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Forensic Pathology

Parachuting fatality: A case report video-recorded

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ABSTRACT

Parachuting accidents are very uncommon and mostly related to landing and incorrect procedures. In these cases, the cause of death is usually easily identified but the events leading up to death are usually a matter for investigation. We describe the case of a former military parachutist who died after civilian skydiving. A total body computed tomography scan, an external examination, and a complete medico-legal autopsy were performed. Furthermore, the fatality was filmed from two different observation points so the specific dynamic of the events and the injuries observed could be explained. This unusual case highlights the importance of a multidisciplinary forensic investigation.

1. Introduction

Death from parachuting is very uncommon: the estimated prevalence is 0.5–0.8 deaths per 100,000 jumps [1,2] and this would suggest that parachuting is safer than other sports. A French epidemiological study showed that mountain sports are more dangerous than skydiving, with 99 fatalities compared to 2 out of 246 deaths [3]. To better understand the mechanisms leading to parachuting injuries/fatalities it is important to understand the phases of parachute jumps [4]:

- The exit
- The free fall
- The opening of the parachute
- The canopy descent
- The landing

When the parachutist jumps out of the aircraft, he or she assumes an arched body position that is essential to reduce the probability of malfunctions. The correct position distributes the landing impact throughout the body, in order to reduce the chances of injury to the lower extremities [4]. Then, the parachutist must grip the chute handle and throw it away from the body [5]. In the correct position, the average speed of descent with the parachute is 20 km/h. Subsequently, the parachutist makes contact with the ground and rolls onto the calves, thighs, buttocks, and back. Finally, he has to rapidly recover from this position to avoid being dragged by the parachute [4]. If the main parachute fails to deploy, the skydiver must quickly disconnect it and deploy the reserve parachute and these actions have to be carried out in the correct order to avoid entanglement [6]. Fatalities related to parachuting have been classified into ten categories, according to a classical taxonomy based on the specific principal cause of the fatality [6]: incorrect procedures, landing, midair collision, no pull/low pull, correct procedures, gear failure, flight, collapse, medical, incorrect gear (see Table 1). The prevalence of these categories varies across different studies [4,6–8]: the majority of fatalities occurring due to landing and incorrect procedures, especially incorrect body positions at the moment of chute deployment [5]. Moreover, civilian and military parachuting differ one from the other in terms of the training received, environmental conditions (wind speed, temperature and time of day), equipment, aircraft exit method, demography, jumping and parachute characteristics [7]. Furthermore, military parachutists jump from lower altitudes, in larger groups and from faster aircraft [4]. We report a unique case of a former military parachutist who died after civilian skydiving. This fatality was recorded entirely by two videos, so it has been possible to accurately define the dynamic of the events by comparing videos with autopsy findings.

2. Case report

A 43-year-old man, a former military parachutist, performed civilian skydiving at a local exhibition in Southern Italy. He had considerable experience in military parachuting and good experience of civilian

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Table 1
Categories of fatalities.

Fatality category	Category definition
No pull/low pull	Fatalities caused by the failure to pull parachute deployment handles or by deployment that was initiated at an altitude too low for successful inflation of the parachute
Landing	Fatalities caused by a conscious skydiver colliding with the ground or an object on the ground while under a fully deployed, undamaged parachute
Gear Failure	Fatalities resulting from a mechanical or structural failure of the gear
Incorrect Gear	Fatalities caused by the incorrect donning or configuring of the gear
Midair Collision	Fatalities caused by a midair collision during free-fall or under parachutes
Medical	Fatalities directly caused by some medical condition such as a heart attack. Also included in this category are clear-cut cases of suicide, e.g., suicide note
Incorrect Procedures	Fatalities caused by pulling parachute deployment or disconnect handles in an incorrect sequence during normal deployment or following a main parachute malfunction
Correct procedures	Fatalities which occur as the result of failed parachute deployments, despite correct procedures
Collapse	Fatalities resulting from a parachute collapse at an altitude too low for corrective action
Flight	Fatalities resulting from parachute control inputs that result in canopy failure or loss of control at an altitude too low for corrective action

skydiving. During exit, a problem occurred with the opening of the parachute and the man fell from around 1000 m. A medicolegal examination was requested by the public prosecutor. A preliminary total body computed tomography scan was performed and revealed several fractures of the cranial vault, of the splanchnocranium, of the right mandibular ramus, of the T5 vertebra, of several ribs, of long bones of the arms, and of the left pelvis bones with dislocation of the femoral head (Fig. 1). Furthermore, the CT scan (Fig. 2a) revealed pneumocephalus, pneumomediastinum, pneumothorax, and pleural effusion (hemothorax) (Fig. 2b). The external examination of the right side of the face revealed lacerated and contused linear-shaped wounds and the left ankle was interested by a transversal linear-shaped abrasion (Fig. 3). The autopsy confirmed the injuries already seen on the CT scan: fracture of the cranial vault and spread fractures of the cranial base were found. In particular, comminuted fractures of the anterior and the middle cranial fossa were observed (Fig. 4). Furthermore, a wide subarachnoid hemorrhage was detected. This large complex of injuries determined the death. Moreover, other CT scan evidence of skeletal fractures was confirmed and associated with soft tissue hemorrhages and with severe blunt injuries to the internal organs. The back cut and arms dissection revealed injuries and hemorrhages. Toxicological analysis performed on the blood was negative for alcohol and drugs consumption. Videos showed the deceased from two different points of view: from a "Go-Pro" digital camera on the helmet of another jumper present on the aircraft and from the mobile phone of a man on the ground. From the first camera it was possible to comprehend the dynamics of the events: during the exit, the parachutist assumed the arched body position and opened the parachute. Nevertheless, one of the parachute cords caught in his left ankle determining the abrasion detected during external examination. Hence, the parachute did not open correctly, and the parachutist opened the emergency parachute which got stuck in the first one and the parachutist fell to the ground (Fig. 5). The second camera showed the sequence of the events of impact: the head hit the ground first, then the parachutist bounced on the ground with the anterior and, subsequently, with the posterior body wall (Fig. 6). So, it was possible to match the autopsy findings with the different sequences of the impact. First, it is known that a human being in freefall with a closed parachute has a vertical velocity range between 200 and 500 km/h [1], so the most severe injuries were found in body parts which hit the ground first and then in the body parts subjected to violent decelerations. Therefore, the linear-shaped injuries of the right side of the head and the wide fractures of the cranial base were determined by the first impact with the ground, the rib fractures and liver lacerations were caused by the anterior body wall impact.

3. Discussion and conclusions

Parachuting is a relatively safe sport with reported injury rates of between 10/10,000 and 120/10,000 in civilian skydivers with a very low fatality rate [4,9–13]. Improvements in skydiving safety over the years have reduced injury rate [14] so that now most malfunctions are related to poor body position during deployment [5]. So, most skydiving fatalities are the result of human error [6,8,15]. Though inexperience could be expected to be a favoring factor in skydiving accident occurrence, even very experienced jumpers can be victims of parachute fatalities [16]. Pathological features of parachute fatalities include

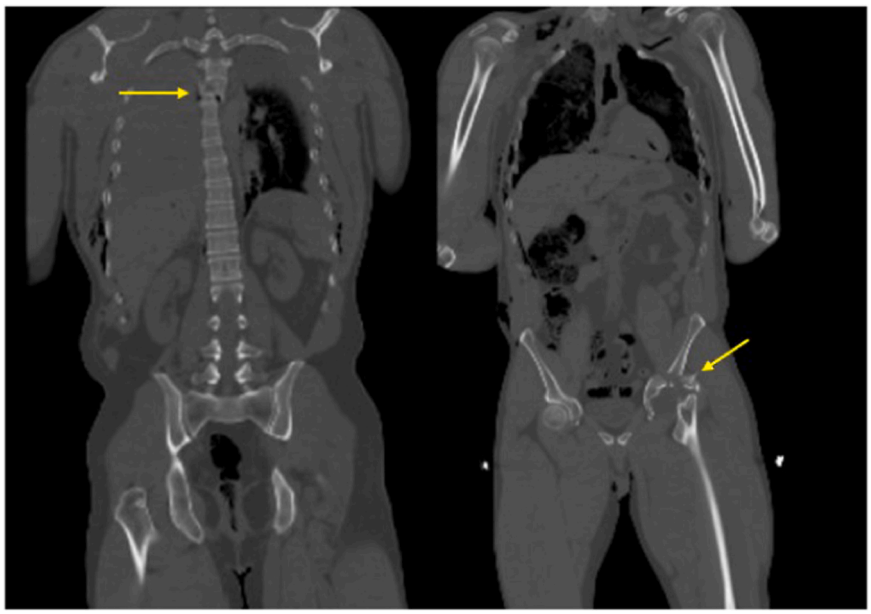

Fig. 1. a: Trunk and extremities CT. Arrows point T5 fracture (CT scan on the left) and left pelvis bones with dislocation of the femoral head (CT scan on the right).

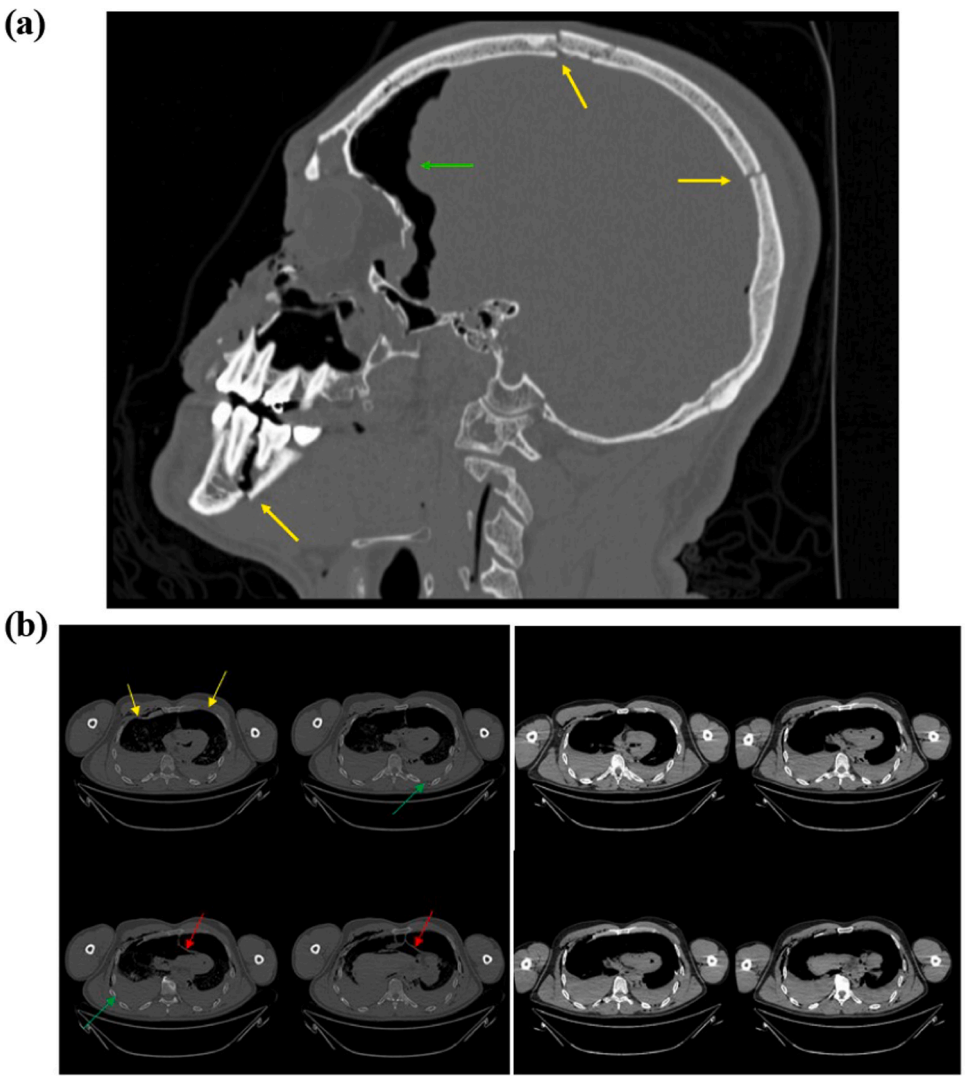

Fig. 2. a: Head CT scan. Yellow arrows point head fractures. Green arrow points pneumocephalus. b: thoracic CT scan revealed pneumomediastinum (red arrows), pneumothorax (yellow arrows), and pleural effusion (green arrows). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

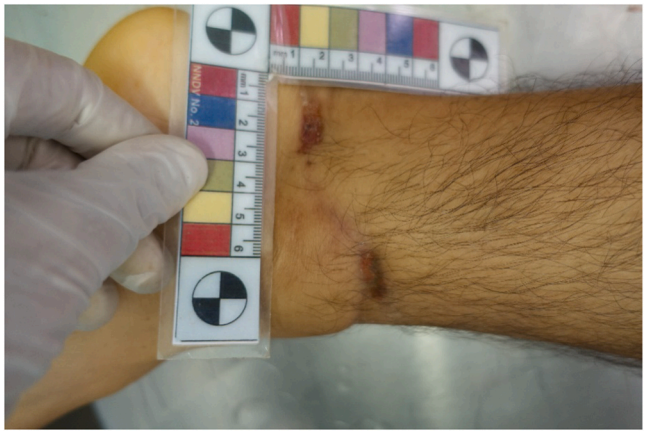

Fig. 3. Ankle abrasion one of the parachute cords caught in his left ankle determining the abrasion detected during external examination.

lacerations of lungs, rupture of heart, lacerations of brain, rupture of aorta, and fractures of spine. Death is instantaneous in these cases. Furthermore, toxicology tests are generally negative because skydivers realize that drugs and alcohol are very dangerous in sport [16]. Thus, in the analysis of fatalities related to skydiving all of the available relevant information is essential for the medical examiner to understand what has happened. Moreover, any available video may also be crucial for the analysis of the events in addition to performing postmortem computed tomography before autopsy [5]. In a case of skydiving fatality, multiple soft tissue lesions and bony injuries are detected as the result of severe blunt force and deceleration. The forensic pathologist has to determine the position of the skydiver when he or she hits the ground and to do so postmortem imaging (especially total body CT scan), a careful external examination of the deceased's body, and a complete autopsy (including arms dissection and back cut) are necessary. Furthermore, the availability of any videos of the events can facilitate the medicolegal analysis. Therefore, the investigation of such an unusual death should involve a multidisciplinary approach in order to correctly evaluate the primary cause of death and to define the dynamic of the events.

Fig. 4. Autopsy findings: fractures of the cranial base, especially of the anterior and middle cranial fossa.

Fig. 5. Frame from the first video.

CRediT authorship contribution statement

Federica Mele: Data curation, Writing – original draft; **Gabriele Mandarelli**: Writing – review & editing; **Giampiero Bottari**: Data curation; **Biagio Solarino**: Conceptualization, Supervision.

Fig. 6. Frame from the second video.

Declaration of interest statement

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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