Mechanisms of Eye Injuries from Fireworks

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Abstract

Injuries from fireworks are prevalent among youth. The eye is the most frequently injured body part and accounts for more than 2000 injuries annually. Although it is suggested the pressure wave caused by explosions (i.e. blast overpressure) can cause serious eye injuries, there is no clear evidence to support this. The purpose of this research is to assess whether blast overpressure or projected material from fireworks causes eye injury. This study evaluates the response of six human cadaver eyes to charges at distances of 22 cm, 12 cm, and 7 cm from the cornea. Due to variability in consumer fireworks, 10 g charges of Pyrodex gunpowder were used to simulate fireworks in a controlled, repeatable manner. A pressure sensor inserted in the vitreous measured intraocular pressure, and four pressure sensors mounted around the eye measured total and static pressures. Pressure measurements were used to calculate rise time, positive duration, impulse, and wave velocity. The charges produced survivable peak overpressures (Average maximum pressure = 51.15 kPa) which correspond to detonating 0.45 kg TNT at approximately 3.0 m. Minor grain-sized corneal abrasions were the only injuries observed. The abrasion size and pattern suggested unspent gunpowder was projected onto the eye, which was confirmed with high speed video. Increasing proximity to the eye resulted in more abrasions. Intraocular pressure was used to calculate injury risk, which was less than or equal to 0.01% for hyphema, lens damage, retinal damage, and globe rupture. The low calculated injury risk further supports the lack of major injuries observed. The combined presence of injuries caused by projected material and lack of injuries directly caused by the blast overpressure indicated serious eye injuries could be caused by projectiles, but not blast overpressure, at these energy levels.