G83 Two Gunshots to the Head: Suicide or Homicide? A Biomechanical Study

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This presentation will use of a finite element head model to demonstrate the lack of incapacitation following a shot with a .22 bullet, demonstrate the importance of crime scene elements, and discuss the consequence of three shots : one to the chest and two to the head.

A 20-year-old man was found dead in his bedroom by his younger brother, in the family house. Investigators found the body lying on the ground, near the bed, with a handgun and a box of bullets at his beside. Examination of the body showed three gunshot wounds: one to the chest and two to the head (between the eyes and above the right ear respectively). Entrance wounds were all contact wounds. The handgun was a single-shot revolver and the box of bullets contained “super x”, .22 caliber bullets. Both the box of bullets and the handgun belonged to the victim who used to practice shooting in a club. Investigators found blood spots on the victim’s bed aiming towards the cupboard where the deceased used to store his gun. Prior to autopsy, X-Ray examination of the body showed that Bullet A was stuck in the dorsum sellae, Bullet B in the left temporal bone, and Bullet C in the spine.

Bullet A penetrated the skull through the ethmoid, crossed the sphenoid sinus and ended in the Dorsum Sellae, close to the external part of the dura mater. This shot was associated with hemorrhage surrounding the two optic nerves. Bullet B penetrated the right temporal bone, crossed the brain and ended in the left temporal bone. Bullet C penetrated the sternum, touched the right side of the heart, crossed the aorta and the 11th dorsal vertebrae and ended in the medulla. Bullet A caused a blindness of the victim. Bullet B led to an immediate incapacitation of the victim. Bullet C caused an internal hemorrhage and a paraplegia. The possibility of a suicide was discussed. Bullet B leading to immediate incapacitation was certainly the last fired. Bullet C was possibly fired just before. But did bullet A led to an incapacitation of the victim or could he still rearm his weapon and shoot twice? The bullet did not penetrate the neurocranium, therefore there was no crush or stretch mechanism involved that could lead to incapacitation. But was a commotio cerebri generated? Commotio cerebri is a matter of sudden acceleration of the skull, which by means of inertia of the brain, results in wounding at coup and contrecoup. The .22 bullet has a mass of 2.5g, measures 5mm diameter and has a muzzle velocity of approximately 230 m/s. This results in an ultra short time span during which the projectile is acting upon the skull. Because of inertia, the skull will not essentially move during transfer of impulse. A high transfer of momentum and energy will result in perforation of the skull without acceleration of the head. To confirm this theoretical approach, a biomechanical study using a finite element model of the head and brain was done. The authors used the ULP model a validated finite element model developed in Strasbourg. The geometry of the inner and outer surfaces of the skull was digitized in the Strasbourg laboratory from a human adult male skull. The data given in an anatomical atlas by Ferner, et al. 1985 was used to mesh the human head using the Hypermesh code. The ULP model includes the main anatomical features: skull, falx, tentorium, subarachnoid space, scalp, cerebrum, cerebellum, and brain stem. Falx and tentorium have a layer of shell elements, skull is simulated by three-layered composite shell and the others were constituted by brick elements. This skull modeling permits simulation of the bone fracture introducing material discontinuity and then to analyze its effects on the head response in case of head impacts involving skull fracture.

The finite element mesh is continuous and represents an adult human head. The subarachnoid space was modeled between the brain and the skull to simulate the cerebral-spinal fluid. This space is constituted by a layer of brick elements and surrounds entirely the brain. The tentorium separates the cerebrum and cerebellum and the falx separates two hemispheres. A layer of brick element simulating the cerebral-spinal fluid surrounds theses membranes. The scalp was modeled by a layer of brick elements and surrounds the skull and facial bone. Globally, the present human head model consists of 11939 nodes and 13208 elements divided in 10395 bricks and 2813 shells. Its total mass is 4.5 kg.

This study shows a very slight movement of the head (less than 1mm) and no shearing injuries to the brain, providing no argument for an incapacitation of the victim following the shot of bullet A. The shot between the eyes could therefore have been the first, followed by a shot to the chest and a final shot to the head, the latter penetrating the two cerebral hemispheres and rapidly leading to death. The localization of blood spotting could be the consequence of a movement of the victim towards the cupboard to seek for his box of bullets to rearm his weapon. The victim was right handed. Important gunshot residues were found on both hands of the victim but mainly on the right hand. Investigators found that the victim was depressed because of personal and professional conflicts. The authors demonstrate that even if, initially, a homicide could be suspected, the possibility of a suicide cannot be excluded and is likely to be the manner of death in this case.

Head Model, Suicide, Incapacitation

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