

Medical Imaging of Explosion Injuries



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Diagnosing and caring for injuries caused by explosives were once almost exclusively the province of combat medical personnel, but with the increase in foreign and domestic terrorism, civilians have become targets. Blasts create complicated medical pictures and paint a wide swath of injuries.¹ Medical responders and hospitals must focus on planning for mass casualty incidents. Medical imaging personnel can learn from worldwide efforts to diagnose and treat blast-related injuries and apply these lessons to the potential for domestic terrorism and to caring for victims of accidental explosions. They also can better understand long-term effects on military and civilian personnel who have been exposed to blast injuries on foreign soil.

This ASRT Directed Reading Classic was originally published in Radiologic Technology, March/April, Vol. 81/No.4. Visit www.asrt.org/store to purchase other ASRT Directed Reading Classics.

After completing this article, the reader should be able to:

- Identify the salient features of a mass casualty incident.
- Describe the characteristic patterns of blast injuries.
- Explain the ways that imaging contributes to triage, identification of injuries and treatment of blast victims.
- List relevant components of mass casualty response plans, including the roles new technologies play in tracking patients and maintaining and transmitting vital health information.
- Promote planning and training opportunities in imaging facilities.

On a single day in August 2009, on a single page of one city's newspaper, the following headlines appeared: "Bike Bomb Kills 2 in Baghdad," "Power Plant Blast Deadly," "Bomb Wounds 7 in Pakistan," "Lockerbie Bomber Freed" and "Afghan Turnout Dampened."² The accompanying stories reported that in Baghdad, the annual death toll rose to at least 101 from a string of blasts; more than 500 people reportedly were wounded on a single, deadly day of coordinated bombings following the simultaneous detonation of truck bombs. In Siberia, more than 1000 rescue workers searched the site of a hydroelectric plant explosion, where more than 17 people were confirmed dead and 57 remained missing. The only person convicted of the Pan American Flight 103 bombing that took place over Lockerbie, Scotland, in 1988, was released from prison and returned home to Libya; the death toll from that single act of terrorism reached 270. At

least 5 bomb attacks occurred in Kabul, Afghanistan, as the Taliban sought to frighten potential voters into staying home. In Pakistan, security forces continued to battle the Islamist militants blamed for numerous fatal, injurious bombings over the preceding 2 years.² Civilian populations have become wholly vulnerable to the death and mayhem caused by explosions.

Wartime use of explosives is nothing novel. In 1864, a Pennsylvania regiment of Union soldiers composed largely of coal miners used their knowledge of explosives to try to end the siege of Petersburg, Virginia, by digging a tunnel beneath the Confederate lines, filling it with gunpowder, and lighting a fuse. The explosion killed 280 Confederate soldiers. In the ensuing "Battle of the Crater," 1500 more Confederate soldiers died and 4000 Union soldiers lost their lives.³

In World War II, roadside bombs came into being; they were used again

in Northern Ireland (along with pipe bombs), later in Israel and now are seen in various conflicts around the world. About 100 years after the Civil War, the Vietnam War saw the introduction of fuel-air explosives, which were used not only to kill soldiers but also to clear minefields and reduce forestation. When the Russians fought in Afghanistan, they used the same thermobaric weapons, which could produce powerfully destructive clouds of kerosene.

Improvised explosive devices (IEDs) were a hallmark of insurgents during Operation Iraqi Freedom; approximately 336 U.S. soldiers were wounded by IEDs each month between 2004 and 2008.⁴ The effectiveness of these weapons prompted the Pentagon to establish the Joint IED Defeat Organization (JIEDDO) in 2006. Since that time, JIEDDO has worked on ways to neutralize IEDs, including supplying troops with armored vehicles, high-tech surveillance gear and remote-controlled robots.⁵ As U.S. forces developed strategies to combat the makeshift devices, bomb makers countered with larger, more sophisticated IEDs. For example, in Afghanistan the Taliban currently use IEDs with less metal that are more difficult to detect.⁶ The cost of dealing with these simple explosive devices is substantial; the 2011 budget for JIEDDO was \$2.8 billion.⁵

Some military experts believe that IEDs will continue to be a threat.⁵ Although American IED deaths in Iraq declined following the withdrawal of U.S. combat forces in 2010, IED attacks in Afghanistan increased dramatically after 2009.⁴ Today, IEDs account for 61% of U.S. military casualties in Afghanistan,⁷ and the harm is not confined to military units. According to statistics compiled by the U.S. Congressional Research Service, IEDs caused one-third of Afghan civilian deaths in 2012.⁸

JIEDDO also issues a monthly summary that tracks global IED statistics. According to the report, which does not include incidents in Iraq and Afghanistan, global IED casualties reached a peak in May 2012, when nearly 600 people were killed. Extremist groups in Africa, the Middle East and surrounding regions have increasingly made IEDs their weapons of choice.⁹

Cluster bombs, which when they explode scatter smaller bomblets designed to kill or maim, have long plagued civilian populations both during and for decades following the official cessation of hostilities. When the bomblets fail to detonate, they lie on the

ground or are buried beneath the surface, injuring people only after the explosives are picked up or stepped on. These unexploded bomblets often are referred to as explosive remnants of war, or ERWs. In December 2008, representatives of 94 countries signed an international treaty banning the use, production, transfer and stockpiling of cluster munitions. Treaty provisions require that land contaminated with cluster munitions be cleared within 10 years of the treaty's ratification.¹⁰

And so, what was once a rarity or something associated only with warfare has become an everyday reality for many of the world's populations. Israel in particular has an unenviable expertise in juggling the chaos generated by terrorist-related mass casualty incidents. Between September 2000 and December 2003, 19 948 terror attacks were reported in Israel; the majority of those attacks involved explosive devices.¹¹ Civilian victims outnumbered victims who were members of the country's security forces: 632 civilians died compared with 268 security force personnel, and 4274 civilians were wounded, compared with 1755 security personnel.

Terrorist-related explosions now routinely elicit calls for significant preventive planning before any large gathering. As the start of the 2010 Olympic Games approached, for example, Canadians conducted simulated mass casualty exercises.¹² Before the 2012 Summer Olympics, the British government acknowledged the threat of international terrorism and operated at the highest security level ("severe").¹³

Although the 2001 World Trade Center tragedy is the largest example of explosion-related loss of life in the United States, between 1983 and 2002 there were more than 36 000 bombings in this country, an increase of more than 60% from the previous decade.¹⁴ The Federal Bureau of Investigation reported that bombs were used not only by terrorists, but also to protect marijuana farms and methamphetamine laboratories. A 2002 Department of Justice summary of worldwide terrorist attacks indicated that 86% of attacks in the United States were bombings, with 11% directed at private residences, 4% toward educational institutions, and 36% toward commercial sites.¹⁴ A 2012 U.S. Department of Justice report anticipates that a large-scale terrorist attack in the United States is unlikely in the coming years because of fragmentation of al-Qaida; however, a limited attack is possible both domestically and against U.S. interests abroad.¹⁵