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Independence Day Explosion on Lovers Key*

ABSTRACT: The display of fireworks is a popular holiday celebration in the United States. Because injuries due to recreational fireworks-related explosions among private consumers are relatively common, the sale of fireworks is regulated by the federal government and is also limited by state and local laws. In contrast, because fireworks display companies are under tight safety regulations, explosions in the professional pyrotechnics industry are uncommon occurrences, and the literature contains rare reports of injuries and fatalities resulting from such explosions. We report the 2003 Fourth of July commercial fireworks explosion on Lovers Key in southwest Florida that resulted in five fatalities. Events occurring during the investigation of the scene of this explosion illustrate the unique considerations and hazards for medicolegal death investigators, law enforcement and other investigative agencies. Additionally, this case demonstrates unusual aspects of the postmortem examinations performed on victims of fireworks-related incidents.

KEYWORDS: forensic science, fireworks, explosion, fatalities

Fireworks are traditionally used in the United States as part of the celebration of the Fourth of July, commemorating the 1776 independence of the United States from Great Britain, as well as in connection with other patriotic and religious festivities (1). Although fatalities resulting from the explosion of fireworks are rare, injuries due to recreational fireworks-related incidents among consumers are relatively common (2). Most injuries occur in children and in individuals actively handling the fireworks (3). Injuries most commonly involve the hands, face, and eyes (3–8). The sale of fireworks to individuals is regulated by federal law and is also limited by state and local laws (9,10). Because fireworks display companies are under tight safety regulations, explosions in the professional pyrotechnics industry are rare (11–13).

In spite of the frequency of injuries related to fireworks, the forensic literature contains little information pertaining to the patterns of injuries resulting from these incidents and the considerations involved in the investigation of fireworks explosions, as well as in the postmortem examinations on the bodies of victims of such explosions. A fireworks explosion that resulted in five fatalities provided an opportunity to explore the unique aspects of scene investigation and the performance of autopsies in such cases.

Case History

A pyrotechnics crew was preparing for a Fourth of July fireworks display on Lovers Key, a 1600 sq. ft. state park in Bonita Springs in southwest Florida, on the afternoon of July 2, 2003. The company had planned to use 853 fireworks shells ranging 3- to 12-inches in diameter and up to 4 feet in length. Three of the six crew members were very experienced in the handling of fireworks. An explosion and subsequent fire occurred while the crew was moving boxes in the rear of a 53 foot semi-tractor trailer in the process of transferring the fireworks to a smaller box truck. The trucks were parked on a peninsula adjacent overlooking a lake. The explosion

demolished both trucks and two other nearby vehicles (Fig. 1). Pyrotechnics continued to explode after the fire department arrived, and a burning tire beneath the semi-tractor trailer provided a continuous source of fire. Efforts to suppress the fire continued throughout the night, with several flare ups.

The investigation of the scene involved 80 people in eight teams from multiple agencies, including the local fire department, the State Fire Marshal's Office, the Sheriff's Office, the Regional Bomb Squad, the Bureau of Alcohol, Tobacco, Firearms and Explosives, the Occupational Safety and Health Administration (OSHA) and the Medical Examiner's Office. The 40 h scene investigation presented unique hazards because of flare-ups of the fire, a secondary explosion, lightning, and because the debris included live firework shells.

After the fire was suppressed, a search was conducted to locate possible unexploded rounds. Once found, the live rounds were marked and left in place until they were later secured in wet sand for removal and destruction (Fig. 2). The potential for the detonation of live ordnance necessitated leaving the bodies at the location until a thorough search could be performed. Debris, including the roof of the semi-tractor trailer, was located up to 300 yards from the blast point (Fig. 3). Vegetation was blackened in 10–15 acres of adjoining woods. Divers searched a lake in the park for explosives that were blown into the water by the blast. Shrapnel was found in the area as long as a year following the explosion. The estimated property damage totaled \$20,000.00.

The five male members of the fireworks crew were inside the semi-trailer at the time of the explosion. Four of these men died at the scene. Two of their bodies were found on the collapsed semi-trailer floor and were largely fragmented and partially incinerated. The remaining two bodies, found approximately 20 yards and 60 yards from the trailer, were relatively intact although badly burned. Another worker, a woman who had been outside of the truck, jumped into the nearby lake and survived, although she suffered burn injuries and smoke inhalation. She later related that she had observed the sixth member of the crew emerging from the water after the explosion, without clothing and with holes in his chest, before collapsing. This man was transported to the hospital where he later succumbed to complications of thermal injuries.

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*Presented in part at the 59th Annual Meeting of the American Academy of Forensic Sciences, February 19–24, 2007, San Antonio, TX.

Received 9 Dec. 2006; and in revised form 11 April 2007; accepted 21 April 2007; published 7 Sept. 2007.



FIG. 1—The destruction of the semi-tractor trailer by the explosion.



FIG. 2—Flags marking live mortar shells.



FIG. 3—A mortar tube rack found 45 feet from the origin of the explosion.

The identification of the four decedents who had died at the site was made either by dental comparison and/or the comparison of antemortem and postmortem radiographs of the axial skeletons. The autopsies also involved unique considerations due to the



FIG. 4—The point of origin of the explosion in the rear of the semi-tractor trailer, on the right side of the photograph.

possible presence of unexploded ordnance within the bodies, because of the possibility of friction causing the detonation of the ordnance. Total body radiographs were therefore performed prior to the autopsies. A 1.0 cm. pyrotechnic load was identified in the calf of one of the decedents.

Injuries to the decedents included thermal injuries resulting from the fire, as well as blunt force injuries including skeletal fractures and visceral injuries caused by the exploding fireworks and by shrapnel from structural materials of the destroyed vehicles. Three of the victims had fourth degree burns involving essentially all of their body surfaces, associated with thermal bone fractures and epidural collections of brown granular material. The clothing was completely destroyed in these three cases. The remaining victim, a man who had been observed to walk a short distance after the explosion and whose body was found 60 yards from the origin of the explosion, had third degree burns involving 85–90% of his body surface, with focal sparing of the skin of the upper neck, anterior chest, mid-groin region, and left thigh. His clothing was also burned, with the exception of sparing of the right boot and a portion of the right sock. The two fragmented bodies also showed perimortem blunt force trauma, including subdural hematomas and multiple skeletal fractures. The two relatively intact bodies showed penetrating wounds, predominately superficial, containing fireworks pellets and dark burning soot. There were no characteristic injuries to air-containing hollow viscera due to shock wave effects. In each case the cause of death was attributed to severe thermal and/or explosive injuries. Postmortem carboxyhemoglobin saturations ranged from 3% to 14.1%. Toxicologic studies were remarkable for the presence of cannabinoids in the blood in three of the four cases.

The investigation subsequently determined that the point of origin of the explosion was located three feet from the rear door of the semi-tractor trailer (Fig. 4). The cause explosion was attributed to the accidental ignition of the fireworks. Although it was theorized that the inciting factor was a static electrical discharge from an electrical storm in the area or from the crew's sliding boxes across the truck floor, the exact cause was never identified. It is unclear whether impairment of three of the crew members by marijuana played a causal role in the explosion.

Discussion

Fireworks are generally recognized as having originated in ancient China (1). After the development of black powder in the

sixth century, the Chinese created hand-carved wooden rockets in the shape of dragons from which they fired from their mouths arrows as weapons. The Mongols are believed to have brought Chinese rockets and gunpowder to Europe in the thirteenth century, where fireworks that exhibited brilliant colors were developed. Since the mid-19th century fireworks have been popular in the United States, although the Chinese are still the world leaders in the production of pyrotechnics (1).

The most popular fireworks today are firecrackers, which consist of explosive powder that creates an explosion in a tight tube, and sparklers, which burn over a period of up to a minute and which produce bright sparks of showery light (1). Aerial fireworks are typically formed as mortars consisting of a firecracker-like charge in the center, a fuse, and stars, which are spheres, cubes or cylinders of a sparkler-like composition. The mortar is launched in a mortar tube. Most commonly, black powder explodes and ignites the fuse that then burns into the mortar and ignites the charge, causing the mortar to explode and the sparklers to burn, providing a sphere of showers of sparkling lights.

Although fireworks were originally regulated by the Food and Drug Administration, the 1973 Federal Hazardous Substances Act transferred the regulatory jurisdiction of fireworks to the Consumer Product Safety Commission (CPSC) (3,10). In 1976, the CPSC banned the sale of fireworks containing more than 50 mg of explosive material, although aerial devices may contain up to 130 mg (1,9). Federal regulations permit the sale of so-called consumer or Class C fireworks that includes sparklers and some small firecrackers, and their sale is regulated by state and local authorities (9). Currently 10 states allow the sale of all Class C fireworks, while others allow the sale of only some types of consumer fireworks. Nine states ban all consumer fireworks, while Nevada has no fireworks laws except at the county level (10).

Injuries resulting from fireworks-related incidents have the characteristics of explosion injuries as well as thermal injuries if the explosion is of an incendiary type. Injuries resulting from the explosions themselves include blunt force injuries caused by physical objects including shrapnel from the explosive device as well as from secondary missiles from surrounding objects and structures (14). Such projectiles necessitate radiographs of deceased victims, particularly if an intentional or terrorist act is suspected, to assist in the identification and recovery of components of the explosive device. External injuries may include or subsequently necessitate amputations, while penetrating injuries most commonly compromise the thoracic and abdominal organs (14). Blunt trauma can also result from the concussive pressure wave that sweeps over the body after an explosion, particularly when the explosion occurs in a confined space (14–16). The most common injuries due to the blast effect include rupture of the tympanic membrane as well as injuries to air-containing organs such as the lungs and gastrointestinal track. Autopsy findings can include patchy subpleural and intraparenchymal hemorrhages and bullae in the lungs and hemorrhage in the stomach and intestines (17). Occasionally these organs may rupture. Delayed deaths following explosions result from infectious complications and hypovolemic shock (13).

The majority of previous reports of injuries and fatalities resulting from pyrotechnic-related incidents have involved private recreational consumers, usually the active participants handling the fireworks, and less commonly bystanders (3). The bulk of these incidents have occurred in association with the Independence Day holiday (6). There was a dramatic increase in fireworks-related injuries in 1976 with the Bicentennial celebration (9). Smith and co-workers (3) reported that two-thirds of injuries that resulted in hospitalization in a series of 316 children injured by fireworks

involved devices that were illegal in the locale in which the injury occurred. The literature contains only rare reports of the explosion of fireworks in a commercial facility. The "Enschede fireworks disaster," in 2003 in the Netherlands, occurred at a storage facility in a residential area (18–20). There were 21 deaths, including four firefighters and one reporter; an additional 947 individuals were injured.

The majority of previous investigators have reported that the largest group at risk for fireworks injuries is children, particularly boys (3,6,9,21). The most common sites of injuries are the head and hands (3,5,6,21). Ocular injuries are common in both children and adults, accounting for 20 percent of injuries in one series of 8500 individuals seen in emergency rooms with injuries due to fireworks (4,7,8). In many cases the primary injuries are burns, often in association with multiple sites of blunt trauma (3). In some cases, burn injuries result from the ignition of clothing. Smith and colleagues (3) reported a unique pattern of burn injury in a subset of children who presented with burns to the thighs, buttocks and/or groin region after the ignition of fireworks in their pants' pockets. Accordingly, in 2001 the American Academy of Pediatrics called for a ban on all fireworks for individual private use (9,21).

Although the majority of fireworks explosions occur accidentally, rare reports have attributed recreational explosives as means of homicide or suicide. Blanco-Pampin (16) reported two suicides using fireworks. One individual put the device in his mouth, the other on the top of his head. In all fireworks-related fatalities the determination of the manner of death necessitates the correlation of the scene investigation and the postmortem examination, allowing a reconstruction of the event (14,16).

The Lovers Key explosion is one of the rare examples of fatalities resulting from a commercial fireworks explosion. The professional fireworks display industry is tightly controlled for safety purposes. The pyrotechnics company must obtain a permit from the fire marshal in the city in which the fireworks display is to be launched. The United States Department of Transportation specifies how to brace and block fireworks so that a load does not shift or become damaged during transportation (12). Standards for the safe set up and display of fireworks are proscribed by the National Fire Protection Association (NFPA) (11). The state of Florida mandates strict adherence to these standards.

The Lovers Key explosion illustrates the unique hazards inherent in the investigation of a fireworks-related fatality and in the performing of postmortem examinations. Extreme caution must be taken at the scene because of the possibility of the ignition of live ordnance. Similarly, unspent pyrotechnic rounds may be lodged in the decedents' bodies. Radiographic studies prior to postmortem examination are essential to rule out the presence of such live ordnance, as well as to aid in the recovery of components of the explosive devices in cases of suspected intentional or terrorist acts.

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