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Case report

Fall from a car driving at high speed: A case report

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ABSTRACT

In cases of falls, the key issue for forensic scientists is to determine the manner of death. They must distinguish between accidental falls, suicidal falls, falls including blows and falls caused by a blow. Several strategies have been proposed in the literature to help explain injury patterns. Here, we report an original case of a man who died after jumping from a car moving at high speed. A mathematical and modeling approach was developed to reconstruct the trajectory of the body in order to understand the injury pattern and apparent discrepancy between the high speed of the car from which the victim jumped and the topography of the bone fractures, which were limited to the skull. To define the initial values of the model's parameters, a technical vehicle evaluation and several test jumps at low speed were carried out. We studied in greater detail the trajectory of three characteristic points corresponding to the dummy's center of gravity, head and right foot. Calculations were made with and without the air friction effect to show its influence. Finally, we were successful in modeling the initial trajectory of the body and the variation of its head energy over time, which were consistent with the injuries observed.

1. Introduction

Despite major advances in investigative techniques and knowledge in the field of forensic medicine, forensic scientists still encounter major difficulties when it comes to explaining the mechanisms of certain traumatic lesions. Medical experts currently focus only on the compatibility of a given trauma with a supposed mechanism of injury, without understanding the factors that may have influenced it. In cases of falls, the primary issue is to determine the manner of death and, more precisely, the differential diagnosis for falls including blows and falls caused by a blow. Several strategies have been proposed in the literature to try to distinguish between the different causes of injury. Some are based on analysis of the injury pattern and the scene investigation [1–10], while others use experimental approaches, with live-test subjects [11,12]. Mathematical models have been produced to estimate the height of a fall on the basis of the injuries sustained [13]. Recently, biomechanical analyses have been developed that use either multibody or digital human body models to gain further information on the mechanisms involved in injury patterns and the circumstances of death [14,15].

We report an original case of a man who died after falling from a car being driven at high speed. Our investigation involved developing a mathematical and biomechanical approach to reconstruct the trajectory of the body, so as to understand the injury pattern determined at autopsy.

2. Case report

A 39-year-old man was found dead, lying on a hard shoulder. According to several corroborating witness reports (from both inside and outside the car), the man, whose hands were cuffed behind his back, was seen to jump from a police van with sliding side doors driving along a highway at a speed of 110 km/h. Crime scene investigators found four traces of blood on the highway, upstream from the corpse (Fig. 1). These traces were aligned in an oblique straight line forming a 7° angle in relation to the traffic axis. The distance between the farthest trace and the corpse measured 28.9 m.

2.1. Multi-detector computed tomography

Prior to the autopsy, a full-body multi-detector computed tomography (AS 128 Siemens, Erlangen, Germany) scan was performed, showing an extensive fracture to the right and base of the skull (Fig. 2), a subarachnoid hemorrhage, a cerebral edema and a ventricular hemorrhage. It also showed a peripheral and

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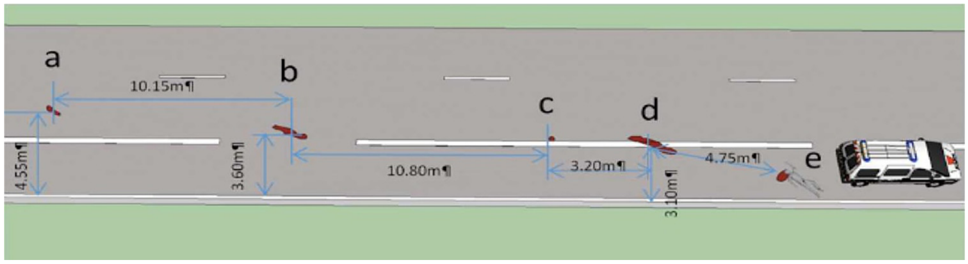

Fig. 1. Crime scene floor plan (a, b, c, d = traces of blood; e = corpse of the victim).

non-segmental opacity on the right upper lobe of the lung and the absence of other lesions, especially in the skeleton.

2.2. Autopsy

On external examination, the body was that of a young Caucasian man, 175 cm in height and 70 kg in weight (=Mass m). Abrasions were found on the face, upper limbs, knees and posterior trunk. Bruising was observed on the right elbow and on the scalp in the right temporoparietal region (Figs. 3–5).

Internal examination revealed serious cranio-encephalic trauma, including occipital cephalhematoma, a comminuted fracture of the right parieto-occipital skull extending into the middle cranial fossa, a sub-arachnoid hemorrhage, severe frontal, parietal and brain stem hemorrhagic contusions, a cerebral edema with cerebellar involvement, and a ventricular hemorrhage. Skull thickness ranged from 0.3 to 1 cm and scalp thickness was 0.6 cm. The autopsy findings also showed moderate bronchial inhalation of blood and a pulmonary contusion in the left upper lobe.

Histological examination of the brain showed diffuse intraparenchymal hemorrhagic lesions.

Toxicological analyses revealed the presence of bromazepam and nordazepam at blood levels compatible with therapeutic use. Blood alcohol was negative.

On the basis of these findings, the death was attributed to a severe cranio-encephalic trauma in relation to at least two impacts on the right parieto-occipital region of the skull and another on the face.

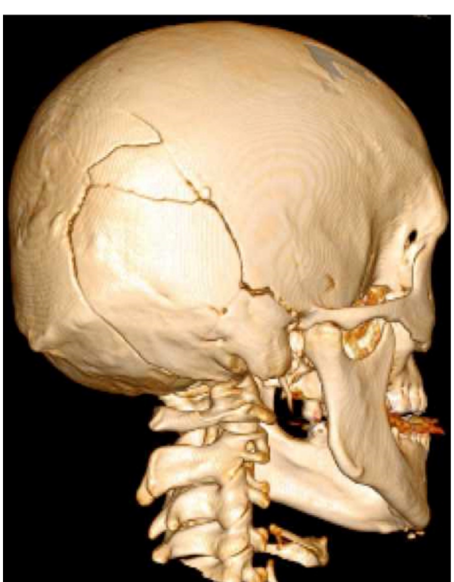

Fig. 2. Posterior and right lateral view from the skull MDCT-3D reconstruction: fracture lines on the skull produced by at least two impacts against the ground.

3. Body trajectory modeling

The trajectory of the body was modeled using a multibody system to understand the apparent discrepancy between the high speed of the car from which the victim jumped, and the topography

Fig. 3. Skin abrasions on the victim's face.

Fig. 4. Skin abrasions on the victim's posterior trunk.