Dr Christina Baxter, of EmergencyResponseTIPS.com and Hazard3.com, offers helpful advice for first responders

Keeping you safe!

This column is intended to provide operational guidance to the hazmat/CBRNE community on the selection and performance of equipment and tactics. In this issue we are focussing on emergency response to toxins, which are natural poisons that are often classified as either chemical or biological warfare agents.

Toxins are chemicals which can be extracted from biological materials including plants, animals, and microorganisms; many can also be synthesised chemically today. This broad definition includes agents such as botulinum toxin, ricin, palytoxins, tetanus, viper venom, scorpion venom, etc. Toxins, typically solids or liquids, can be ingested, injected, inhaled, or absorbed dermally. The lethality of toxins depends on their identity, the dose and route of exposure.

Current threat landscape

While examples of toxin use go right back to ancient times, interest in weaponising toxins gained pace leading up to and during world war two. Of the toxins available today, the materials considered to be of greatest interest in a terrorism context include botulinum toxin (agent X), ricin (agent W), abrin, saxitoxin (agent TZ), tetrodotoxin and nicotine. This is due to a combination of factors including ready access to starting products, simple extraction procedures, stability of the product in storage and multiple dissemination methods.

Background

Of the high interest toxin threats, ricin is increasingly used in domestic criminal activity and terrorism. The highest profile uses of ricin include the 1978 assassination of Georgi Markov in London by injection using a weaponised umbrella and the attempted assassination of Boris Korczak in Virginia in 1981.

Many of the incidents in the US have been 'the stuff that movies are made of'. These have included the December 2017 incident in a Vermont retirement community and the May 2013 letters to President Obama and Mayor Bloomberg by a jilted, relatively unknown actress. In April 2013 letters were sent to a judge and a senator in Mississippi, and President Obama, by a conspiracy theorist Tae Kwon Do instructor attempting to implicate an Elvis impersonating conspiracy theorist. In November 2011 four men in Georgia, aged 65 to 73, plotted varied terrorism activities including releasing ricin from an airplane and deploying it using explosive devices; and there have been many others. More recently, dispersion devices containing ricin and abrin have been confiscated in Germany (2018) and Indonesia (2019).

Recipes for producing ricin toxin from the castor bean and abrin from rosary peas are prevalent across social media and within anarchist/terrorist literature. The toxic protein only makes up a small percentage of the bean/pea material. To put this in perspective, the production of 2lb (0.9kg) of ricin requires 80lb (36kg) of castor beans! The lethal dose (LD50) for ricin is 3-5µg/kg via inhalation, 24µg/kg via injection, and 20,000µg/kg via ingestion. Abrin is slightly more toxic with an LD50 of 3.3µg/kg via inhalation, 0.3µg/kg via injection, and 10 – 1000µg/kg via ingestion.

Botulinum toxin saw its first military application in the early 1930s, when it was fed to prisoners in Japan. Researchers from the US, UK, France, and Germany began weaponising botulinum toxin shortly after. In 1995, Iraq admitted to the UN Special Commission inspection team that it had manufactured 4,900 gallons of concentrated botulinum toxin for use as a biological weapon in 1989/1990. The weapons that were produced, including SCUD missiles and R-400 bombs with the toxin, were not used, and later destroyed.

The Aum Shinrikyo cult in Japan also attempted to produce briefcase-based aerosol dissemination devices in the early 1990s but were unsuccessful, potentially due to the cult's scientists unsuccessfully isolating and cultivating C. botulinum. Unlike with ricin, abrin, and nicotine, botulinum has not been used successfully. Botulinum toxin is the most toxic substance known with a lethal dose via inhalation of 10 – 13ng/kg and via ingestion of 1,000ng/kg.

The first recorded use of nicotine as a weapon was in 1850. In recent times, a 2011 Norwegian right-wing extremist manifesto named the substance as an ideal weapon due to its ease of access. Unlike many toxins of interest, nicotine is also a dermal threat. With the advent of electronic cigarettes and vaping, the availability of nicotine in high concentrations has skyrocketed. Nicotine e-liquids are commercially available at levels up to 60mg/mL.

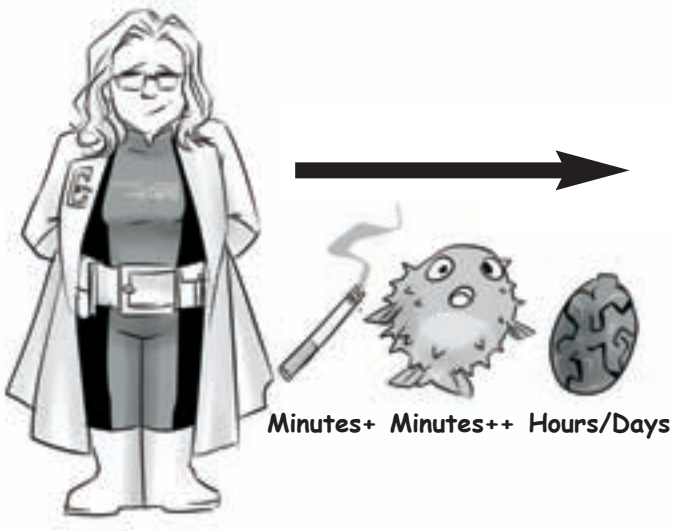
Keeping you safe!

Nicotine has been used as a targeted assassination tool more frequently in recent years. In the US, the 1994 murder of Linda Curry in California, the 2003 intentional contamination of hamburger meat in Michigan and the June 2010 attempted murder of Kevin Mengel in Pennsylvania are all examples. Just last year, a man attempted to murder his ex-wife in Roseville, Minnesota using liquid nicotine. This event was originally treated as an organophosphate exposure due to early symptoms but was later identified as nicotine as she had extremely high levels of cotinine (a metabolic byproduct of nicotine) in her urine. This case was unique in that it was an attempted murder taking advantage of the dermal toxicity of nicotine rather than ingestion as in past cases. Nicotine is the only toxin of interest that has permissible exposure limits (0.5mg/m3) (US) and an immediately dangerous to life and health rating (5mg/m3) (US) due to its recreational use and former application as an insecticide. The estimated lethal dose via ingestion in humans ranges from 0.5 to 60mg/kg.

The paralytic marine toxins, saxitoxin (STX or agent TZ) and tetrodotoxin (TTX) are receiving more attention of late, mainly because they can be synthesised as well as extracted from marine life. Intoxication with these materials can cause nausea, vomiting, cranial nerve dysfunction, headaches, muscle weakness, vertigo, respiratory failure, and paralysis. These potent neurotoxins have similar modes of action and clinical signs of intoxication making it difficult to differentiate between them.

Response considerations

As with many biological agents, symptoms of exposure may be delayed, with the onset of symptoms being fastest for nicotine (minutes), followed by saxitoxin and tetrodotoxin (30 minutes). Botulinum, abrin, and ricin may take many hours to days. Inhalation and injection cause quicker onset of symptoms than ingestion. Where dermal exposure is possible, it generally takes many hours to days.



Because the impacts of a toxin release may not be obvious for some time, it is important to follow the epidemiological clues to an unnatural event: specifically, an uncommon disease with large numbers of patients, dead animals, unusual manifestations of symptoms across many people, downwind plume patterns, and direct evidence of an attack. Using these clues, the traditional epidemiological tracking of personal movement, and standard incubation periods for the threat of interest, you must work backwards to find the point of initiation before proper sampling, detection, and decontamination can occur.

It is important to identify the toxin release characteristics such as purity, amount, and toxin particle size early in the response as this will drive the requirements for sampling, detection, protection and decontamination. For example, the risk level of an event involving a bean/pea mash is far lower than that involving purified toxin.

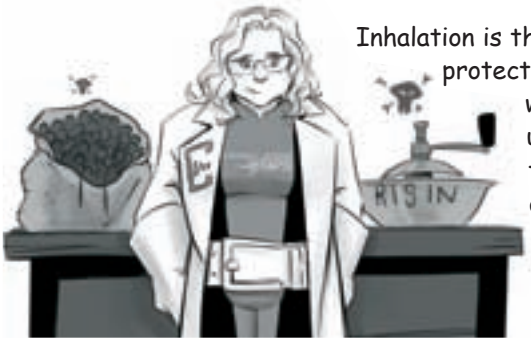
Sampling and detection

Toxins can be dispersed as powders, liquids or aerosols. When available in bulk liquid or solid states, the powders and liquids can easily be sampled and tested using available equipment, although care should be taken to avoid aerosolising the product. Due to the high inhalation threat associated with toxins, it is prudent to introduce technologies such as vacuum based sampling which allow the operator to work more closely with samples while retaining an enhanced protective posture.

The field of biological toxin detection has grown rapidly in recent years, however most of the commercial technologies are still based upon protein content, lateral flow immunoassays, and polymerase chain reaction (PCR). Operationally, a quick protein test, or alkaloid test, can be used to manage risk levels while waiting for immunoassay (15 minutes) or PCR (hours) results. In addition, monitoring for airborne particulates is also an indirect detection method that can be used to monitor the risk level.

Protection

Protection requirements will be driven by the size and complexity of the event, the phase of the production process, and the amount of processing chemicals present. For example, mashed or ready to mash beans, extract solutions, and precipitated abrin/ricin pose little threat whereas sampling and dismantling milling machines and chemicals present a much higher risk. To avoid dispersal of a solid biological agent, consider wetting any observable agent prior to removal of outer clothing, PPE removal, decontamination, or destruction.



Inhalation is the most significant route of exposure for toxins, therefore protection of the responder's airway should take priority. In an area where the hazards are not fully characterised or are considered unknown, self-contained breathing apparatus is required. If the toxin was not dispersed as an aerosol and airborne concentrations are low, a full-face respirator (with a P100 filter) or a powered-air purifying respirator (with a HEPA filter) can be used. Ricin, abrin, botulinum, saxitoxin and tetrodotoxin do not easily penetrate unabraded skin, therefore dermal protection can be as simple as a coverall or an ensemble certified against NFPA 1994, Class 4 or NFPA 1999 Multi-Use ensemble. Care should be taken to fully characterise other threats in the response area to ensure that there are no solvent or caustic materials to drive a higher level of skin protection. At small events, PPE designed for biological events will likely be sufficient with continuous monitoring for particulates. For large scale processing labs, PPE designed for chemical protection may be required, based upon continuous monitoring for particulates, toxicity, flammability, and corrosivity.

Decontamination

Most toxins (except nicotine and similar alkaloids) are not considered dermal hazards, however any contact with toxins should be minimised by washing the skin with soap and water as soon as feasible. The Emergency Response Decision Support System incorporates a new destruction tool to help operators determine the best methods for destroying toxins using hypochlorite, hydroxide, and peracetic acid solutions.

Most importantly, if you have reason to believe that a toxin has been deployed, it is always best to call upon your specialised assets at the local, state, federal, or international level to deal with the incident.

Stay safe!

Images are courtesy of Phil Buckenham *https://philbuckenhamart.wixsite.com/philbuckenham*