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**Backgrounder**
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# Ricin: The Very Poor Man's Toxic Terror Weapon

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**COOPER:** *Right. An official keeps saying traces of ricin. What exactly does that mean?*
**FEYERICK:** *Well, you know, what it suggests is that this ricin, the tainted ricin,* ***was not weaponized. That would be instantly lethal.*** *But the substance in these -- in these envelopes was an orange-ish pink color and also oily. And the source tells us that, you know, for example, if you crush these castor beans which is where you get ricin, you're going to get a certain trace amounts. And when they say trace amount, it is substantially different in terms of its toxicity and its danger than, for example, a weaponized ricin*.
**COOPER:** *All right. The investigation goes on. Deb Feyerick, thanks. Ricin is obviously one of the deadliest toxins known to man.* ***Less than a pinpoint can kill a person at 36 to 48 hours if it's ingested****. Using it as a weapon, though,* ***is not easy as it may sound****.*

***Transcript from Anderson Cooper 360 degrees, CNN, aired on May 30, 2013***

## Current Events with Ricin

Anderson Cooper got the last part right. Unfortunately, there was quite a range of comments delivered during this exchange that would leave the listener believing that mere exposure to ricin would cause instant death, which is untrue, even with "weaponized" ricin.

Within the past three months at least five letters containing the toxin ricin have been mailed to local and Federal government officials and a non-profit gun control organization. To date no one has become ill from the effects of the toxin in the letters and yet the media tends to conflate the threat posed by these primitive ricin preparations with highly lethal ricin weapons developed by state actors. There is no debate that ricin is a formidable toxin. To truly appreciate the risk to individuals and the public at large, however, the threat posed by "ricin letters" must be placed in context with attention to the amount of toxin, its purity, the means of delivery and how it stacks up to other chemical and biological threats. With this sudden spike in the use of ricin as a weapon of terror, this is an opportune time to review its history, capacity as a terrorist weapon, its toxic properties and countermeasures developed by the United States. This review will put the threat and risk of ricin into perspective as well as give a broad look at US programs towards combating ricin as a terrorist weapon.

## Background

Ricin comes from the beans (seeds) of the ricin plant *Ricinus communis* commonly referred to as castor beans. Castor bean plants are native to Africa, but are found around the world including the United States and are sought after as a decorative plant. Castor beans are oblong measuring approximately 2

cm in length and are light brown with dark brown splotches. These beans are used around the world for different purposes and can be purchased inexpensively over the Internet. The main commercial use of castor beans is in the production of castor oil. Over one million tons of castor beans are processed annually worldwide for the production of this oil which is used in a number of commercial products including paints, varnishes, lubricants and as a purgative.[1] The mash left over from this production is equivalent to around 3-5% of ricin by weight. The media's description of the envelopes containing an "oily substance" most likely indicates a crude preparation that failed to separate the oil from the ricin. Castor beans can be fatal if eaten; however, the number of beans needed to cause illness, just like other poisonous plants, is highly variable and dependent upon the dose received as well as the health status of the individual.

Ricin has a long but mostly unsuccessful career as a weapon. Ricin has been developed to serve four purposes: as a military weapon, a tool of assassination, a terrorist weapon, and an instrument for homicide.

Ricin was first investigated as a potential weapon by the U.S. military during World War I. During World War II, the British developed a ricin-filled bomb and Iraq is also known to have experimented with the use of ricin as a weapon in the 1980s. However, no nation is believed to have deployed ricin-based weapons.

Ricin's notoriety stems from its use as a tool of assassination. The only successful example of the use of ricin as a weapon was the assassination of the Bulgarian dissident Georgi Markov in London in 1978 by the Bulgarian secret police. Markov was injected with a small pellet containing ricin fired by a pen-shaped device (not a modified umbrella as widely believed). This injection proved fatal. Another Bulgarian dissident targeted for assassination with ricin around the same time survived the attack.

Because castor bean plants are ubiquitous worldwide and the ricin can be produced relatively easily with fairly simple techniques, it is an attractive toxin to would-be terrorists. However, an adversary would have to produce very large amounts with some degree of sophistication for the toxin to truly be considered a weapon of mass destruction. Perhaps lured by the James Bond-esque mystique associated with the toxin, ricin is particularly popular with violent extremists and anti-government fringe groups.[2] Ricin's status as a weapon of mass destruction, however, has more to do with sensationalistic media reporting and the inexplicable fondness of extremist groups with the toxin than its actual threat.

Several domestic extremists have produced ricin for use as a domestic terrorism weapon. In 1994-1995, four members of the "Minnesota Patriots Council", an anti-government and anti-tax group, were arrested by the FBI plotting to attack Federal buildings and assassinating law enforcement agents using ricin which they had produced using castor seeds ordered through the mail. In 2003, two ricin-filled letters protesting proposed changes to trucking regulations were intercepted. The letters, signed "Fallen

[1] Food and Agriculture Organization of the United Nations. FAOSTAT Agricutltural data. http://apps.fao.org/page/collections?subset=agriculture .

[2] Charles P. Blair, "Barely Lethal," Bulletin of the Atomic Scientists (June 12, 2013), http://www.thebulletin.org/web-edition/columnists/charles-p-blair/barely-lethal Accessed 18 June 2013.

Angel," caused no injuries. In 2011 four members of a fringe Georgia militia group were arrested for plotting to kill government employees and spread ricin in major cities.

Foreign terrorist groups have also shown an interest in ricin. Al-Qaeda operatives reportedly received training on ricin at camps in Afghanistan, jihadi manuals contain recipes on how to produce the toxin, and several al-Qaeda affiliates have been suspected of developing ricin for use as a weapon. Al-Qaeda, however, is not known to have committed any attacks with the toxin.

Ricin has also featured in several criminal cases. In 1995 a Kansas City physician, Dr. Debora Green, used ricin as a means to try and murder her husband by mixing the toxin in his food. Although she did make her husband profoundly ill, she was unsuccessful in killing him and subsequently pled guilty to attempted murder, among other charges. In 2006 Federal agents arrested a man near Richmond, VA for manufacturing ricin in an attempt to kill his estranged wife.

## The Ricin Threat in Context

Ricin is listed as a Category B threat agent by the Centers for Disease Control and Prevention (CDC) indicating it is moderately easy to disseminate and can cause moderate levels of illness and low rates of death. Assessing the risk posed by a specific incident involving ricin requires careful consideration of the toxin's purity, the route of exposure, means of dissemination, and dose received by the victim.

**Table 1. Ricin's Toxicity vs Chemical and Biological Agents**

| Agent | $LD_{50}$ levels for mice in µg/kg (Inhalation) |
|---|---|
| Botulinum Toxin | .001 |
| Shiga Toxin | .002 |
| Tetanus Toxin | .002 |
| Staphylococcus aureus | .02 |
| Abrin | .04 |
| Diptheria Toxin | .10 |
| Saxitoxin | 1 |
| Ricin | 3-5 |
| VX | 15 |
| GF (chemical agent) | 16 |
| Staphylococcus enterotoxin B | 20 |
| Mycotoxin | 25 |
| Tetrodotoxin | 30 |
| T-2 | 50 - 200 |
| Soman | 64 |
| Sarin | 100 |

Sources: Army, U. S., U. S. Navy, and US Air Force. "Potential military chemical/biological agents and compounds." US Army Field Manual, FM (1990): 3-9; Franz, David R. "Defense against toxin weapons." Medical aspects of chemical and biological warfare 6 (1997): 603-19; McKone, Thomas E. *Strategies to protect the health of deployed US forces: detecting, characterizing, and documenting exposures*. National Academies Press, 2000.

People can become poisoned by ricin through ingestion, injection or by inhalation. Fortunately, ricin is usually produced as a crude crystal by would-be terrorists and murderers. This form of ricin, while effective at poisoning food or using to inject an adversary, has limited potential as an aerosol hazard, such as in opening an envelope. Toxins are not volatile, which means the perpetrator has to ensure

a specific particle size in order for the ricin to become a respirable aerosol.[3] This is the so called "weaponized" ricin that the media is fond of using as a descriptor, but it is usually not the case. Despite the perceptions of some terrorists, toxins, such as ricin, do not directly affect the skin other than localized reactions. Thus there is no risk of inflicting injury or death from smearing ricin on doorknobs or escalator handrails. This toxin is also not a very good candidate for poisoning water systems either. Generally speaking, attempting to poison water systems usually proves ineffective at the water source due to chlorination and dilution. Although ricin is water soluble, the amount of ricin needed to have even the slightest impact would be prohibitively significant, rendering it unattractive as a means of poisoning a large population. Like other proteins, ricin can be deactivated using heat or appropriate concentrations of chlorine.

## Clinical Aspects of Ricin

Ricin is a protein toxin (toxalbumin) that works by disrupting the ability of cells to make proteins as well as other mechanisms that ultimately will produce cell death and organ failure. The primary clinical symptoms depend on how the toxin is delivered: as an aerosol, ingestion or injection of the toxin. There are no known antidotes for ricin poisoning and, like a majority of toxic exposures; supportive care is the main stay for therapy.[4]

**INGESTION**: The median lethal dose of ricin (LD50, the dose at which 50% of the test animals died) in mice is approximately 30 milligrams (mg) per kilogram (kg) which is 1,000 times higher than injection or inhalation[5]. Reports from ingestion of castor beans in humans gives a wide range of dosing from 1 to 20 mg/kg required to be lethal. The clinical effects are significant and usually begin within 4-6 hours but may be delayed until up to 10 hours post ingestion. Patients will usually present with colicky abdominal pain, nausea, vomiting and diarrhea. These non-specific symptoms, similar to other toxic exposures, can complicate timely diagnosis. There can be significant fluid loss and electrolyte imbalance if left untreated.[6] [7-19]

[3] Franz, D. Defense against Toxic Weapons. U.S. Army Medical Reserarch Insitute of Infectious Diseases. Ft. Detrick, MD. 1997.
[4] Audi J, Belson M, Patel M, Schier J, Osterloh J. Ricin Poisoning A Comprehensive Review. JAMA, November 9, 2005—Vol 294, No. 18
[5] Balint GA. Ricin: the toxic protein of castor oil seeds. Toxicology. 1974;2:77-102.4; Bradberry SM, Dickers KJ, Rice P, Griffiths GD, Vale JA. Ricin poisoning. Toxicol Rev. 2003;22:65-70.;Brugsch HG. Toxic hazards: the castor bean. N Engl J Med. 1960;262:1039-1040;Challoner KR, McCarron MM. Castor bean intoxication: review of reported cases. Ann Emerg Med. 1990;19:1177-1183
[6] Klaim GJ, Jaeger JJ. Castor Seed Poisoning in Humans: A Review: Technical Report # 453. San Francisco, Calif: Letterman Army Institute of Research; January 1990; Rauber A, Heard J. Castor bean toxicity reexamined: a new perspective. Vet Hum Toxicol. 1985; 27:498-502; Kopferschmitt J, Flesch F, Lugnier A, et al. Acute voluntary intoxication by ricin. Hum Toxicol. 1983;2: 239-242.;Kinamore PA, Jaeger RW, de Castro FJ. Abrus and ricinus ingestion: management of three cases. Clin Toxicol. 1980;17:401-405; Koch LA, Caplan J. Castor bean poisoning. AJDC. 1942;64:485-486; Malizia E, Sarcinelli L, Andreucci G. Ricinus poisoning: a familiar epidemy. Acta Pharmacol Toxicol (Copenh). 1977;41(suppl 2):351-361.; Reed RP. Castor oil seed poisoning: a concern for children. Med J Aust. 1998;168:423-424;Satpathy R, Das BB. Accidental poisoning in childhood. J Indian Med Assoc. 1979;73:190-192; Palatnick W, Tenenbein M. Hepatotoxicity from castor bean ingestion in a child. J Toxicol Clin Toxicol. 2000;38:67-69; Wedin GP, Neal JS, Everson GW, Krenzelok EP. Castor bean poisoning.AmJ Emerg Med. 1986;4:259-261; Furbee B, Wermuth M. Life-threatening plant poisoning. Crit Care Clin. 1997;13:849-888; Meldrum WP. Poisoning by castor oil seeds. BMJ. 1900;8:317.

**INJECTION**: The lethal dose of ricin in animal models is significantly less than other routes with an LD50 of 5-10 micrograms (µg)/kg in mice.[7] [20-21]

The clinical effects, like in ingestion, are non-specific and include fever, headache, nausea, and abdominal pain. Symptoms may be delayed for up to 10-12 hours after injection.[8] Diagnosing ricin exposure via injection is facilitated by patient reporting, such as that provided by Markov, as well as physical signs of the injection, including pain and swelling at the site of injection. The clinical course can progress to multiple system failure and death. Aggressive supportive care will be needed in treating these individuals.

**INHALATION**: The effectiveness of ricin as an aerosolized weapon is greatly dependent upon its particle size. Ricin contained in smaller-sized particles that can be inhaled and deposited in the lower respiratory tract are much more hazardous than larger particles.[1] Producing small particles, that maintain their potency and purity, however, are more challenging and require advanced expertise than producing the larger crudely produced particles typically found in ricin preparations.[1,7,9] The LD50 in mice exposed to particle sizes of less than 5 microns is 3-5 micrograms per kilogram body weight (µg/kg). The toxic effects of aerosolized ricin are usually limited to local damage to the lungs which can lead to respiratory failure, but they do not display the systemic effects seen in other routes of exposure.[9] These patients can present with fever, cough, shortness of breath, and muscle pains within 4-8 hours of inhaling ricin. These are non-specific symptoms that could fool a clinician especially during an influenza season. Again, supportive care with aggressive airway maintenance is the key to treating these patients.

## US Countermeasures to Ricin

Since 2001, the United States has developed and deployed capabilities to detect and analyze chemical and biological threats, including ricin; funded research on ricin vaccines and therapeutics; and provided training and guidance to first responders on how to safely handle ricin letters.

### *Detection and Analysis Capabilities*

In 2001, postal workers were the primary casualties of anthrax spores sent via the US postal service to media outlets and U.S. Senators. It became apparent during the investigation that the sophisticated preparation of the anthrax spores combined with the high speed mail sorting machines and the porous nature of envelopes created an ideal aerosol dissemination technique. A sophisticated ricin powder

[7] Godal A, Fodstad O. Ingebrigtsen K. Pihl A. Pharmacological studies of ricin in mice and humans. CancerChemother Pharmacol. 1984;13:157-163.
Fodstad O, Olsnes S, Pihl A. Toxicity, distribution and elimination of the cancerostatic lectins abrin and ricin after parenteral injection into mice. Br J Cancer. 1976;34:418-425.

[8] Godal A, Fodstad O. Ingebrigtsen K. Pihl A. Pharmacological studies of ricin in mice and humans. CancerChemother Pharmacol. 1984;13:157-163; Fodstad O, Olsnes S, Pihl A. Toxicity, distribution and elimination of the cancerostatic lectins abrin and ricin after parenteral injection into mice. Br J Cancer. 1976;34:418-425.

[9] Griffiths GD, Rice P, Allenby AC, et al. Inhalation toxicology and histopathology of ricin and abrin toxins. Inhal Toxicol. 1995;7:269-288; Doebler JA, Wiltshire ND, et al. The distribution of [125 I] ricin in mice following aerosol inhalation exposure. Toxicology. 1995;98:137-149.

composed of small particles could present a similar threat, however, the particle size in the crude preparations found in the recent ricin letters were too large to pose a respiratory threat.

Since 2001, the United States has invested billions to research, develop and deploy chemical and biological agent detection technologies and systems. Following the 2001 anthrax letter attacks the United States Postal Service (USPS) deployed the Biohazard Detection System (BDS) designed to detect anthrax.[10] In addition, mail for certain Federal agencies, such as Congress and the White House, are now routed to special facilities for screening. As a result, the envelopes containing ricin never made it to their intended target. The use of environmental sampling and aerosol collection and testing using sophisticated methods to look for ricin, as well as other agents, are employed by various Federal agencies and are analogous to the techniques and procedures used in the Department of Homeland Security's BioWatch program. The recent media reports of the ricin letters being "intercepted" at these mail sorting facilities speaks to the advantages of using environmental sensors in looking for agents of concern and the protection of individuals.

The mail of local politicians and the gun-control organization that received ricin letters in April and May 2013 did not go through such a screening process and thus the individuals were potentially exposed to ricin. Fortunately, it appears these letters contained the crude products described above and presented little if any risk to the recipient other than the need for appropriate decontamination.

The Centers for Disease Control and Prevention (CDC)'s Laboratory Response Network (LRN) is a national network of 150 local, state, and federal public health, food testing, veterinary diagnostic, and environmental testing laboratories. The LRN's chemical testing component has 62 member laboratories. All 62 laboratories participate in Level 3 activities, which include being trained in specimen handling, shipping and chain-of-custody procedures. Thirty-seven labs participate in Level 2 activities which include the capability to detect exposure to a limited number of toxic chemical agents in human blood or urine. LRN reference laboratories that test for ricin in environmental samples are public health and partner laboratories with specialized procedures and test reagents provided by the LRN laboratories at CDC. Ten laboratories also participate in Level 1 activities. At this level, personnel are trained to detect exposure to an expanded number of chemicals in human blood or urine, including all Level 2 laboratory analyses, plus analyses for mustard agents, nerve agents, and other toxic chemicals.[11]

The National Bioforensic Analysis Center (NBACC) run by DHS is a highly sophisticated laboratory that conducts specialized work in bioforensic analysis. Located at Ft. Detrick, MD, this laboratory is the designated federal facility to conduct and facilitate technical forensic analysis and interpretation of materials recovered following a biological attack.[12]

[10] http://www.irconnect.com/noc/press/pages/news_releases.html?d=172132. Accessed 14 June 2013.
[11] http://www.bt.cdc.gov/lrn/. Accessed 14 June 2013.
[12] http://www.dhs.gov/national-biodefense-analysis-and-countermeasures-center

## Medical Countermeasures

One of the significant problems with treating ricin is its relatively non-specific presentation. As was witness in the Debora Green case, unless there is a high degree of suspicion, it is likely that cases of ricin poisoning will go undetected.

Due to the low risk that ricin poses for causing mass casualties, there is only a limited effort to develop new medical countermeasures against the toxin. The National Institute of Allergy and Infectious Diseases (NIAID) at the National Institutes of Health (NIH) funds basic research on the toxin as well as on countermeasures. The Department of Defense has invested in several products to counter the threat of ricin, including a new vaccine and monoclonal antibodies for post-exposure treatment. These products are still in the early phases of development. The Biomedical Advanced Research and Development Authority (BARDA) in the Department of Health and Human Services (HHS), which is responsible for developing the next-generation of biodefense medical countermeasures, does not fund any work on ricin vaccines or therapeutics. This is consistent with the low priority placed on ricin by the Department of Homeland Security which has not stated that ricin is a material threat to national security.[13]

## Protecting First Responders

Absent a high degree of suspicion, exposure to ricin might not be evident due to the delay in the toxin's symptoms and the non-specific nature of the symptoms. In most instances, when dealing with a crude preparation of the toxin, this is not a significant issue. A sophisticated preparation of ricin powder, however, that can be inhaled could expose first responders to a potentially lethal dose.

The National Institute for Occupational Safety and Health (NIOSH) and the CDC have published guidelines for the protection of first responders and healthcare workers that may be exposed to ricin, especially in the aerosolized form. Proper personal protection practices including respirator use as well as decontamination of exposed individuals are required.

## Conclusion

Although ricin is a highly toxic poison, it is much too simplistic to state that all exposures are equal. The popular media recently has been intellectually lazy by inductively suggesting that highly sophisticated preparations of ricin used as an assassination tool by state actors are the same as the crude preparations sent through the mail by fringe elements and amateur chemical terrorists.

While ricin is among the more accessible chemical and biological threat agents, due to the ease of acquiring castor beans and extracting the toxin, the openly available recipes are insufficient for producing a form of ricin that could be easily aerosolized and pose an inhalation hazard which would put the recipient of these letters at risk. Although the crude preparations of ricin, such as those sent through the mail recently, pose a minimal hazard to the recipients, we must remain cautious about

[13] www.phe.gov/phemce/strategy. Accessed 13 June 2013

dismissing this threat entirely. In 2001, anthrax spores were effectively spread through the mail system, a novel dissemination mechanism that no one had anticipated.. This incident also speaks to the expertise required to create a potent weapon since the main suspect in the anthrax letter attacks was a highly skilled microbiologist with access to sophisticated equipment. These same barriers would need to be overcome for a successful delivery of respirable ricin that could pose a threat through the mail system.

The biggest impact of the recent spate of ricin letters has not been due to the toxicity of the contents but the sensationalism of the media coverage. The lethality of ricin depends on formulation of the toxin, the dose, the route of exposure, and the health of the individual. At the end of the day, the ability of ricin to attract attention, not kill people, is what makes it such an enticing terrorist weapon. Suggesting that death will come to all those who come into contact with ricin is just not supported by the evidence. As it currently stands ricin will most likely remain the very poor man's toxic weapon.

**About the Author**: *Dr. Garza is an Affiliate Research Scientist with the George Mason University Biodefense Program. He served as the Assistant Secretary for Health Affairs and Chief Medical Officer at the Department of Homeland Security from 2009 until April of 2013. During his career at DHS he managed the Department's medical and health security matters, and oversaw the operational health aspects for all chemical, biological, radiological and nuclear hazards. He led efforts to ensure that the Department was prepared to respond to chemical and biological weapons and was in charge of the major CBRN preparedness and response programs inside DHS including the National Biosurveillance Integration Center, the Chemical Defense Program and the BioWatch program.*

**About the Backgrounder**: The Backgrounder, produced by GMU Biodefense faculty and affiliate research scientists, aims to concisely present fundamental knowledge on critical CBRN issues. Editor: Gregory D. Koblentz, Associate Professor and Deputy Director of the Biodefense Graduate Program, Department of Public and International Affairs, George Mason University. For more information on the Graduate Program in Biodefense or its academic publications, please see here.