

THE CONTRIBUTION AND LIMITS OF THE MEDICO-LEGAL AUTOPSY IN ESTABLISHING THE CAUSES OF FATAL EVENTS IN PARACHUTING

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Abstract: Introduction. Skydiving is a relatively safe sport, with fatalities occurring in approximately one per 100,000 jumps. Investigating parachuting-related deaths involves assessing human factors, equipment failure, and environmental conditions. Forensic doctors play a key role in determining the contribution of human error to fatal events.

Material and method. This study examines six parachuting fatalities from Ilfov and Buzău counties, analyzing historical data, autopsy findings, and laboratory results. The forensic results are correlated with investigations conducted by the Romanian Aviation Safety Authority (AIAS) and judicial authorities.

Results. A 29-year-old man died during a military parachute exercise from a helicopter at 1200 m;

- Three skydivers were involved in an accident at Clinceni Aerodrome: a 49-year-old man died instantly, a 27-year-old woman died during surgery, and the instructor survived;

- A 34-year-old student parachutist died after an uncontrolled spiral descent from 4000 m;

- A 40-year-old military man died after a parachuting training jump from 2000 m due to equipment failure;

- A 37-year-old captain died at Boboc Aerodrome when both main and reserve parachutes failed to function properly.

Human error was responsible in four cases, while equipment failure was the cause in two. No physiological or pathological conditions contributed to the deaths.

Conclusions. The primary challenge in forensic investigations of parachuting fatalities is not determining the cause of death but objectively analyzing the human factor. Medico-legal autopsies, in conjunction with aviation safety investigations, are crucial for establishing responsibility and preventing future incidents. While autopsy cannot detect “human error,” it helps exclude or confirm organic factors. The findings aid judicial decisions and support preventive measures to enhance skydiving safety.

Keywords: parachuting, death, causes of the event, forensic autopsy.

INTRODUCTION

Deaths due to skydiving are rare (1 death per 100,000 jumps) [1], and skydiving is considered a sport with a high degree of security [2].

Establishing the causes of the occurrence of fatal events in parachuting is the attribution of judicial authorities that must evaluate the three possible factors involved: the human factor (piloting errors, possible organic causes), equipment, and environmental conditions.

The role of the forensic pathologist in the investigation of deaths following a parachute jump is

essential in assessing the weight of the human factor (identification of possible organic causes, but not pilot error) in the production of a fatal event [3, 4].

CASE PRESENTATIONS

1. BDV, male, 29 years old, in a parachute launch exercise from a helicopter, from approximately 1200 m, carried out by the Special Intervention Brigade of the Gendarmerie at the Clinceni Airport, Ilfov County, falls on an agricultural land with tall grassy vegetation on 02.07.2007, south of the natural landing-takeoff runway of the aerodrome. Both the main and safety parachutes

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had manual controls that were not activated.

The following traumatic injuries were found at the autopsy: deformation of the cephalic extremity, ecchymoses, excoriations, wounds, multischillous fracture of the mandible, multiple fractures of the facial bones, left humerus fracture, left olecranon open fracture, left forearm fracture of both bones, left femur open fracture, comminuted fracture of the left patella and proximal epiphysis of the left tibia, open fractures of both bones of the left leg, right patella, and both bones of the right leg, and wound of the scrotum with evisceration of the left testicle, bleeding from the ear and nose, liquefaction of subcutaneous thoracoabdominal cellular tissue, epicranial blood infiltrates, multiple vault and skull base fractures, dural rupture, meningocerebral laceration, cerebral edema, chest wall blood infiltrates, thoracic spine fractures with medullary transection, multiple rib fractures, bilateral hemothorax, pulmonary atelectasis, pulmonary contusions and ruptures, right hilar rupture, hemopericardium, left ventricular laceration, complete aortic arch rupture, abdominal wall blood infiltrates, mesenteric disinsertion, hemoperitoneum, liver cracks and lacerations, splenic laceration, left perirenal blood infiltrates, left renal rupture, pubic symphysis fracture, left coxofemoral fracture, and sacrolumbar fracture with medullary transection.

Histopathological (no notable pathological aspects), serological (group A), thanatochemical (normal vitreous humor glucose values), and toxicological examinations (negative results for current toxic substances, including narcotics and their metabolic products, and blood alcohol level of 0 g ‰) were performed.

It was concluded that the death was violent and was due to massive bodily destruction caused by multiple injuries following polytrauma. These injuries could have been caused by hitting a solid surface following a fall from a great height.

In this case, we had no further information regarding the causes of the event. Human error was possible (the opening commands of the main and reserve parachutes were not activated).

2. OP, a 40-year-old man, died on 09.06.2010. He was a soldier in a training activity parachuting from the KC-130 type aircraft on the Boboc Aerodrome, Buzau County.

Autopsy revealed bruises, excoriations, wounds, crushing of the head, comminuted fractures of the vault and of the base of the skull, massive facial destruction with missing of the soft parts and

bone substance, traumatic amputation of the upper 1/3 of the left arm, telescoping of the cervical spine into the skull, comminuted fractures (thoracic and lumbar spine, sternum, ribs) with missing of the bone substance, bilateral sacro-iliac disarticulation, wide pubic disjunction, lacerations, and missing of parts of thoracoabdominal and pelvic organs.

Toxicological examination (HPLC and GC-MS) performed on the blood, stomach, and kidneys were negative (blood alcohol level-0 g ‰).

In this case, no histopathological, thanatochemical, or serological examinations were performed.

The medico-legal autopsy report concluded that the death was violent and was due to the suspension of vital functions, the consequence of crushing of the head as part of a polytrauma.

These injuries could have been caused by falling from a great height.

Judicial investigation has shown that the parachutist left the aircraft from a height of 2000 m, descending to a stable position of approximately 300 m, after which he fell rapidly until the impact with the ground in an area cultivated with wheat.

The soldier tried to operate the command of the main parachute, but failed, lost his balance, entered into an evolutionary movement that progressively intensified, and was unable to stabilize and operate the command of the safety parachute until the impact with the ground.

The PPK-U-type parachute was assisted by an automatic parachute opening device (AADP), which was mounted on the main parachute and had the role of opening the parachute when the parachutist was unable to do so, for various reasons.

The automatic parachute opening device did not work because of a mobile foreign body inside (a piece of a locking nail flexible paper clip, which did not come from the device in question but coming from a previous jump) which blocked the kinematic mechanism (according to the technical-scientific findings made by the aviation specialists).

The direct cause of the event was the technical failure of the equipment, and the underlying cause was a human error (failure to operate the main and reserve parachute controls) or inadequate procedure for the post-flight check of the equipment (failure to detect a broken locking pin on a previous flight).

3. FDA – a 49-year-old man

4. NAV- a 27- year-old woman

On 18.10.2015, TNT Brothers Sports

Association organized at Clinceni Airport a launch of skydivers who were performing recreational jumps. Three parachutists were involved in an event with a tragical end.

The first individual jump was of a 49-year-old man, followed by a tandem jump (a 43-year-old instructor and 27-year-old woman).

The two parachutes hang in the air at an altitude of approximately 60-70 meters.

The man who jumped alone died on the spot (the doctor of the Emergency Service helicopter confirmed the death). The woman was transported to the hospital and died during surgery. The instructor, who was also transported to the hospital, survived.

3. FDA – 49-year-old male

The autopsy revealed reddish-purple ecchymotic streaks located: on the supraumbilical mesogastric area, transverse, 24/4 cm; on the right flank, with a pale center, 10/4 cm, with a long longitudinal axis; on the left flank, longitudinal, 10/ 3 cm.; on the right thigh, anterior, upper 1/3 part, 14/4 cm, oblique infero-median; on the left thigh, antero-internal, 1/3 lower part, 10/3 cm; left femur diaphysis fracture, upper 1/3 part (oblique); tibia bilateral fractures, lower 1/3 part; blood infiltrates on the left temporo-occipital lobes, of 5/3 cm, and on the right temporo-occipital lobes, of 6/4/0.2 cm.; vault and skull base fractures, meningeal hemorrhage, subdural hemorrhage, liquid blood at the base of the skull, in the posterior part, bilateral; blood collection, consisting of blackish, glossy, peritruncular coagulated blood at the level of the midbrain; ventricular hemorrhage; right frontal cerebral contusion parasagittal and in the basal nuclei on the left side; right parasternal blood infiltrate, sternal fracture with blood infiltrate; no rib fractures; tracheo-bronchial blood aspirate (“sprinkled” appearance with diffuse reddish areas contrasting with the rest of the whitish parenchyma); no hemoperitoneum or damages of the abdominal viscera; pubic symphysis disjunction fracture.

Histopathological, thanatochemical, and toxicological examinations (HPLC and GSMS on the blood, urine, and stomach) were negative.

It was concluded that the death was violent and was due to meningocerebral hemorrhage following craniocerebral trauma with vault and cranial base fractures produced as part of a polytrauma. Traumatic injuries may have occurred through body impact by a solid plane (fall from a great height) in the conditions of an aeronautical-skydiving event.

4. NAV, a 27-year-old woman

The woman was transported to Bucharest University Emergency Hospital in serious condition but in a state of consciousness, cooperative, agitated, with BP= 106/66 mmHg, HF = 140/min, Sat O₂ = 85% with O₂ on mask 6l/min, then BP decreased at 100/60 mmHg and HF increased at 201/min.

During the emergency CT investigation, the patient experienced cardiorespiratory arrest and was urgently transported to the surgery room. An exploratory supra-and subumbilical laparotomy was performed. In the abdominal cavity, there was a large amount of blood that was aspirated. The woman also had a spleen rupture and a large hematoma that occupied almost the entire retroperitoneal space. A splenectomy in the hilum was performed. The exploratory dissection of the retroperitoneal space (with a cardiovascular surgeon) found a diffuse hemorrhage.

The patient went into cardiac arrest on the surgery table. External and transdiaphragmatic cardiac massage were performed, without any result.

Despite the intensive resuscitation care, the woman had ventricular fibrillation, for which defibrillation was performed, followed by unresponsive asystole and exit through irreversible cardiorespiratory arrest on the background of the traumatic and hemorrhagic shock.

The autopsy revealed signs of medical and surgical treatment, thoracic electrodes, venous punctures, pleurotomy tube, and xipho-suprapubic surgical incision 23 cm long, with sutures.

Traumatic injuries found at the autopsy: frontal ecchymosis and excoriations; “binocular” ecchymosis, base of the nose ecchymosis; ecchymosis and excoriations on the: right subclavicular and right deltoid areas (textile print), right breast, right parasternal area, right oral area, right submandibular area, right anterior thigh, left, dorsal face hand, right elbow; pelvis fracture; epicranial blood infiltrate; meningeal hemorrhage; cerebral edema; chest wall blood infiltrates corresponding to rib fractures; multiple right rib fractures; pleura ruptures, corresponding to the rib fractures; right hemothorax of 300ml; left lung collapsed; bilateral lung contusions and ruptures; posterior pericardial blood infiltrate; cardiac contusion; right diaphragmatic dome blood infiltrate; hemoperitoneum of 320 ml blood and 50 ml blood in the splenic area; massive retroperitoneal hematoma; right psoas blood infiltrate; peripancreatic blood infiltrate; right perirenal blood infiltrate; left and right renal hilum ruptures; renal anemia and surgically absent spleen (placed in formalin with splenic ruptures and lacerations).

HPLC examination of the blood identified metamazole, lidocaine, mepivacaine from the medication administered to the patient. Blood alcohol level was 0 g ‰.

Histopathological (without relevant pathological aspects) and serological (blood group) examinations were performed.

In the conclusions of the medico-legal autopsy report, it was shown that the death was violent and was due to hemorrhagic and traumatic shock following polytrauma. The injuries could have been caused by sudden deceleration as a result of hitting the ground, in the condition of a fall from a great height (parachute jumper).

The investigation and analysis authority for civil aviation safety, a member of the European Network of Civil Aviation Safety Investigation Authorities (Website: www.aias.gov.ro) made a report in this case which concluded: "The probable cause of the accident represents the error in the surveillance of the airspace by the solo parachutist during the execution of the turn to enter the landing direction" [5].

5. GVF, a 34-year-old man, died on 22.08.2020 during his first alone parachute jump, at the Clinceni airfield. The man fell into a field around Cornetu, Ilfov County. The ambulance found the patient dead and resuscitation was performed without any result.

The medico-legal autopsy found: ecchymoses, excoriations, wounds, blood infiltrates, intact skull bones, meningeal hemorrhage on the right, lateral fronto-parietal lobe and on the left, upper, paramedian, parietal lobe, double sternal transverse fracture, right costal fractures-all ribs on the anterior axillary line, turning posteriorly, to the posterior axillary line; hemothorax - 750 ml of blood on the right side and 900 ml of blood on the left side, complete rupture of the thoracic aorta, retroaortic hematoma, right lung wounds, bilateral lung contusions, no pathological content in the peritoneal cavity, two purple, contusive areas on the posterior face of the liver of 2/4 cm and 3/3 cm, the rest of the abdominal viscera being intact.

Histopathological, thanatochemical, and toxicological examinations results were negative.

The medico-legal autopsy report concluded that the death was violent and was due to internal hemorrhage (bilateral hemothorax) following damage of the internal organs (thoracic aorta, lungs) through chest trauma with multiple right rib fractures and a double sternum fracture, which occurred within a polytrauma. Injuries may have occurred by hitting solid surfaces during a fall from a great height (parachute fall).

The investigation showed that, after opening the parachute, the parachutist performed normally up to approximately 400 m, after which he continued to descend in a controlled spiral. The spiral descent continued until contact with the ground, on an agricultural land around Cornetu, at a long distance from the place intended for landing [6].

6. SCC, a 37-year-old male, fell from approximately 3000 m on 25.05.2022 in a parachute jump exercise at the Boboc airfield, Buzau County. He was transported to the ambulance, where he was pronounced dead.

The autopsy showed: bruises, excoriations, wounds, blood infiltrates, multiple comminuted fractures, with displacement, lower limbs, atlanto-occipital disarticulation; cervical vertebral fracture; right transverse apophyseal cervical fractures, bilateral sternoclavicular dislocation, sternum fracture with displacement and bilateral rib fractures, bilateral sacroiliac comminuted, with displacement fracture, wide pubic disjunction, bilateral scapulohumeral dislocation, open fracture of both left forearm bones, right occipital blood infiltrate, intact skull bones, diffuse cerebral and cerebellar meningeal hemorrhage, intraventricular hemorrhage, tracheo-bronchial blood aspirated, bilateral hemothorax, bilateral pleuro-pulmonary ruptures and contusions, complete pulmonary artery rupture and almost complete aortic artery rupture of the intrapericardial segment, cardio-pericardial ruptures, diaphragmatic ruptures, moderate hemoperitoneum, mesenteric ruptures and blood infiltrates, liver ruptures, bilateral retroperitoneal hematoma, renal ruptures.

The toxicological examination revealed: blood alcohol level: 0.04 g ‰ and urine alcohol level: 0.03 g ‰

The histopathological examination did not reveal any notable pathological features.

The medico-legal autopsy report concluded that the death was violent and was due to mixed, massive, internal, and external hemorrhage, the consequence of ruptures of the thoraco-abdominal viscera as part of polytrauma. The injuries found could have been caused by falling from a great height, most likely by the "standing" impact with the ground, possible under the conditions shown by the investigation, and have a direct, unconditional causal link with death.

Although the captain operated the control of the main parachute, this did not open properly and he also operated the control of the reserve parachute, but it could not brake the descent, resulting in the violent impact of the ground on the sunflower crop.

In conclusion, in four cases, human error was blamed, and in two cases, the equipment malfunctioned. Following autopsies, physiological or pathological conditions that could have led to the occurrence of these events were excluded.

The main difficulty in medico-legal practice in the events resulting in the death of parachutists is not to establish the causes of death and the types of traumatic injuries and their mechanisms, but to provide objective and scientifically substantiated information on the human factor, which can be useful to the judicial authorities in establishing the causes of the event.

Medico-legal autopsies and investigations carried out by aviation specialists are essential in making the final decision, and they must be correlated.

The medicolegal autopsies in such cases must be done exhaustively and can provide a multitude of medical information that essentially helps to appreciate the role of the human factor in the production of deaths in parachuting.

However, the limitations of this method should not be ignored.

Autopsy cannot detect the “human error,” but can incriminate or exclude organic/physiological causes that may or may not have played a role in the occurrence of the event.

The final goal of the entire investigation of the aviation fatal events in parachuting is the legal framing of the facts; however, the investigation of these cases also plays an important role in avoiding similar subsequent events by taking preventive measures.

Conflict of interest

The authors declare that they have no conflict of interest.

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