D28 Fatal Launch: Fireworks Fatality and the Determination of Generated Recoil Force

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After attending this presentation, attendees will better understand the construction and lethality of consumer-grade fireworks as well as how to measure force production.

This presentation will impact the forensic science community by describing the method for quantifying the magnitude of recoil generated by consumer-grade fireworks, presenting recoil force data from such fireworks, and reporting a case study proving how lethal this force can be.

Every year, fatalities occur due to improper use of fireworks. In 2015, one of these fatalities occurred through the use of a reloadable 60-gram canister shell fireworks mortar.

A 30-year-old male was with friends consuming alcohol and methamphetamine while shooting off fireworks. The decedent decided to launch a mortar off of his chest. From a standing position, the decedent placed the mortar to his chest and lit the shell. The firework ignited and the decedent stumbled back and fell unresponsive to the ground. Cardiopulmonary resuscitation was initiated by bystanders. Emergency services responded and continued advanced cardiac life-saving measures, then transported the decedent to a local hospital where he was pronounced dead.

During external examination prior to autopsy, an 11cm x 8cm contused, red-brown abrasion was on the upper left side of the chest with smaller surrounding abrasions. There were abrasions and contusions of the back of the head, the lower left side of the abdomen, and the upper extremities. Internal examination revealed fractures of the sternum and the anterior aspect of left ribs 3, 4, and 5, contusions and lacerations of the lungs, and contusions and lacerations of the heart and great vessels.

To determine the amount of recoil force generated by the firework, five different 60-gram mortar shell tubes from two different fireworks companies were tested. The mortars varied in price, quality, and construction. The mortars tested were either a two-piece fiberglass/High Density Polyethylene (HDPE) tube with a particle board base (similar to the variety used by the decedent) or a solid HDPE plastic single mold. The mortar base was 11.43cm square. The mortars were placed, without restraint, on a flat, 11.43cm square and 1.27cm thick aluminum plate. The plate was mounted on two Link ICP® quartz force sensors. An identical aluminum base plate was mounted to the bottom of the sensors and was placed, without restraint, on level concrete pavement. A Data Acquisition (DAQ) system converted the analogue voltage output of the sensors to a force reading. A total of 22 shells were tested in this manner.

Each of the five mortars tested produced a unique and somewhat consistent force signature. Force amplitude among the shells/mortars tested varied greatly, with peak values ranging from 742N to 2,410N (mean = 1,589N, *SD* = 497N). The average force production varied between 271N and 686N (mean = 442N, *SD* = 114N). Among the shells tested, the entire force event lasted between 16ms and 28ms (mean = 21ms, *SD* = 3ms). The impulse (integral of force with respect to time) ranged between 6.0N-s and 12.6N-s (mean = 9.0N-s, *SD* = 1.6N-s). The estimated

kinetic energy of the shells varied between 145 to 624 Joules (J) (mean = 320J, *SD* = 113J). The findings illustrate that a considerable force can be rapidly generated by these fireworks. This would put significant sudden force on the ribs in a small area, causing the ribs to fracture, resulting in lacerating and contusing the lungs, heart, and great vessels.

Fireworks Fatality, Recoil Force, Kinetic Energy