs may be possible, but more definitive identification of the presence of an FGA will require specialized resources. Standard field instruments (CAM or HazID) may not detect FGA's.

Fire Fighting Measures
Allow fire to continue to burn unless these actions would result in greater risk to the public. Use protocols established for organophosphate pesticides. Use dry chemicals, carbon dioxide, alcohol-resistant foam or other foam materials to extinguish fires. Fight fire from upwind and uphill, if at all possible. Avoid using water to extinguish fires. FGAs are highly soluble in water, will persist, are highly mobile, and could contaminate larger areas.
Dike fire control water for later treatment and disposal; runoff from fire control or dilution water maybe extremely toxic resulting in contaminated water supplies and further complicate clean-up efforts. Smoke/steam plume may be contaminated by the agent; large areas downwind of fire may be affected by contaminated smoke/steam plume. Finally, control runoff from patient decontamination areas.

This information is by no means complete, or even 100% accurate, but is provided for general guidelines in dealing with FGA's. Use established local protocols, but get started by having the conversation. The Novichoks are now acknowledged as real agents. The politics of who did what in the UK or why is no longer relevant. Novichok is real.