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Case Report:

Blast Injuries: Case Series

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Abstract: The objective of an autopsy is to ascertain the injuries sustained and the agents responsible for them. This process can significantly support the investigation by validating the case's historical context. Blast injuries, while uncommon, are invariably lethal. A collection of blast injuries resulting from various circumstances and types of explosives is presented herein with the aim of emphasizing the severe nature of such injuries, the critical need for licensing and regulatory compliance as stipulated in the Explosives Act, and to convey a social forensic message regarding the occupational risks associated with explosive handling, as well as the necessity for specialized training for individuals engaged in its lawful application.

Key words: Explosion, Marshal triad.

Introduction: A blast injury represents a multifaceted form of physical trauma that arises from either direct or indirect exposure to an explosion [1]. Such injuries manifest with the detonation of high-order explosives as well as the

deflagration of low-order explosives. The severity of these injuries is significantly heightened when the explosion transpires within an enclosed environment.

Blast injuries are categorized into four distinct classes:

Primary injuries: Primary blast injuries result from the overpressure waves or shock waves produced by an explosion. These injuries are particularly associated with high-order explosives and can affect multiple anatomical regions. Pulmonary barotrauma, rupture of the tympanic membrane (eardrum), perforation and hemorrhage of hollow viscus organs, and globe rupture, which may lead to substantial ocular damage. The term "blast lung" pertains to significant pulmonary contusion, bleeding or edema, coupled with damage to the alveoli and blood vessels, or a combination thereof [2]. These injuries are often perilous and frequently represent internal trauma that is not immediately apparent.

Secondary Injuries: Secondary blast injuries are attributable to projectiles and shrapnel propelled by the explosion [6].

These injuries can be critical and may lead to penetrating trauma—injuries inflicted by sharp objects such as glass, metal, or other fragments. Blunt trauma—injuries resulting from being struck by larger debris. Lacerations—deep cuts and wounds caused by sharp debris. Fractures—broken bones due to the impact of airborne objects. Tertiary Injuries: Tertiary blast injuries arise when the explosive force propels an individual into a solid object. This may result in a combination of blunt and penetrating trauma, which includes: bone fractures—broken bones due to impact. Head injuries—traumatic brain injuries stemming from forceful impact. Crush injuries—damage to muscles and tissues from being pinned or compressed. Spinal injuries—damage to the spinal column due to the blast's force. These injuries can be grave and often necessitate urgent medical intervention.

Quaternary Injuries: Quaternary blast injuries encompass all other injuries that do not arise from primary, secondary, or tertiary mechanisms. These injuries may result from a

variety of factors linked to the explosion, including burns—resulting from the heat and light generated by the explosion. Inhalation injuries—caused by toxic fumes, dust, or smoke. Crush injuries—resulting from collapsing structures or heavy debris. Exacerbation of pre-existing conditions—such as asthma or chronic obstructive pulmonary disease (COPD) due to inhaled irritants.

Cases Report 1 [Victim 1-Images 1-3]:

An autopsy was performed on 16th February 2023 at Tirunelveli Medical College, Tirunelveli, Tamil Nadu on three individuals who succumbed to injuries sustained during an explosion while managing explosive materials for well excavation. The individual in question was a 24-year-old male who had direct exposure to the explosive substances. He presented with a total of 23 distinct injuries, including a classic triad of abrasions, contusions, and punctate lacerations, globe rupture, fractures of the C1 vertebra and the base of the skull, thermal injuries in the thigh and lower limb regions,

compound fractures in both upper and lower limbs with complete disruption of the lower segment of the left upper limb, minor bone fractures, and disruption of the right hand, multiple rib fractures, and small metallic projectiles retrieved from the subcutaneous tissues of the chest and abdomen, alongside a small wire fragment found in the subcutaneous area of the neck. Additionally, burst lacerations of solid organs were also noted. The cause of death was determined to be shock and hemorrhage resulting from blast injuries. Chemical analysis of the viscera yielded positive results for ethyl alcohol.

Cases report 1 [Victim 2-Images 4-6]:

He is a 53-year-old male who was positioned adjacent to the blast source, holding a wire connected to the explosive material. He sustained significant blast-related injuries to the cranial region. There was a classic presentation of abrasions, punctate lacerations, and contusions across multiple areas of the body. Additionally, there were numerous fractures of the facial bones, including a

fracture of the maxilla, along with subdural and subarachnoid intracranial hemorrhages within the cranial cavity, a fracture of the left radius, a fracture of the left toe, multiple lacerations of the extremities, and burn injuries to the neck and chest regions, totaling 13 distinct injuries. The cause of death was determined to be blast injuries to the cranial region. The viscera tested negative for poison or ethyl alcohol.

Cases Report 1 [Victim 3-Image 7]:

He is a 26-year-old male who was positioned at a distance from the explosion while grasping the wire linked to the explosive material. He sustained secondary blast injuries. There was a classic presentation of the Marshall triad, analogous to that of the other victims, particularly in the extremities and the right side of the abdomen. A laceration was observed on the left thigh, which harbored a 10 cm metal fragment (missile). The missile had severed the femoral artery, leading to significant hemorrhage. Upon internal examination, all organs were

found to be intact and pale. The cause of death was determined to be Hemorrhagic Shock resulting from the femoral artery injury attributable to the blast. Chemical analysis of the viscera yielded negative results for poison or ethyl alcohol.

Case Report 2 [Victim 1- Images 8-10]:

A 35 year old male victim of blast injury at a Cracker Company in Tirunelveli was brought for autopsy on 5th March 2023. He was an employee in the company since 3 years and involved in the mixing of low explosives for crackers preparation. He suffered secondary blast injuries. There was classical triad of Abrasions, Punctate Lacerations and Contusions in multiple regions of the body with cracker powder residues. Green plastic material (missiles) were recovered from the injuries at multiple sites. Burns injuries were noted all over the body. There was Subarachnoid hemorrhages in the Head. There were Compound fractures of both legs and a deep laceration in the left thigh. The cause of death was opined as Shock and

Hemorrhage due to Blast injuries. Chemical analysis of Viscera was negative for any poison or intoxicating substance. Swab taken from the body was sent for detection of explosive substances/residues. Sulphur, Aluminium, Potassium ions, Nitrate ions, Sulphate ions and Thiosulphate ions were detected. These are considered as Low Explosive.

Case Report 3 [Victim 1- Images 11-13]:

On March 4, 2024, a 35-year-old male blast victim employed as a daily wage laborer at a Fireworks Company near Sivakasi was presented for autopsy. He had been in this role for two years, during which he was engaged in filling cracker pipes with explosive materials at the time of the incident. He sustained primary, secondary, and tertiary injuries. The entirety of the body was extensively fragmented. Numerous body parts—including the skull, brain, cervical vertebrae, sections of both arms, forearms, and hands—were absent on both sides, as were both legs and portions of the thighs. The classical Marshall triad was

evident in the remaining body parts. All solid organs exhibited signs of shattering. Multiple lacerations of hollow organs were observed. Numerous fractures were identified at various levels of the spine. The cause of death was determined to be complete bodily disruption resulting from blast injuries. A swab taken from the body was dispatched for the detection of explosive substances and residues. The analysis revealed the presence of sulfur, aluminum, potassium ions, chlorate ions, sulfate ions, and thiosulfate ions. These compounds are categorized as low explosives. The examination of viscera returned negative results for poison or alcohol.

Discussion: The classical triad comprising Abrasion, Punctate Laceration, and Contusion - referred to as the Marshal triad [3] - was evident in all examined cases. The individuals involved in Case 1 sustained critical injuries - primary, secondary, and tertiary - as a result of the confined environment and the characteristics of the explosive material utilized. In Case 2, the victims primarily

experienced secondary injuries, predominantly consisting of burn injuries. The individual in Case 3 endured primary, secondary, and tertiary injuries, resulting in dismemberment. None of the victims had received formal training nor possessed safety equipment, such as protective suits. All individuals were engaged in handling explosives without the requisite licenses mandated by the authorities, except for the victim in Case 2, where the incident occurred within a licensed company that lacked adequate safety gear or protective equipment. The victim in Case 3 acted with urgency and clandestinely prepared the firecracker for an event. All cases were filed under the Indian Explosives Act.

Conclusion: Blast injuries exhibit a discernible pattern, with the classical triad manifesting in every instance. The severity of injuries is contingent upon the type and quantity of explosive material utilized, alongside the individual's proximity to the explosion. Given the inherent risks associated with handling explosives, it is imperative

that authorities conduct periodic reviews of licenses for explosive handlers. Furthermore, workplaces should undergo thorough safety assessments. Personnel must receive regular training, and a comprehensive health record should be maintained. Public awareness regarding the legal ramifications associated with the illegal handling of explosives and the corresponding penalties should be promoted.

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Ethical Clearance: Not required.

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