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CASE REPORT

Suicide by head explosion: unusual blast wave injuries to the cardiovascular system

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Abstract A 57-year-old employee in a military scientific institute was found acephalous in a supine position in an anteroom to the bunker. On the walls was abundant spattering of blood and tissue, concentrated above shoulder height. A mobile ignition device stood on the control desk. The complete destruction of the head down to the cervical spine suggested that the explosive charge (RDX) detonated in his mouth. The hands were virtually uninjured. The pressure effect in vessels caused numerous tears to the wall of the carotid arteries and the left vertebral artery, a tear-off of the left carotid artery of the aortic arch, and a 2.5-cm long crack of the thoracic aorta with 540-ml blood in the pericardial sac and a shredded window-like disruption of the left aortic valve cusp. The autopsy also showed an infraction of the sternum from the inside, and a contusion of the superior lobes of both lungs. The trace pattern on the right arm suggested suicide. A bone fragment of the mandible penetrated the right biceps muscle as a secondary projectile.

Keywords Suicide · Blast · Pressure wave · Arterial vessel disruption · Secondary missile

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Introduction

Use of explosives is highly restricted in Germany. As a result there are few observations of explosion incidents unrelated to military settings. Apart from occupational incidents and rare accidents [14], explosives-related fatalities among civilians are primarily suicides. Rajs et al. [12] found in Sweden that from 1979–1984 41% of explosives-related fatalities were suicides and 36% were occupational accidents; only 5% were due to terrorist activity. Marshall [9] described the pattern of injuries on bombing victims in Northern Ireland. A recent review [4] surveys explosion-related injuries inflicted on combatants and victims of terrorism. The peculiar aspects of blast-related neurotrauma are set out by Ling et al. [8]. In the literature, suicides by explosives without a terrorist background are rare [13]. Case reports of suicides by explosives describe mutilation of the trunk [3, 15, 17] as well as of the head [1, 3, 13, 15]. In 2008, Allaire and Manhein described a suicide that used blasting caps with extensive bone damage to the skull [1]. The cases reported by Shields et al. showed severe craniofacial injuries [13].

Fatalities due to explosion comprise a challenge in medicolegal casework, since the mutilated corpses must be identified, and the cause and manner of death must be cleared and differentiated from other types of injury (e.g., high-velocity gunshot trauma [1]) which could be masked by the explosion [9, 13]. Only a thorough autopsy provides information about the position of the explosive device relative to the body, and is therefore essential in distinguishing between homicide, suicide, and accident.

The number of primary blast injuries from explosions presenting to military medical care facilities is limited. Of greatest clinical importance are tympanic membrane ruptures, primary blast lung injury, and very rarely primary blast injury

Fig. 1 Complete decapitation without open thoracic injury

to the intestine [18]. From the forensic pathology viewpoint concerning primary blast injuries, the rupture of gas-containing organs, especially the lungs, middle ear and gastrointestinal tract, is of primary importance. According to a recent review by Tsokos [16], direct blast wave exposure almost exclusively affects gas-containing organs and contributes to 47–57% of injuries in survivors and 86% of fatal injuries. Below, unusual blast wave injuries to the cardiovascular system are considered.

Case background

At 10:30 a.m. in a military scientific institute, a 57-year-old employee was found dead in an anteroom to the bunker. He was in a supine position, with complete destruction of the head (Fig. 1). He was clothed normally in a thick pullover and blue jeans. On the walls were much blood and tissue, concentrated above shoulder height (Fig. 2). Shattered skull fragments were found throughout the room. The ears had been torn off the head and were found to the right and left sides of the corpse at similar distances to the feet. A mobile electrical ignition device stood on the control desk; the wires lay unrolled and disrupted on the desk. According to the control of the explosive inventory 10 blasting caps at 10 g Hexogen were missing.

The man was an electrician by profession and had worked in that laboratory for 15 years, in which tests of blasting caps were performed. He was reputed to be very careful. No tests had been planned that morning. His last telephone calls, 1 h before his death, were about an imminent shift of his workplace, but did not suggest a critical state of mind. No farewell letter was found, so that the suicide might have been decided on the spot. He was not known to have any mental or somatic diseases.

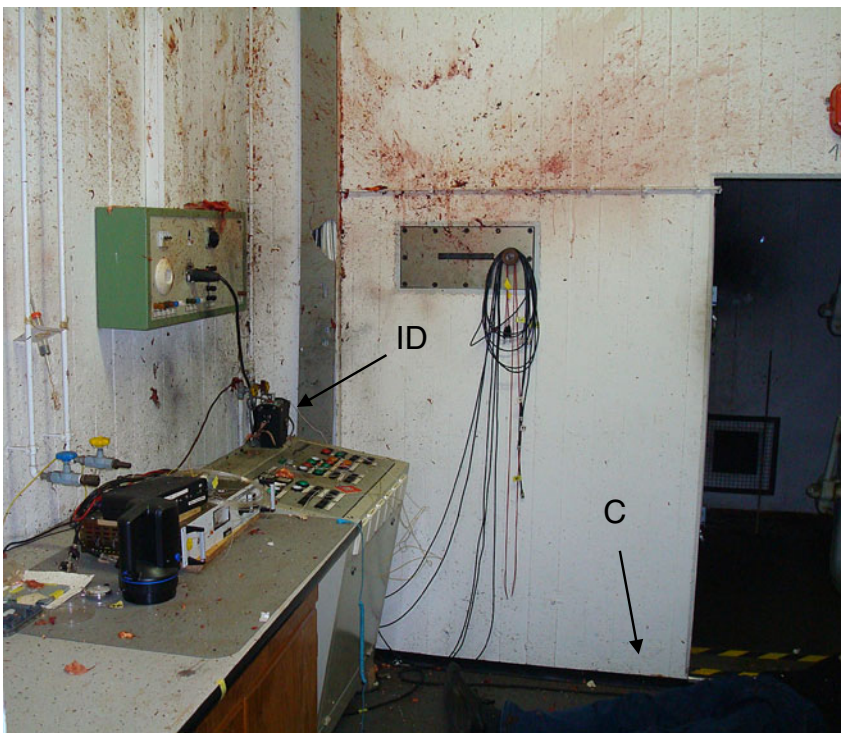

Fig. 2 Control desk with the electric ignition device (*ID*). *C* indicates the legs of the corpse. A pattern of high-speed spatter was visible on the walls

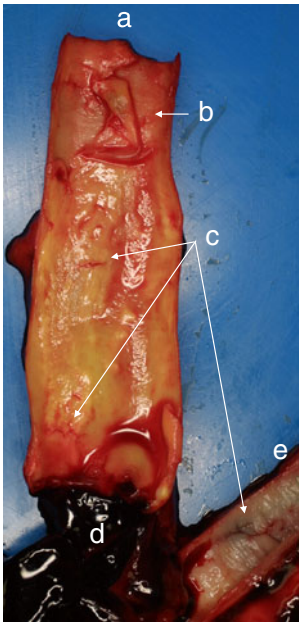

Fig. 3 Multiple injuries to the left carotid artery. *a* Destruction of the upper part, *b* dissection of the wall, *c* tears in the inner wall, *d* tear-off from the aortic arch, *e* left vertebral artery (anomalous origin)

Results of the autopsy

Sparse postmortem lividity.

Complete destruction of the skull, crushing of the superior cervical spine and the larynx; extended undermining soft tissue damage down to the suprasternal notch.

Loss of the carotid bifurcation on both sides.

Numerous tears in the wall of the carotid arteries and the left vertebral artery; tear-off of the left carotid artery of the aortic arch (Fig. 3).

A 2.5-cm long crack of the thoracic aorta (Fig. 4) with 540-ml blood in the pericardial sac, and shredded window-like disruption of the left aortic valve cusp (Fig. 5).

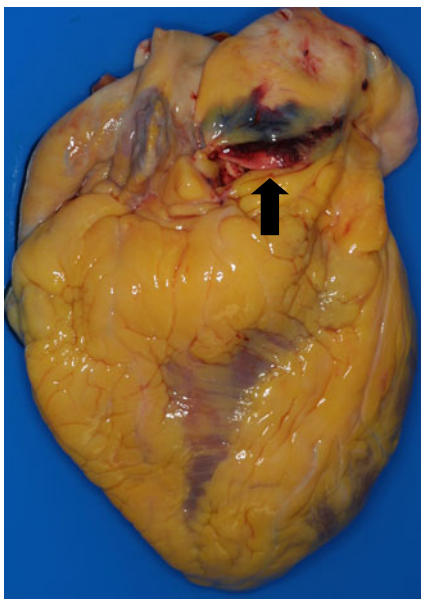

Fig. 4 Rupture of the aortic root (*arrow*). The pericardial sac was not injured

A tear of the aortic arch between the brachiocephalic artery and left common artery.

Seventy percent tear-off the left subclavian artery (Fig. 6a).

Two hundred milliliters of blood in the left pleural cavity, vast mediastinal bleeding, contusion of the superior lobes of both lungs (Fig. 6b), and infraction of the sternum from the inside.

No bone or other fragments in the mediastinum or thoracic cavities.

A penetrating oval injury (23×13 mm) in the middle of the anterior right upper arm (Fig. 7a). Within it was a ca. 7-cm long compressed soft tissue stripe bearing skin from the upper bearded neck. At the end of the wound track in the biceps was a bone fragment of maximum length 1 cm (Fig. 7b).

The hands were virtually uninjured.

Under autopsy no foreign bodies were found in the body, but tissue debris collected from the scene contained a few pieces of aluminum smaller than 1 cm.

Histological examination of lung tissue revealed bleeding, acute emphysema, and alveolar septal tears.

Toxicological analysis for alcohol and drugs in the venous femoral blood was negative.

Discussion

In the forensic pathologist's occupational routine, suicides caused by explosives are rare. In the present case there are further peculiarities:

- Decapitation with complete destruction of the head
- Multiple tears and disruption of the neck vessels and the aorta
- Hemopericardium
- Penetration of soft tissue debris and bone fragment through clothes into the right biceps muscle

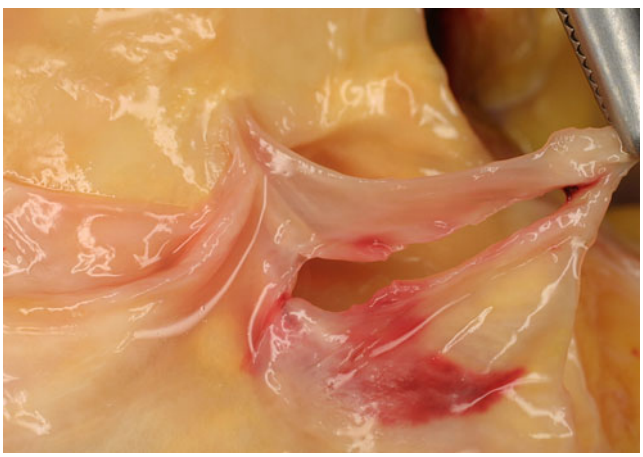

Fig. 5 Disruption of the left aortic valve cusp

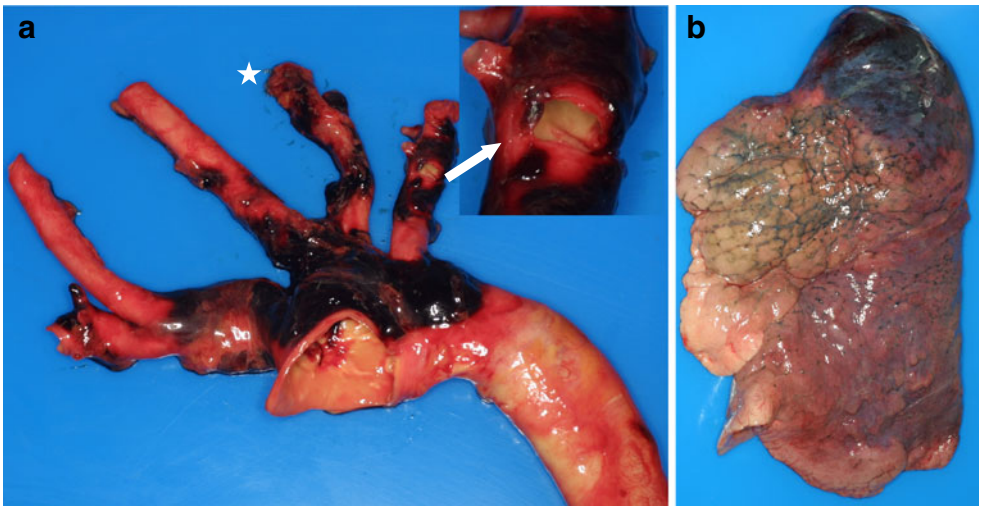

Fig. 6 **a** Arch of the aorta with mediastinal bleeding. Disruption of the left subclavian artery (see magnification). Left vertebral artery (star) with large caliber and anomalous origin from the aortic arch. **b** Left lung with apical contusion

Suicides by explosives almost always result in destruction of the head, but complete decapitations are less common. In 1987, Rajs et al. published a survey of explosives fatalities over a 6-year-period in Sweden. In a total of 61 cases, 36% were fatalities after occupational accidents, and 41% were suicides [12]. In 23 of 25 suicide cases the head was destroyed. Shields et al. [13] gave a morphological description of two cases of suicide by destruction of the head. In both cases severe craniofacial injuries were observed, although without decapitation. Tsokos et al. [15] published four cases of suicide by explosives among which two men had placed the explosive charge close to their heads. The main trauma involved the head, the neck, and the upper thorax. In one case the head was nearly separated from the trunk. Skull base fractures and subarachnoid bleeding were noted. The other man was decapitated, with scattering throughout the room of shattered fragments of the skull, brain tissue, and blood. In both cases a direct thoracic trauma caused lung lacerations. In the first case the heart was torn off from the aorta, but in the second case the heart and aorta were uninjured. Davis et al. [5] related a suicide by pipe bomb in which the posterior aspects of the head, neck, and upper trunk were injured. In 2009, Große Perdekamp et al. referred to a 44-year-old

Fig. 7 **a** Penetrating wound on the upper arm with bearded skin inside. **b** Removed "flag" of soft tissue and bone fragment (scales in centimeters)

blaster who placed a charge of 196 g pentaerythritol tetranitrate at his neck, resulting in extensive destruction of the head and a severe thoracic trauma with injuries to the lungs, heart, and aorta. Allaire et al. [1] reported a decedent who had placed blasting cups at or slightly above the ears, leading to shattering of the skull. Other autopsy findings were not given, probably because the corpse was already in advanced decomposition.

In the present case the symmetric forward directed destruction of the head above the larynx suggested that the explosive charge (RDX) was lit in the mouth. This hypothesis was sustained by the nearly symmetrical placement of the ears torn off in the room. Rajs et al. [12] state that symmetry is typical of suicidal explosive injuries. The burns and tissue impacts on the right shoulder (Fig. 1) and arm indicated that the head was slightly directed to the right hand while triggering the ignition device. Rajs et al. [12] found electric ignition devices in nine of 25 cases. Other authors noted the presence of electrical wires close to the corpse [1, 13, 15], which facilitated the interpretation of the event as suicide.

The complete destruction of the head was immediately explicable by the use of ten blasting caps containing, overall, 100 g Hexogen (RDX, T4, cyclotrimethylenetrinitramine). This is a powerful military explosive.

Medicolegal observations formerly involved dynamite [6, 11, 19]. The effects depended on the quantity of explosive and the mechanism of ignition. Detonation was often started by biting the cap. In such cases the overpressure acted only in part on the base of the skull. In the present case an electrical device was used, and the load of caps could therefore be placed fully in the mouth.

The high-speed spatter of pulpified soft and bony tissue on the walls of the room are in correspondence with published observations [1, 13, 15].

In the present case, great overpressure was observed inside the body, following the route of the vessels from the head down to the heart. All vessels showed multiple tears and disruption. Even an aortic valve cusp was disrupted. Most astonishing was a complete hemopericardium caused by a rupture of the aortic root, which indicates that the heart continued beating for some time.

The superior parts of the lungs were contused and the sternum broken from inside, due presumably to a blast wave through the soft tissues of the neck. In contrast, the cases cited [15, 17] presented lung lacerations as direct trauma after open injury to the thorax. Shields et al. [13] reported two cases who had each placed an explosive charge in their mouths which destroyed the heads but did not cause injuries to the trunk.

As well as the blast injuries to neck and intrathoracic vessels, the most curious finding was a penetrating injury on the right upper arm (Fig. 7a). A bone fragment of 1 cm length, with a 7-cm long stripe of skin with soft tissue (Fig. 7b), was found in the biceps muscle. Morphologically, it was identified as a fragment of mandible which had penetrated deeply, passing through the thick pullover, the skin, and subcutis. This "secondary missile" was further inhibited by the long "flag" of soft tissue. This observation relates to discussions of the wounding capacity of bones as secondary missiles [2, 7].

Conclusion

This case was remarkable not only for complete destruction of the head but also for the injuries caused by internal overpressure. Mayorga [10] distinguished between primary, secondary, and tertiary blast injuries, and the present findings can be interpreted as primary blast injury, which is defined by an interaction of the pressure wave and the body. Secondary blast injuries, resulting from the impact of other objects on or into the body, could not be observed. The explosion did not produce tertiary blast injuries, i.e., injuries caused by the displacement of the body by the pressure wave.

Although fatalities due to explosions are exceptional, the present case underlines that the medicolegal task of distinguishing between homicide, suicide, and accident demands teamwork between medical examiners, investigators, and crime scene investigators.

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