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## Case Series

### Autopsy in Occupational Blasts- A Case Series.

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#### Abstract

**Introduction:** We live in times of rapid industrialization and urbanization leading to induction of large workforce in the formal and informal occupational sectors. Every occupation has its own inherent risks and some of them can cost the life and limb of manpower at times. It is an undeniable fact that human errors are responsible for a lot mishap at workplace that is preventable with due care and caution. Occupational safety legislation regulates the formal industrial sector whereas the large informal sector in our country remains unregulated and highly prone to serious fatalities. **Case study:** Explosion cases have a peculiar presentation at autopsy and the autopsy findings of such cases are described in this case series along with fault analysis leading to each blast and thereby suggesting prevention strategies in similar industrial/occupational settings. **Conclusion:** The occupational safety and health regulations are laid down by statute and enforced through agencies like Directorate General Factory Advice Service and Labour Institutes, DGFASLI, Government of India and the state level inspectorates of factories & boilers in India. These standards are to be scrupulously followed to prevent any industrial mishaps in the formal industrial sector.

#### 1. Introduction

Safety at occupational sites has become a concern across the globe in view of ever-increasing accidents at workplace. The International Labour Organization (ILO) estimates that some 2.3 million women and men around the world succumb to work-related accidents or diseases every year; this corresponds to over 6000 deaths every single day.<sup>1</sup> Blasts at occupational sites in both industrial set up and in the informal sector are one of the significant

causes of mortality. In this case series, we present nine occupational blast cases reported at different medico-legal centres, analyze the reasons for blast and discuss the prevention strategies.

**Case 1:** On the fateful morning of 17/02/2016, the deceased a 43 years old man and his friend, residents of Manchirevula village, Rajendra Nagar, Ranga Reddy district, Telangana state went to trade their scrap paint boxes in sale unit located within

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the limits of Narsingi police station. The deceased sitting on a chair attempted to break open half used ten-liter paint tin by placing it on the floor between his both legs. The tin suddenly exploded causing severe blast injury (Fig. 1). The blast also set two 'shrapnel' among multiple fragments of tin into projectile motion. The scrap tin projectiles entered the abdomen of the deceased by penetrating through his right groin and caused widespread trauma leading to his death. A bomb disposal squad and a team of forensic experts made a preliminary assessment at the blast scene and made out it to be a prima facie compression blast. Physical evidence was collected at the scene for subsequent final opinion. The corpse was subjected to autopsy at Medico legal center, Osmania General Hospital, Hyderabad.

Shirt of deceased got torn at multiple sites, blood and soil strewn on the surface of the clothes. A rent extending from crotch point parallel to the center seam is noted on the right slack of trousers, moist blood stains and fine yellow sandy particles are present on it. Corpse is in supine position, eyes closed, and mouth partially open, thin built and is of dark complexion. Bluish green color paint stains are present on the anterior surface of both palms. Dried blood stains present on the face and front of thighs. A loop of large intestine protruded from the right groin. Skin over the lower part of abdomen and groin is blackened.

**Figure 1:** Crime Scene showing the fragments of the chairs along with the exploded Tin



Multiple contused abrasions present on face and front of chest. Multiple abrasions and lacerations are present on fingers of right hand. A penetrating injury measuring 12 cm x 2 cm over the right groin, paint smudged over margins. Comminuted fracture of right superior ramus of pubis present. Multiple

omental tears and mesenteric contusions present. Haemoperitoneum noted, right kidney lacerated and perinephric hematoma present and bowel loops protruded out. All visceral organs pale. The cause of death in this case was due to hemorrhagic shock due to penetrating injury over the right groin consequent upon pressure blast.

**Case 2:**

On the fateful morning of 23/03/2021, the deceased a 28-year-old man and his friend were manually loading oxygen cylinders in their auto at their workshop within the limits of town VI police station, Nizamabad. One of the oxygen cylinders exploded while being placed on the trolley of the auto and caused fatal injuries to the deceased leading to his death on the spot (Fig. 2).

**Figure 2:** Crime Scene showing exploded oxygen cylinder along with the trolley of the auto.



**Figure 3:** Exposed viscera through the disrupted thoraco-abdomino-pelvic cavities.



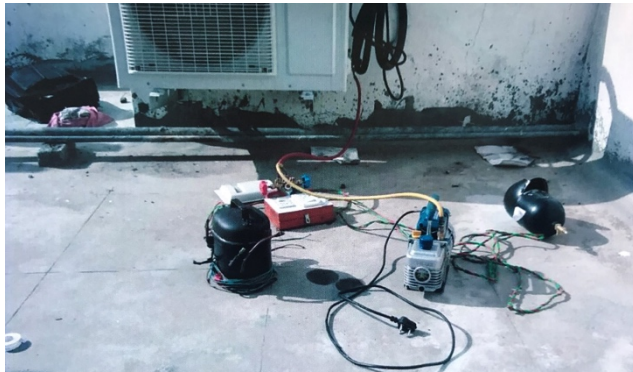
The shirt of the deceased is burnt in its lower half, torn in to pieces at places and trousers also charred at sites. Blast injury over back of lower chest, abdomen and pelvic cavities with an open laceration of size 99cm x 36 cm x cavity deep, margins of the injury are burnt and viscera torn and exposed through the disrupted thoraco-abdomino-pelvic cavities (Fig. 3). Dermo epidermal burns present over upper half of anterior surface of right thigh. 5-12 ribs fractured at multiple sites and levels on both sides. Lungs, diaphragm and abdominal viscera lacerated and multiple blood clots present. D10, L1, L2 vertebrae fractured with disruption of spinal cord. A 3cm x 1cm abrasion present over nose and another 2cm x 1cm

abrasion present over right cheek. The cause of death in this case was due to hemorrhagic shock due to blast injury to the chest and abdomen consequent to oxygen cylinder blast.

### Case 3:

A 28-year-old male, working as an AC technician in Hyderabad city attended for repair and Service of split AC in an apartment along with his untrained helper on 23/06/2017 at 10 am. During the process of repair of the split AC, he needed to refill the gas (Fig. 4). So, he started gas filling and assigned his helper to supervise the task and left for attending some other work. When he returned and inspected the process of refill, the compressor of the outdoor unit exploded suddenly. The AC technician sustained a fall from height and was later shifted to OGH Hyderabad for treatment where doctors declared him brought dead and shifted to mortuary for post mortem examination.

**Figure 4:** Crime scene showing the exploded compressor along with the equipment.



**Figure 5:** External injuries seen during the postmortem examination.



During the post mortem examination, on external examination there were two reddish contused abrasions each of size 2cm x 2cm on the right mid axillary line along the 7<sup>th</sup> and 8<sup>th</sup> intercostal

space and a reddish contused abrasion of size 3cm x 2cm on the left scapular region 10 cm away from midline and 3cm below and 8cm inwards from left tip of the shoulder (Fig. 5). Apart from these injuries no other external injuries were present.

**Figure 6:** Lacerated liver seen during postmortem examination.



On internal examination, 7<sup>th</sup> and 8<sup>th</sup> ribs fractured with corresponding hemorrhage in the surrounding area with laceration of the liver (Fig. 6). Mesenteric vessels ruptured at the root of the mesentery in the upper part near the duodeno-jejunal flexure. The cause of death was due to blunt injury to the chest consequent to AC unit compressor blast.

### Case 4:

A 40-year-old male, working as chemist in a pharmaceutical company was on duty at his workplace. On the early hours of 08/02/2016 at around 6:15 am the Nutsche filter attached to reactor exploded resulting in the death of the individual who was working in the reactor room. During the post-mortem examination, the body of the individual was seen to be completely mutilated by the explosion of the reactor leaving only the lower third of both legs intact. There was complete disfiguration of face with underlying comminuted fracture of whole skull including the mandible with only remnants of brain matter in the skull cavity. The trunk along with upper limbs was completely mutilated and all the internal organs dissipated across the room, bowels charred and shrapnel deposited on the body parts. The skin is hardened due to the chemical spillage on them. The

cause of death was due to blunt injuries all over the body. The manner of death was accidental.

**Case 5:**

A 24-year-old male, working as helper in a pharmaceutical company was on duty. On the early hours of 08/02/2016 at around 6:15 am the Nutsche filter attached to reactor exploded resulting in the death of the individual who was working in the reactor room. During the post mortem examination, body of the individual was supine and the whole body including the clothes was covered with intermediary chemicals which spilled out from the exploded reactor. On external examination the projectile from the reactor explosion has caused traumatic amputation of the right upper limb at the shoulder level and at the elbow corresponding to the laceration of the chest and abdomen causing multiple fractures of the entire right rib cage along anterior axillary line and evisceration of the bowel loops from the abdomen. Another projectile from the reactor explosion caused traumatic amputation of the right lower limb at the hip and the middle third of the right leg exposing the underlying tissues.

On internal examination, the rib cage is fractured on the right side causing the rupture of the right lung along with rupture of the liver and perforation of the bowel loops along with mesenteric rupture and part of bowels ruptured and eviscerated. The exposed bowel is burnt and became like a string. Internal organs are pale. The cause of death was due to hemorrhagic shock consequent to multiple injuries. The manner of death was accidental.

**Case 6;**

A 42-year-old male, working as chemist in a pharmaceutical company was on duty. On the early hours of 08/06/2021 at around 6:15am the Nutsche filter attached to reactor exploded resulting in the death of the individual who was working in the reactor room. During the post-mortem examination, the body of the individual was completely mutilated by the explosion of the reactor leaving only the lower third of the both legs was intact. There was complete disfiguration of face with underlying comminuted fracture of whole skull including the mandible with only remnants of brain matter present in the skull cavity. The trunks along with upper limbs were completely mutilated and all the internal organs were dissipated across the room, bowels charred with deposition of shrapnel on the body. The skin is hardened due to the chemical spillage on them. The

cause of death was hemorrhagic shock due to multiple injuries. The manner of death was accidental

**Case 7:**

A 25-year-old male, working as helper in a pharmaceutical company was on duty. On the early hours of 08/02/2016 at around 6:15 am the Nutsche Filter attached to reactor exploded resulting in the death of the individual who was passing by along the stairs outside next to the reactor room. During the scene examination, body of the individual was found in the rubble as result of collapse of the walls of reactor room due to the blast. After retrieving the body and on examination, the whole body including the clothes is covered with intermediary chemicals spilled from the exploded reactor. Injuries on the body included, a laceration of the size 6cm x 3 cm x muscle deep on the outer aspect of the upper third of right arm exposing the underlying tissue along with traumatic amputation of lower third of the left thigh exposing the underlying tissue including the bone.

On internal examination, A reddish colour sub scalp contusion of size 3cm x 2cm present on the right temporal region. On opening the abdomen, around 1 liter of blood-stained fluid present in the peritoneal cavity along with multiple lacerations on the surface of the liver with extravasation of blood into surrounding tissue. The cause of death was hemorrhagic shock due to multiple injuries. The manner of death was accidental.

**Case 8:**

A 23-year-old male, working as helper in a pharmaceutical company was on duty. On the early hours of 08/02/2016 at around 6:15 am the Nutsche Filter attached to reactor exploded resulting in the death of the individual who was standing outside next to the reactor room. During the post-mortem examination, on external examination the whole body including the clothes are covered with intermediary chemicals spilled from the exploded reactor and the body of the individual was lying supine with both upper limbs covering the face and in rigor, right lower limb is adducted, internal rotated with swelling at the hip joint. Avulsed laceration of the right foot at the level of the metatarsal phalangeal joint exposing the underlying tissue including the bones with extravasation of blood into the surrounding tissues. Left leg is shortened with swelling, abnormal mobility with crepitus with underlying fracture dislocation of both bones of left leg along with avulsed laceration of the skin of the

sole completely exposing the underlying fascia. On internal examination multiple contusions 3cm x 5cm are present over the frontal region of the scalp. On opening abdomen organs are pale with multiple lacerations over the surface of the liver. Closed fracture dislocation of the pelvic bone at the symphysis pubis and right sacroiliac joint. The cause of death was hemorrhagic shock due to multiple injuries. The manner of death was accidental.

#### Case 9:

A 22-year-old male, working as helper in a pharmaceutical company was on duty. On the early hours of 08/02/2016 at around 6:15 am the Nutsche filter attached to reactor exploded resulting in the death of the individual who was working in the reactor room (Fig. 7). During the post mortem examination, the head of the individual is severed from the trunk at the level of C6 and C7 vertebrae. The trunks along with upper limbs are completely mutilated and all the internal organs are dissipated across the room, bowels charred with deposition of shrapnel on the body parts (Fig. 7-10). Skin was hardened due to the chemical spillage on them. The cause of death was hemorrhagic shock due to multiple injuries. The manner of death was accidental.

**Figure 7:** Crime scene showing the rubble due to collapse of wall as a result of reactor explosion.



**Figure 8:** Complete disintegration of the body as a result of reactor explosion.



**Figure 9:** Amputation of the upper limb and lower limb along with evisceration of bowel loops as result of the projectile arising from the reactor explosion.



**Figure 10:** Eviscerated bowel loops as result of the projectile arising from the reactor explosion.



#### 4. Discussion:

##### Probable hypothesis for blast in this case 1:

Any remnants of thinner used in painting or thinner soaked cloth material might have supposedly caught fire due to a spark generated on sudden strike of axe on the iron lid. Burning of thinner material might have generated gasses which found difficult to get out through the small vent created by the deceased. The compression generated thereby might have led to a blast. Few other things like a plastering trowel piece left in the tin may have taken a projectile course. Thinner used in paints contains Mineral spirits/ white spirit, Acetone, Turpentine, Naphtha, Toluene, Methyl ethyl ketone (MEK), Dimethyl formamide (DMF), 2-Butoxyethanol, or any of the other glycol ethers which are potential inflammable materials

##### Probable hypothesis for blast in case 2:

Sudden breaking of pressure/flow regulator knob of the oxygen cylinder while placing it in the trolley of auto led to a sudden decompression of pressurized oxygen leading to a heat and blast wave generation which led to shattering of glass and

disruption in scene and death of individuals handling the cylinder.

**Probable hypothesis for blast in case 3:**

Failure of the valve that regulated pressure/volume flow in to the AC compressor led to

increased thrust of the gas inside, which led to sudden explosion.

**Probable hypothesis for blast in cases 4-9:**

Industrial safety experts concluded that pressure dysregulation within the agitated nutshce filter lead to a reactor blast causing the fatalities.

**Table no. 1: Causes and prevention of common occupational blasts**<sup>2, 3, 4, 5, 6, 7, 8, 9, 10</sup>

S.No	Occupational Set-up	Reasons for Explosions	Prevention
1	Boiler blasts/Reactor blasts/Furnace blasts	Tube failure in steam boiler or heat exchanger, furnace explosion and boiler explosion are caused due to wear and tear of the industrial apparatus and improper maintenance in several industries. Ex: cracks in the boilers etc	Intensification of repair and maintenance works. Regular safety audit of apparatus.
2	Working in scrap units/plants	Hammering/dismantling an old bomb shell for retrieving metal, reaction between chemical solvents in scrapped containers, unexploded explosives catching fire when they are manipulated during scrapping operations. Unexploded ordnance (UXO) in scrap can be a reason.	Scrap should be segregated at source and personnel working in this sector should be educated about proper management of scrap.
3	Working with unauthorized LPG refilling	Pressure differential, faulty technique and using unfit adapters for transferring LPG from a large cylinder to smaller cylinders.	Refrain from unsupervised and unauthorized transfer of LPG from one cylinder to another.
4	Working with Air Conditioning units/ Refrigerators for gas refilling related tasks	Filling different types of gasses, using inexpensive, inappropriate coolant gas and dysregulation of pressures while filling, failure of pressure/volume control. Blasts can also occur if coolant is filled without clearing nitrogen gas used for testing any leak.	Use only R22, R12, R32, R410 or R134 as coolants and never use propane/butane as coolant which is highly inflammable.
5	Working with Oxygen/Nitrogen/Hydrogen gas cylinders- manufacture and supply	<ul style="list-style-type: none"> <li>Placing oxygen cylinders under the sun, using lubricants like oil or grease, lifting the cylinders at the neck/junction of the valve and completely emptying the cylinder.</li> <li>Though nitrogen gas is not inflammable, sudden pressure decompression incidents lead to blasts.</li> <li>Reactions inside pressure vessel can lead to hydrogen cylinder blasts</li> </ul>	<ul style="list-style-type: none"> <li>Using proper material like Cu, Fe for making the cylinders, placing the cylinders gently on ground without any jerk to prevent mechanical shock, always transport cylinders in trolley/ lifting bucket / pallet.</li> <li>Design the filling plants with all due precautions from regulatory authorities like the OSHA.</li> </ul>
6	Other industrial fires & explosions	<ul style="list-style-type: none"> <li>Improper management of combustible dust.</li> <li>Hot work including brazing, burning, welding, torch cutting etc.</li> <li>Flammable liquids and gasses in chemical plants.</li> <li>Faulty equipment and machinery.</li> <li>Electrical Hazards</li> </ul>	<ul style="list-style-type: none"> <li>Applying the safest industrial vacuum for the workplace.</li> <li>Ensure that hot-work area is clear from flammable or combustible materials.</li> <li>Storing flammable liquids properly, controlling the ignition source and providing PPE.</li> <li>Training personnel, proper cleaning and housekeeping &amp; regular maintenance.</li> <li>Proper load management of circuits, avoiding extension cords and using antistatic equipment where required</li> </ul>

All the blast scenarios discussed above included abrasions, contusions, lacerations, produced typical injuries described in literature which penetrating trauma and internal injuries like blast

lung, acoustic trauma, disruption and perforation because of blast wave.<sup>11</sup> Injuries due to explosions are generally categorized as primary, secondary, tertiary and quaternary blast injuries.

As discussed above, sometimes there can be fatal internal injuries due to blast wave with trivial external injuries for humans working within the vicinity of the explosion. Apart from specific causes and prevention strategies described in the table, one has stress upon the use of appropriate personal protective equipment and safety awareness as a culture in formal industrial setup to reduce morbidity and mortality due to explosions.

### 5. Conclusion:

The occupational safety and health regulations are laid down by statute and enforced through agencies like Directorate General Factory Advice Service and Labour Institutes, DGFASLI, Government of India and the state level inspectorates of factories & boilers in India. These standards are to be scrupulously followed to prevent any industrial mishaps in the formal industrial sector. Maintaining check lists, running mock safety drills; doing early hazard analysis, ensuring regular maintenance of equipment will do a great favor in reducing the loss of life and limb due to explosion injuries. However, the bigger challenge before all of us is to look after the safety of a large chunk of workforce in the informal sector which is largely composed of semiskilled manpower. Conducting regular free skill training and safety workshops will transform their lives by instilling as sense of care and caution in their work.

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