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CASE REPORT

PATHOLOGY AND BIOLOGY

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Machinery-Related Deaths: Relevance of Workplace Investigation and Antemortem Radiological Data in Reconstructing the Fatality

ABSTRACT: Machinery-related fatalities are one of the leading causes of traumatic occupational deaths. In our report, we present the case of a 40-year-old male who suffered a severe head trauma while working in a cut-foam industry and died despite an early craniectomy. The radiological reconstruction of the skull based on preoperative computed tomography scans disclosed a large depressed conical fracture of the left parietal bone. The 3D-reconstruction of the work area, combined with a fit-matching analysis between the machinery and the depressed skull fracture allowed us to conclude that the head was crushed between the sliding bar of the cutting device and the metallic protuberance on the opposite side. The case underlines the importance of a detailed workplace investigation and of a thorough evaluation of all circumstantial, clinical, radiological, and autopsy data in the reconstruction of machinery-related fatalities to identify any possible legal responsibilities of the worker and/or the employer.

KEYWORDS: 3D-CT reconstruction, blunt trauma, craniectomy, forensic science, skull fracture, workplace investigation, work-related death

Work-related death can be defined as any persons fatally injured as a result of conditions made by their own work action(s); by those of others; or, by the work environment itself. Moreover, a work-related death can be the result of a fatal injury while travelling to or from work (Monash University National Centre for Coronial Information, 2001) (1).

In 2006, 1341 Italian workers died from work-related injuries (Istituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro) (2), whereas in the same year, 5703 U.S. workers lost their lives while on the job (United States of Labor Statistics) (3).

The reconstruction of a fatal accident can be complex and incomplete because of the lack of detailed information concerning incidents surrounding the event, not to mention the design and description of the machinery involved in a death (4).

A victim does not always die at the workplace but rather is often admitted to hospital to undergo surgical intervention. In such cases, the iatrogenic alterations of internal and external wounds as well as the time interval between the work-related injury and forensic examination, not to mention the subsequent healing of lesions, can hamper reconstruction of the dynamics involved in the event (5–7).

We report the case of a 40-year-old man who suffered a severe head trauma while working in a cut-foam industry and died 6 h after the accident, despite an early craniectomy. A radiological reconstruction of the skull based on preoperative computer tomography (CT) scans combined with a thorough investigation into the work area allowed for a reconstruction of the unusual work-related fatality.

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Case Report

A colleague found a 40-year-old worker unconscious and in a pool of blood, slumped backward at a cutting machine of foam products. The victim was transported to the general hospital where a spiral CT of the head (slice thickness 2 mm, reconstruction interval 1 mm, kV 120, mA 202) showed a large, depressed left temporo-parietal fracture with comminuted and diastasic fractures at the lambdoid suture. Several fracture lines were recognizable in the lateral wall and the roof of the left orbita, in the clivus and the basisphenoid, in the right temporal bone with involvement of the petrous bone, in the ethmoid and in the lateral walls of both maxillary sinuses. Marked subcutaneous emphysema in the neck, numerous intracranial air blebs, several brain contusions, and extensive subarachnoid and intraventricular hemorrhages were also evident. Despite early craniectomy and admission to an Intensive Care Unit, the male victim died 5 h after the recovery.

Autopsy Findings

Performed 2 days after the death, a forensic autopsy revealed:

1. a laceration of the right ear;
2. a curved surgical incision at the left side of the head (Fig. 1*A*);
3. a lack of portion of the left parietal bone because of the craniectomy (Fig. 1*B*);
4. a linear fracture of the right parietal bone;
5. a laceration of the left cerebral hemisphere;

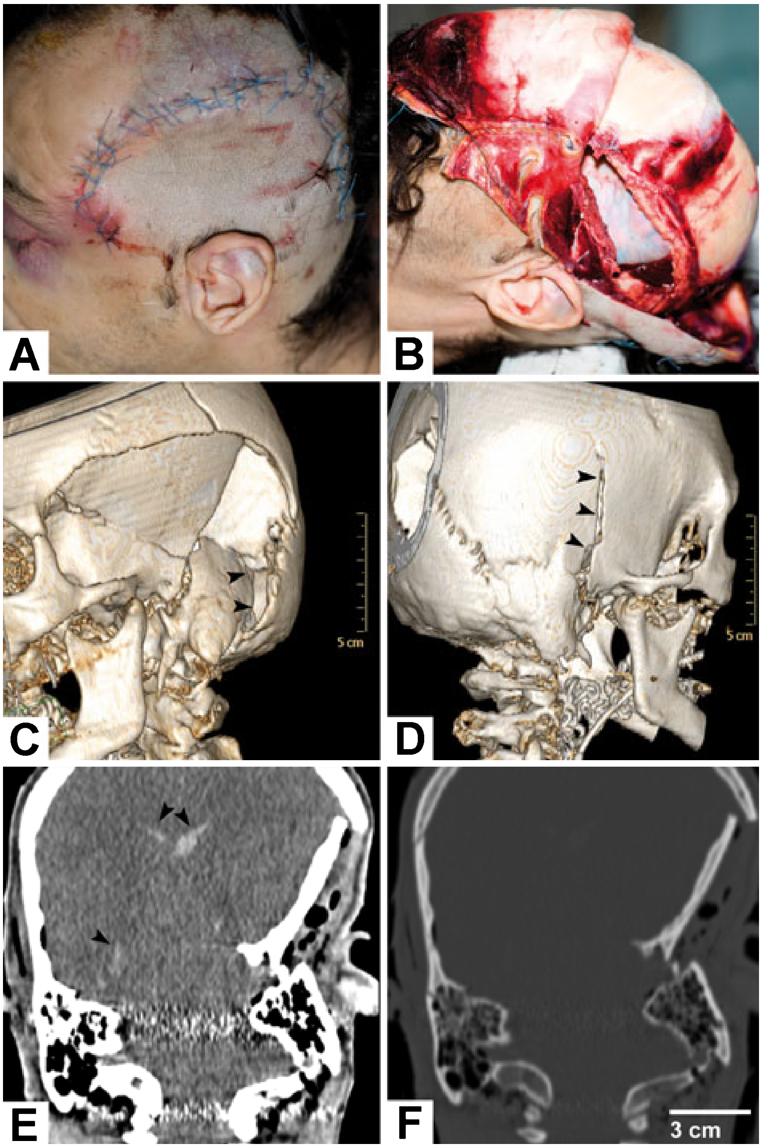

FIG. 1—*(A) Curved surgical incision at the left side of the head. (B) Lack of portion of the left parietal bone because of the craniectomy. (C–D) 3D volumetric reformations of the skull SSD based on preoperative CT scans. On the left side, the depressed temporo-parietal fracture with a conical shape and an elliptical base. The posterior border of the fracture presents comminuted and diastasic fractures at the lambdoid suture (black arrowheads). On the right side, a temporal bone fracture involving the anterior part of the petrous bone (black arrowheads). (E–F) Coronal multiplanar reconstruction CT images through the petrous bone. Parenchymal window (E): the depressed fracture causes moderate midline shift of brain parenchyma; despite the poor quality of the image because of beam hardening artifacts, diffuse brain edema with loss of subarachnoid spaces and intraventricular hemorrhage (arrowheads) are recognizable; pneumoencephalos and subcutaneous emphysema are also evident. Bone window (F): the left fronto-parieto-temporal fracture presents a larger superior fragment (about 6 cm in diameter) and an inferior fragment involving the mastoid (about 4 cm in diameter); the resultant fracture depression is about 3 cm in depth; other fracture lines are recognizable on the right petrous and parietal bones.*

6. extensive subarachnoid and tetraventricular hemorrhage;
7. a hemorrhagic infiltration of the pons and medulla oblongata.

No alcohol, psychoactive substances, or drugs of abuse were found in the blood and urine collected at hospital admission. No drugs of abuse were found in hair collected at autopsy. The cause of death was identified as diffuse brain damage because of a penetrating head injury.

3D-CT Reconstruction

To analyze the original morphology of the fractures and their location, 3D volumetric reformations (shaded surface display—SSD) and coronal multiplanar reconstructions (MPR) based on preoperative CT scans were generated (8).

The 3D-CT images disclosed:

1. a large depressed conical fracture of the left parietal bone with several bone fragments within the brain parenchyma. The fracture depression had an elliptical base of 14.0 × 10.0 cm and a height of 3.0 cm (Fig. 1*C*);
2. two fracture lines extending from the depressed fracture along the left parietal bone and into the lateral portion of the left orbit;
3. one longitudinal fracture involving the pars petrosa of the right temporal bone (Fig. 1*D*);
4. bilateral temporo-mandibular lateral luxation.

Workplace Investigation

The victim was working on a cutting machine of foam products consisting of a charge roller, cutting device, and discharge roller (Fig. 2*A*). The cutting device included a computer-controlled saw mounted on a sliding bar and moving horizontally. A metallic fence enclosed the work area where the victim was found. It was possible to access the area by way of a door, the opening of which activated an automatic stoppage of the machine. A crime scene investigation carried out by the police on the day of the accident revealed that the safety device installed on the door had been deactivated. A bloodstained spanner/wrench and bolt were observed in the cutting area next to the pool of blood (Fig. 2*B*, red circle).

Suicide notes were not found. Interviews with the victim's colleagues, friends, and family revealed that the deceased suffered no physical or mental disorders, that he had no work or family problems, and that he had never attempted suicide.

Discussion

The crime scene investigation, the toxicological analyses, and the victim's medical and family history identified no suicidal tendencies. On the other hand, the presence of tools (bloodstained spanner/wrench and bolt) in the cutting area where the worker was found (Fig. 2*B*, red circle) indicated that he was probably injured upon repairing the machine, thus pointing toward an accidental death.

There are many potential contributing factors to any work-related accident resulting in injury, including conditions set up by work protocol; by type of equipment and materials used; by the environment itself and the worker. Cases are classified as *Design-Related* if available information strongly suggests that the accident would not have occurred, or would not have resulted in a fatal outcome if a particular work design had not been present or had been different. An important part of the definition focuses on whether: "*…It is realistic to expect that this design factor could have been modified to avoid the incident or the subsequent fatal injury*" (4).

In the majority of cases, information provided by the police and a coroner's office is sufficient to reconstruct the dynamics involved in the work-related accident. In certain circumstances, however, even a detailed description of the workplace and of injuries suffered by the victim may prevent the identification of the cause of the fatality: which is to say, whether any malfunctioning equipment or neglect for safety measures played a role in causing the incident (4).

In the case of the cut-foam worker, there were no witnesses. At the autopsy, the absence of skull fragments (Fig. 1*B*) removed during neurosurgical procedures did not allow us to conclude whether the skull had hit the ground violently or had impacted against an object with a narrow surface. We were thus unable to gain a clear view of the dynamics involved in the incident.

Fortunately, the radiological investigation executed at the admission to hospital provided precious information on the morphology of the fractures prior to the craniectomy. The wide diffusion of the CT scanners presently provides excellent techniques for diagnostic efficacy. Virtually every victim of head injuries today receives a CT examination in the emergency room setting (6,9). This kind of radiological examination is sensitive to bone fractures and parenchymal changes, possibly providing a great deal of information to the forensic pathologist (8).

In the above case, to analyze the location and morphology of the skull fractures, different types of 2D and 3D virtual reconstructions were obtained using the preoperative CT scan.

The 3D-CT reconstruction performed with the SSD technique precisely depicted the depressed skull fracture involving the left sphenoid and temporal bones with penetration of bone fragments into the left temporal lobe (Fig. 1*C–D*), whereas the 2D sagittal and coronal reformations (MPR technique) permitted the measuring of its size and depth (Fig. 1*E–F*).

A depressed skull fracture is an important and well-known sign of blunt-force trauma brought on by an object with a narrow surface of impact (10–13). In our case, its radiological visualization and measurement enormously restricted the range of possible leading objects (i.e., blunt object with a surface of about 25–50 cm^2) and forced us to perform a second work-area investigation 2 weeks after the accident. On that occasion, we observed that the sliding bar moved horizontally very slowly and that in the rear zone (exactly where the victim was found), it was subject to sudden acceleration in the direction from the discharge roller to the charge roller. On the machine frame, furthermore, a metallic protuberance with a cubic shape and an area of 25 cm^2 located at a height of 66 cm above the ground surface was identified. Closer inspection of the original scene photographs revealed that the metallic protuberance was covered in blood (Fig. 2*B–D*, red box).

Finally, the 3D-reconstruction of the work area, combined with a fit-matching analysis between the components of the machinery and the depressed skull fracture allowed us to reconstruct the exact position of the victim and the cause of the cranial trauma. It was concluded that the worker was able to enter the cutting area with the cutting device in function because the door alarm was tampered with. The deceased most probably got on his knees and put his head in the way of the cutting device, possibly to repair the machinery (Fig. 2*C*). Because of the sudden acceleration of the

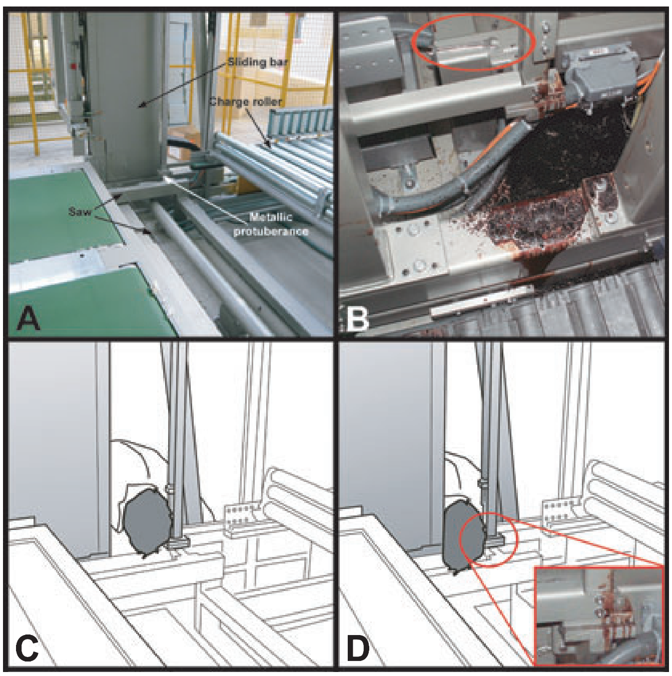

FIG. 2—*(A) Cutting machine of foam products, formed of a charge roller and a cutting device consisting of a sliding bar and a saw. (B) Illustration of the first workplace investigation showing the pool of blood where the worker was found. The bloodstained spanner/wrench and bolt are circled in red. (C–D) Sketches depicting the position of the victim at the moment of the trauma. The right picture illustrates how the head was crushed by the metallic protuberance because of the sudden acceleration of the sliding bar. The bloodstained metallic protuberance is shown in the red box.*

sliding bar his head was evidently crushed between the cutting device and the metallic protuberance on the opposite side (Fig. 2*D*).

This case underlines the importance of a detailed workplace investigation and of a thorough evaluation of all circumstantial, clinical, radiological, and autopsy data in the cases of suspected machinery-related fatalities (14).

Particularly, if external or internal wounds are surgically explored and treated, preoperative CT images, also by means of different types of radiological virtual reconstructions, may yield precious information about the cause of death and the reconstruction of the dynamics involved in the event. This would facilitate proper identification of any legal responsibilities of the worker or employer.

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