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Death by Polonium-210: lessons learned from the murder of former Soviet spy Alexander Litvinenko

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The medical response to radiation—whether the result of radiological warfare, terrorist deployment of improvised radiation dispersal weapons, political assassination, occupational or industrial accidents or the medically radiated patient remains one of the least taught among all disciplines within medical education. In the aftermath of 9/11 among medical vulnerabilities to toxicant threats, of all the categories of weapons of mass destruction (WMD)—whether using the CBRNE (chemical, biological, radiological, nuclear, explosive) or NBC (nuclear, biological, chemical) acronym—radiation is the least taught in professional schools, responder cultures or civil preparedness organizations. To date, few health care professionals (HCP) possess the fundamental knowledge or skills to identify and diagnose, let alone treat a radiation victim; this vulnerability made even more obvious in the aftermath of the high profile assassination of former Russian agent Alexander Litvinenko. He was poisoned with $Polonium^{210}$. Radioactive substances are ubiquitous with radiation sources being in or transported through virtually every region nationwide. It is essential to increase preparedness among community and rural health care facilities as well as urban and university hospitals. Managing radiation injuries effectively requires access to specialized equipment and expertise. Radiation sickness is progressive and may require acute, critical and long term care throughout the course of illness. Regardless of the source, preparedness rests upon acknowledging a threat exists and dedicating the resources to address the risks including the enhancement of training and equipment. Mass or individual exposures to radiation present unique challenges to the entire response continuum from law enforcement, first responders and emergency medical care. Increased education about and practice in responding to radiological threats is essential to enhance preparedness.

"The chilling reality is that nuclear materials and technologies are more accessible now than at any other time in history," said former CIA Director John Deutch in testimony before the Permanent Subcommittee on Investigations of the Senate Committee on Government Affairs on March 20, 1996.[1] This reality became all too evident in November 2006 when Alexander Litvinenko, a Russian dissident who had publicly criticized the leadership in Moscow, was murdered by poisoning with radioactive Polonium-210 in the United Kingdom.[2-5]

Litvinenko, a former KGB agent, was tasked with investigating political corruption as a member of the elite organized crime unit of the Russian Federal Security Service (FSB) before defecting to London. His former job took on

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greater significance than is generally credited to the time-honored but often underappreciated component of the assessment and diagnostic process—the occupational history.

Health care professionals often overlook a patient's travel history and obtain less-than-thorough occupational histories. A recent study showed that, among patients presenting to the emergency department (ED) with a travel-related illness, only 16% were asked about recent travel, resulting in missed diagnoses.[6-8] In this era of emerging pathogens, global travel, and high-risk occupations, such information can offer important clinical clues and prove critical to patient diagnosis.

Case report

On November 1, 2006, a previously healthy, athletic, 43-year-old Russian male who had emigrated to London 5 years earlier presented to a North London hospital with acute, severe, progressive gastrointestinal symptoms. He was a writer. Of course, we now know what his prior occupation was. Whether Litvinenko intentionally withheld his prior occupational history or it was not initially pursued by clinicians remains unclear.

Litvinenko's health rapidly deteriorated: his hair fell out and he developed pancytopenia (ie, a shortage of all types of blood cells, including red and white blood cells, as well as platelets). Because his symptoms were consistent with radiation or thallium toxicity, physicians obtained urine and blood samples and subjected them to gamma spectrometry.[2,5] But the tests did not register anything unusual.[5]

While clinicians began searching for other causes of illness, including exotic toxins, biologicals, and poisons, the patient's condition steadily declined. Because Litvinenko was not responding to treatment, his urine was sent for more advanced laboratory analysis to Britain's Atomic Weapons Establishment (BAWE), where tests revealed significant amounts of alpha particle radiation.[5] Not long thereafter, on November 23, Litvinenko died of internal contamination from Polonium-210 (^{210}Po).

In the aftermath, Litvinenko's death was classified as murder. An international investigation identified several other victims, and numerous locations in the UK tested positive for traces of ^{210}Po contamination. ^{210}Po was found at a London restaurant and bar that Litvinenko visited,[2] and some traces were found on British Airways aircraft; fortunately, none of the 1700 passengers or 250 patrons of the restaurants were contaminated or became sick. However, another former KGB agent and a former Russian army officer both tested positive for ^{210}Po in Moscow.[3] A substantial amount of ^{210}Po must have been used to cause such widespread contamination.[5]

Weeks elapsed between the poisoning and realization that radioactive materials were used,[5] and as of January 2007, at least 12 people had tested positive for contamination.[3] The incidental exposure of these individuals did not appear to pose a risk.[3] However, fears of ^{210}Po contamination led thousands of people to contact the National Health Services direct helpline, established in the aftermath of the assassination.[3]

Understanding Polonium-210

^{210}Po is considered one of the most hazardous radioactive materials, but it must be internalized to pose a toxic threat. Patients affected by ^{210}Po do *not* pose a health risk to responders.[9-13]

Emergency responders should think about two concepts associated with radiation as a threat, especially as related to detection and protection: the source as a *contaminant,* although certain radiation sources can harm without direct contact, and the source as a *toxicant,* affecting the patient.[13]

In the case of alpha emitters, such as ^{210}Po, identifying the source's nature as a contaminant on the victim or in the area—especially if the responder is in proximity to a radioactive source (alpha, beta, gamma ray or radiograph)—requires equipment capable of detecting the full range of ionizing radiation types.

The good news about alpha threats

Intact skin is a good barrier. However, inhalation and ingestion are access points. Also, in the case of alpha emitters as toxicants, once inside the patient, especially if the victim is not externally contaminated, further investigation to determine the etiology should be recommended on the basis of the clinical picture because external detection methods are unlikely to be of value for an internal toxicant. Advanced laboratory testing is required to evaluate biological samples and conduct blood tests.

Although Litvinenko's symptoms were consistent with radiation illness, as a result of the initial hospital assessment, which apparently focused on gamma radiation, radiation was abandoned and other diagnoses were sought. Of note, the CDC recommends a 24-hour urine collection to assay for the presence of ^{210}Po when suspected; levels in excess of background are suggestive of internal contamination. The essential issue is suspecting radiation toxicity early and employing a full range of testing until it can be ruled out.

Few human data are available on the health effects of ^{210}Po, but the toxicity of orally administered ^{210}Po appears to be consistent with the amount reaching blood (bioavailability). Damage to the gut mucosa is a probable contributory cause of death after oral administration.

In a Russian case of interest, a male worker accidentally inhaled an aerosol of ^{210}Po.[9] Death occurred after 13 days. Vomiting was severe at the time of admittance to a clinic, 2 to 3 days after the intake. A high fever was reported, but there was no diarrhea. Thrombocyte counts were 150×10^9 L^{-1} on day 6 and 80×10^9 L^{-1} on day 8.

Within minutes of ingesting ^{210}Po, the cells lining the victim's gastrointestinal tract would begin to die and slough