C2 Investigation Methodologies Based on Structural Analysis and Material Mechanical Behavior Correlated With Postmortem Verifications to Reconstruct Events and Acquire Evidence in Forensics

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The goal of this presentation is to discuss technical methodologies to support forensic activities of judges and lawyers. The topic of forensic engineering integrated with forensic medicine expertise will be presented as a unique means to reach the truth.

This presentation will impact the forensic community by demonstrating how the proposed integrated approach, besides the judge for a conscious and objective decision, represents a kind of crossroads among different scientific disciplines. They cooperate equally to the solution of the case, as demonstration that integration strengthens science, giving a practical meaning to theoretical principles. When the judge discusses a case, for which scientific and technical advice is required, he needs both an engineer and a coroner. This significantly increases the chance the truth will be brought to his attention.

As known, forensic engineering consists in applying engineering principles and methods to solution of technical problems in judicial area. A forensic engineer investigates on causes and responsibilities of a harmful event. In a homicide made using varied tools and equipment, as an example, he aids clarifying mechanisms of injuries or death. Also, contribution during disasters (earthquakes, floods, collapses of buildings, air crashes, rail disasters, etc.) has to be mentioned. However, engineering knowledge may not be sufficient to reconstruct events and to acquire evidence in after-the-fact investigations on accidents or failures to be discussed as cases in front of court. A multidisciplinary approach is required and its use is proposed on routine basis.

The purpose of the paper is to demonstrate the usefulness of integration between forensic engineering and forensic medicine. An autopsy can provide information that it is not easy to find in other ways. *Postmortem* tests and verifications can be treated using the engineering traditional means, such as material behavior, stress analysis, Finite Element Method (FEM), etc. Also, simulations made with dummies can be validated with the use of real elements of human bodies acquired through an autopsy.

The proposed integrated approach makes it possible to establish certainties and to speculate about probable hypotheses of event dynamics. A number of cases were reported. They include events like knifing, drowning, shooting, explosion, hanging, car dragging, and accidents at workplace while operating machinery or other equipment. An example is the case where a man head was engaged by a press for scraps. Exhumation of the body allowed highlighting lesions of head and cervical region, confirmed by radiological and histological observations. The correlations among cervical rachis mathematical model, simulations of press working operations, and tests with dummy as well as with foreign bodies (similar to human head) made it possible to establish event dynamics and value of damaging forces applied to cranium and mandible. Another example was the discovery of a dead body in the Po River. A forensic engineer defined the methodology to calculate the movement of the body both on the bed and the surface of the river.

Since each part of the human body can be assimilated to a machine, bibliography is rich of cases solved using mechanical models. Energy required for generating injuries with side-arms or other improper materials, like glass, can be evaluated. After establishing wideness and deepness of the continuum lesion, biomechanics can also explain the laws regulating the tissular regeneration and the three-dimensional organization of fibers and cells engaged in the *restitution ad integrum*. Expansion pressure of bullets, whether on body surface or inside cavities (cranial, thoracic, abdominal) can be calculated. Linear and angular velocity and acceleration given by an abrupt shaking or a violent impact against a rigid obstacle can be measured. In such accidents finite elements method is applied to the cephalic region (a bond case bounding a cavity containing encephalon, blood vessels, and nerves). Structures involved have dissimilar constitution, so they react differently to traumatic attacks. Crash speed and volume of blood drops, found on the crime scene, can be deducted. The related models help arguments about possible moving of a dead body. Mechanisms and characteristics of lesions in motor vehicles drivers can be studied in detail.

Autopsy, Investigation, Material

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