Vehicle-Mounted High-Power Microwave Systems and Health Risk Communication in a Deployed Environment

LTC John L. Westhoff, MC USA; Brad J. Roberts†; Kristin Erickson, MD, MPH**

ABSTRACT Vehicle-mounted high-power microwave systems have been developed to counter the improvised explosive device threat in southwest Asia. Many service members only vaguely comprehend the nature of these devices and the nonionizing radio frequency (RF) radiation they emit. Misconceptions about the health effects of RF radiation have the potential to produce unnecessary anxiety. We report an incident in which concern for exposure to radiation from a high-power microwave device thought to be malfunctioning led to an extensive field investigation, multiple evaluations by clinicians in theater, and subsequent referrals to an Occupational Health clinic upon return from deployment. When acute exposure to RF does occur, the effects are thermally mediated and immediately perceptible—limiting the possibility of injury. Unlike ionizing radiation, RF radiation is not known to cause cancer and the adverse health effects are not cumulative. Medical officers counseling service members concerned about potential RF radiation exposure should apply established principles of risk communication, attend to real and perceived risks, and enlist the assistance of technical experts to properly characterize an exposure when appropriate.

INTRODUCTION

Improvised explosive devices (IEDs) have been used against coalition forces to deadly effect in Iraq and Afghanistan. Among the many innovations fielded to counter this threat are vehicle-mounted high-power microwave (HPM) systems. HPM devices such as the "Jackal" and "Calilgo" use directional radio frequency (RF) antennas to assist in the neutralization of IEDs via detection or premature detonation.

Although the use of HPM devices by coalition forces in theater is common, some service members lack a basic understanding of the mechanism of operation of the devices and have concerns about potential health effects related to exposure to the nonionizing radiation they emit. Misconceptions about the health effects of RF radiation have the potential to produce unwarranted fear among those whose duty requires them to work in proximity to the systems. Providers caring for these soldiers should understand the nature of HPM devices and be prepared to effectively communicate regarding the risks, real and perceived, associated with exposure.

We report an incident in which concern for exposure to a "malfunctioning" HPM device led to a field investigation, multiple visits to health care providers in theater, and subsequent referrals to a military Occupational Health clinic for evaluation upon redeployment. Following this vignette, we present a concise characterization of HPM devices followed by a brief summary of what is known about the health effects of exposure to RF radiation. In conclusion, we summarize established principles of effective risk communication likely to be useful to providers charged with explaining the health risk associated with HPM devices to operators and commanders.

*Department of Preventive Medicine, Madigan Healthcare System, Building 9920-A East Johnson Street, Tacoma, WA 98431.

†Radio Frequency Program, Army Institute of Public Health, United States Army Public Health Command, 5158 Blackhawk Road, Aberdeen Proving Ground, MD 21010-5403.

doi: 10.7205/MILMED-D-12-00134

INCIDENT SUMMARY

In the fall of 2011, four out of six soldiers from two separate teams experienced symptoms of nausea and headache during routine night convoy operations in southwest Asia. The first team reported their symptoms immediately after completing their mission and expressed concerns that their symptoms had been caused by a malfunctioning counter-IED system on their vehicle. Members of the second team arrived later and were told what had happened to the first team. Two out of the six soldiers also endorsed having had nosebleeds, which each considered to be an unusual event. Both teams were sent to the Combat Support Hospital for evaluation. None of the soldiers experienced any unusual sensation of thermal energy while in their vehicles. None of the soldiers complained of a recurrence of their symptoms after the mission.

The soldiers' perception that their symptoms had been caused by a malfunctioning HPM device was due in part to a perceived temporal relationship. Both teams reported that their symptoms began 30 minutes after the devices had been placed in "transmit," and subsided when the devices were placed on standby during breaks in the mission; their symptoms returned when the devices were reactivated.

A subsequent investigation in accordance with Army Regulation 15-6 determined that the devices were functioning as designed and concluded that the symptoms exhibited by the soldiers could not be linked with exposure to the HPM system in any manner "consistent with current scientific literature." The hot, arid climate, carbon monoxide exposure, and combat stress were contemplated as alternative explanations to the reported symptoms. Even so, the soldiers told investigating officers that they "did not feel confident" in the HPM device and expressed concerns about the long-term effects of RF radiation exposure. Investigators ultimately recommended that the soldiers involved obtain documentation of the event for inclusion in their Veterans Administration medical file "in order to receive follow-up care." On

redeployment, five out of the six were referred to Occupational Medicine after indicating on their Post-Deployment Health Assessment that they "worried" about their health after exposure to "Radar/Microwaves."

KNOWN HEALTH EFFECTS OF RADIO-FREQUENCY RADIATION

RF waves lack the energy quanta necessary to break covalent bonds and cause the genetic damage associated with higher frequency ionizing radiation such as X-rays and γ-rays. When injuries from acute exposure to microwave radiation do occur, they are thermally mediated and are the result of the denaturing of proteins, not ionization. The effect is readily apparent in microwave cooking in which nonionizing radiation passed through food forces the oscillation of polar molecules—so called dielectric heating.

Thermally mediated burns from acute exposure to microwave radiation are well described and are associated with symptoms typical of other burns, i.e., a warming sensation, skin erythema, and pain. Tissues with a diminished capacity to dissipate heat are particularly vulnerable to diathermic damage. The lens of the eye, in particular, lacks the blood supply required to mitigate heat stress, and animal models have demonstrated the formation of cataracts following exposure to high power levels of RF for extended periods.[1] In practice, however, a human is unlikely to willingly tolerate the prolonged discomfort associated with the intensity of RF radiation required to damage the lens.

The existence of nonthermally mediated health effects from low-level RF exposure such as cell phone use has been the subject of a great deal of recent media interest. Although the difficulty of proving "noneffect" should be acknowledged, exposure to RF radiation has not been shown to cause cancer. In fact, decades of research has failed to show a consistent link between RF exposure and any nonthermally mediated long-term health effects, even in the most theoretically vulnerable populations.[2,3]

HPM DEVICES AND DOD SAFETY STANDARDS

HPM devices are installed on tactical vehicles to defeat IEDs. Although the technical specifications of the systems are classified, we can state that they transmit a subset of RF radiation. The antennas of the devices are directional, emitting RF away from the protected vehicle over a wide azimuth and narrow elevation beam away from the cab.

Although there are no specific U.S. standards regulating exposure to RF and microwave radiation,[4] the DoD has issued DODI Instruction 6055.11 to protect personnel from the thermally mediated effects of RF during peacetime "and to the maximum extent possible during wartime." There is explicit acknowledgement in the instructions that "during war or combat operations, requirements in this Instruction may not be feasible."[5] In essence, the DoD instruction adopts the national consensus standard of the Institute of Electrical and Electronics Engineers C95.1-2005 on human exposure to RF radiation.[6]

It is official DoD policy to limit RF exposure to levels that are within maximum permissible exposure (MPE) levels and to investigate and document RF overexposure incidents. A maximum permissible exposure is a time-averaged exposure value established at a level such that no adverse health effects can be expected to occur even with repeated or long-term exposure. In testing the currently fielded vehicle-mounted HPM devices, RF radiation levels inside the cab areas of test vehicles were found to be an order of magnitude lower than required by DoD instructions. RF radiation levels directly in front of the HPM device antennas can exceed MPEs, however. As a safety control measure, technical manual instructions recommend a "stand-off" distance forward of the vehicle bumper to minimize the potential for thermal injury of personnel in front of a radiating antenna. For the Jackal, the control distance is 14 ft (4.3 m); the distance for other HPM systems are specified in the systems technical manuals and typically incorporate a 10-fold safety factor. Of note, control distances apply when a vehicle is stationary; typically, the vast majority of RF transmission would occur when the vehicle is in motion.

SUSPICION OF RF RADIATION OVEREXPOSURE

The term "overexposure" should be reserved for exposures that have exceeded the agreed-upon technical standard; therefore, a clinical history consistent with exposure necessitates investigation by technical personnel trained in RF dosimetry before an incident can be properly characterized as an overexposure. Such an analysis takes into consideration the time duration of potential exposure and part of the body exposed. The sensation of warmth associated with proximity to an HPM device is not de facto evidence of overexposure.

When evaluating a patient suspected of having sustained a thermal RF injury, the Institute of Electrical and Electronics Engineers Committee on Man and Radiation recommends particular attention to symptoms concurrent with beam exposure. An otherwise neurologically unimpaired patient who denies pain or thermal sensation during suspected exposure is unlikely to have sustained an RF injury. When RF injury is a clinical concern, the examining provider should note the presence of any areas of erythema or evidence of surface burn, particularly in proximity to metallic items. A qualified physician should then perform a meticulous ophthalmologic history and exam, documenting visual acuity and the presence or absence of lenticular opacities. In cases of potentially serious exposure, when superficial injury is likely and deep tissue damage is suspected, further workup should include diagnostic modalities appropriate for the organ system involved, such as an ECG or appropriate serum enzymes.[7] Appropriate interpretation of these tests requires that clinicians rely on the same established principles of burn management associated with the care of non-RF-associated burns; patients with RF thermal injury should ultimately be

dispositioned in a manner analogous to those with conventional thermal or electrical injury.

RISK PERCEPTION AND COMMUNICATION

People notoriously estimate health risk poorly. Risks tend to be perceived as acceptable when they are familiar, are associated with voluntary exposure (i.e., control), and are associated with a clear benefit. It is to be expected then that troops might be suspicious of radiation borne of a "black box" they are compelled to use and whose potential benefit (i.e., preventing death by IED) is not directly perceived. The universal confusion of radiation with radioactivity coupled with the use of the commonly used but poorly understood term "microwave" compound the challenges associated with health risk communication in this area.

Providers counseling service members who are concerned about exposure to HPM devices should first establish a relationship of trust with patients based on empathy, competence, honesty, commitment, and accountability.[8] Careful attention to patient concerns about RF radiation will prevent needless angst and avoid the subsequent cascade of mistrust that has the potential to affect morale, impact unit safety and compromise mission effectiveness.

Empathy is established by acknowledging concern, e.g., "I can see how it would be a little scary to have to work around a device like that, especially when you're not even sure how it works." Establishing competence requires that a provider explain in layman's terms what real health concerns exist, i.e., the potential for thermal injury. This will avoid the pitfall of being perceived as being prematurely dismissive of the very real, albeit rare, adverse health effects of acute RF overexposure. Honesty, commitment, and accountability are inherent in any healthy provider–patient relationship. Accordingly, openness about the limitations of your expertise in this area and an honest commitment to enlist technical experts when necessary to properly characterize hazards and address concerns will go a long way toward building the requisite therapeutic relationship.

RECOMMENDATIONS

Military health care providers should familiarize themselves with vehicle-mounted HPM devices and the thermally mediated health effects of exposure to RF radiation. Providers should recognize that in counseling patients they are more likely to communicate effectively if they earnestly apply established principles of risk communication, e.g., empathy, competence, and honesty.

Medical officers should work within command channels to ensure that initial and ongoing training addressing the risks of exposure to nonionizing radiation emitted by HPM devices is conducted in accordance with DoD policy.

ACKNOWLEDGMENTS

The authors gratefully acknowledge Timothy L. Schickedanz of U.S. Army Public Health Command for his expert guidance regarding health risk communication and assistance in reviewing this manuscript.

REFERENCES

1. McKinlay AF, Allen SG, Cox R, et al: Review of the Scientific Evidence for Limiting Exposure to Electromagnetic Fields (0-300 GHz), p 223. Oxfordshire, United Kingdom, National Radiological Protection Board, 2004.
2. Wiedemann P, Schutz H: Children's health and RF EMF exposure. Views from a risk assessment and risk communication perspective. Wien Med Wochenschr 2011; 161(9–10): 226–32.
3. Heynick LN, Johnston SA, Mason PA: Radio frequency electromagnetic fields: cancer, mutagenesis, and genotoxicity. Bioelectromagnetics 2003; Suppl 6: S74–100.
4. OSHA. Safety and Health Topics: Radiofrequency and Microwave Radiation. Available at http://www.osha.gov/SLTC/radiofrequencyradiation/; accessed November 28, 2011.
5. DoD Instruction 6055.11: Protecting Personnel from Electromagnetic Fields; August 19, 2009.
6. IEEE C95.1-2005: IEEE Standard for Safety with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz; April 19, 2006.
7. IEEE Committee on Man and Radiation (COMAR): Medical aspects of radiofrequency radiation overexposure. Health Phys 2002; 82(3): 387–91.
8. Reynolds BJ: When the facts are just not enough: credibly communicating about risk is riskier when emotions run high and time is short. Toxicol Appl Pharmacol 2011; 254(2): 206–14.