

Virtopsy: Touch-free autopsy

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Abstract

The word “autopsy” denotes “to see with own eyes.” Autopsy (postmortem) is a process that includes a thorough examination of a corpse noting everything related to anatomization, surface wounds, histological and culture studies. Virtopsy is a term extracted from two words “virtual” and “autopsy.” It employs imaging methods that are routinely used in clinical medicine such as computed tomography and magnetic resonance imaging in the field of autopsy, to find the reason for death. Virtopsy is a multi-disciplinary technology that combines forensic medicine and pathology, roentgenology, computer graphics, biomechanics, and physics. It is rapidly gaining importance in the field of forensics. This approach has been recently used by forensic odontologists, but yet to make its own mark in the field. This article mainly deals with “virtopsy” where in various articles were web searched, relevant data was selected, extracted, and summarized here.

Key words: Autopsy, forensic odontology, image processing, radiology, virtopsy

Introduction

Every human being lives to die another day and it is imminent, at few occasions forensic examination of deceased becomes a necessity. Recent scientific technologies have reached a point of advancement wherein different disciplines are interconnected to solve problems in medical field, especially in establishing reasons for death. The branch of forensics has made exemplary and path breaking contributions to solve these problems.

Forensic science is a specialty that is used in judicatory that involves principles and procedures for the systematic application of knowledge involving the collection of data through observation and experimentation, leading to recognition and formulation of a problem. It includes various

disciplines such as criminalistics, engineering, general, jurisprudence, odontology, pathology/biology, psychiatry and behavioral science, questioned documents, toxicology, and physical anthropology. This article reviews on “virtopsy” where in various articles were located through web search, relevant data were selected, extracted, and summarized here.

History

Erasistratus and Herophilus dissected dead bodies to study organs and nerves.^[1] In 1700, Giovanni Morgagni – the founder of today’s autopsy – composed a book on “The seats and causes of disease” and published it in 1761 in which 700 autopsies that he performed were described.^[2]

In 1800, William Osler was credited for teaching autopsy as part of the medical education.^[3]

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Regarding plain X-rays, first experiments by the German physicist Wilhelm Röntgen were done around November 1885 and were first discovered on November 8, 1895. Photography and conventional radiographic methods were two key techniques that were adopted by forensic personnel for accurate report writing.

A group in 1999 initiated first body scans for a high-profile case using project names such as “digital autopsy” or “scalpel-free autopsy.” With that, the virtopsy project was built-in. Virtopsy project was not the first trial to use computed tomography (CT) or magnetic resonance imaging (MRI) postmortem scanning worldwide, but it was the very first to integrate a broad range of technologies such as CT, MRI, invasive biopsies, and three-dimensional (3D) external scanning, while also examining a greater number of cases over an extended period of time and in a systematic manner. Scope of virtopsy include research with focus on gun shots, sharp and blunt force trauma, heat and strangulation, postmortem interval estimation, injury related to skull and brain, research with focus on heart, and 3D surface pattern matching.^[3-6]

Background

Virtopsy combines very powerful scanning and radiographic technology with the power and resolution of modern computers. It is a key tool that helps in establishing the manner and cause of death. Furthermore, it avoids the need to physically dissect the corpse allowing the examiners and investigators to discover important clues, more quickly and effectively. The saved scans can be replayed that would allow investigators to bring in more experts.

Equipment for Virtopsy

Virtopsy includes the following tools:

- 3D surface scan using 3D photogrammetry-based optical surface scanner
- Postmortem CT (PMCT) with adjuvants such as PMCT-guided biopsy (pm-biopsy and PMCT-guided angiography
- Postmortem MRI (pm-MRI).^[7]

Autopsy and Virtopsy

Autopsy means “to see with own eyes,” derived from Greek words “autos” meaning “self” and “opsomei” means “I will see.” An autopsy consists of several aspects that notes all the anatomization, external wounds, histological studies, and cultures.^[8] Thali *et al.* coined the term virtopsy. It is extracted from the terms “virtual” and “autopsy” where virtual is derived from the Latin word “virtus” which means “useful, good, and efficient” and adding “opsomei” with the replacement of autos, i.e., “self” thus leading to the scientific canopy “virtopsy.” Virtopsy is a multi-disciplinary

technology that combines forensic medicine and pathology, roentgenology, physics, biomechanics, and computer graphics.^[9]

Conventional autopsy involves invasive procedures that are the traditional means of postmortem examination in humans. Contrary to it, virtopsy is a minimally invasive emerging technology in the field of forensic medicine that incorporates imaging technology of radiologists and forensic clinicians to reflect an ethical face in forensic examination.

Procedure of Virtopsy

In virtopsy, there is fusion of the technologies of medical 3D imaging techniques as well as a 3D surface scan used in the automobile designing used to map the external surface of the body. It records and documents the 3D image of the body surface area in detail.^[10]

The first step in performing a virtopsy is to prepare the corpse for imaging. It can be accomplished by having a personnel place small disks along the exterior of the body, so that the surface scan and the interior scans could easily be aligned. These disks mark points that can be used for rendering the images into a single cohesive image. Virtibot (robotic machine) avoids interpersonal inaccuracies by placing the markers on the surface of the body. This makes the results of the virtopsy more standardized and accurate. The markers are used by the computer processors to calibrate the exterior scan of the corpse and match with internal imaging processes.^[10]

After the markers are placed by the virtibot, it creates a 3D color model of the corpse. The scan utilizes stereoscopic cameras to capture the color image, and a projector is used to cast a mesh pattern on the body. These cameras have a resolution of 0.02 mm. The robot moves over the body creating a 3D image and the process takes as little as 10 s.^[10]

After the surface scan, the body is brought to the CT and MRI workplace usually double-covered inside a blue bag through which X-rays can easily pass, in order to prevent contamination and then the body is laid on the sliding table of the CT, MRI, and MRS equipment. The bag will remain closed while the body is scanned both to respect privacy of the dead, maintain hygiene of the surroundings and to remain undisturbed by any nonforensic personnel in the room. The body then undergoes a CT scan, a procedure that finishes in 20 s and acquires up to 25,000 images; each image is a slice or cut through the body.^[10] Further, the corpse is also subjected to MRI and MRS scans. The information from the interior and surface scans are fed to powerful desktop computers where in data are combined, further rendered using computer-aided drafting-style programs and ultra-powerful graphics processors. In a short interval as 10 min, crisp, detailed images

of bone and tissue are reconstructed using powerful desktop computers, from the data representing thin X-ray slices of the body.^[10] Different tissues, foreign objects (such as bullets) and bodily substances absorb the scanner's X-rays in varying amount and the different absorption levels are rendered into a 3D visualization of different colors and opacities. The computer can assign the density differences of any color, but this is often standardized as blue for air pockets, beige for soft tissues, red for blood vessels, and white for bones. A pathologist has the freedom to peel through the layers of virtual skin and muscle with the click of a computer mouse.^[10]

Pathologists and radiologists can decipher and study the pattern. At the same time, images can be manipulated up and down and rotated at various angles, providing instant flexibility that is absent in conventional autopsy.^[10] After analysis of the 3D model, internal and surface scans, a needle biopsy can be done if internal body samples are needed. Virtibot [Figure 1], when used, alleviates the need to expose someone's hand under the CT scan to extract the biopsy. All the data scanned are then captured and saved on compact discs.^[10]

Uses of Virtopsy

Radiology was superior to autopsy in revealing certain cases of cranial, skeletal, or tissue trauma. Some forensic vital reactions in the body were diagnosed equally well or better (MSCT) and MRI. These preliminary results, based on the concept of "virtopsy," are promising enough to introduce and evaluate radiology in forensic science.^[11]

Timing of death

The timing of death can be determined by virtopsy using changes seen in both MSCT and MRI in head injury cases.^[12]

For identification of individuals

Smith *et al.* described a case report on positive identification of a deceased individual which was accomplished by

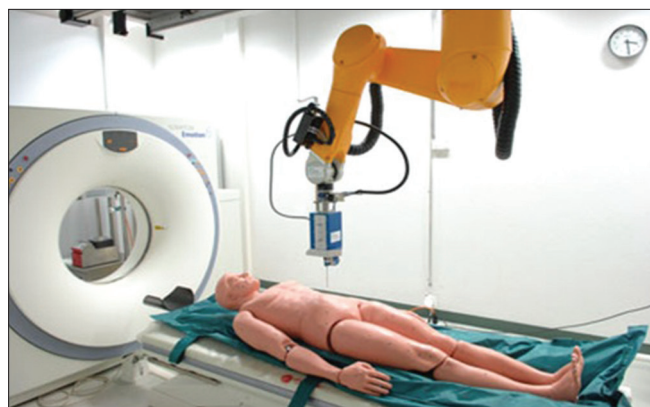


Figure 1: Virtibot system with biopsy mounted module. Courtesy: Lars C. Ebert, Wolfgang Ptacek, Martin Furst, Steffen Ross, Michael J. Thali, Gary Hatch. Minimally Invasive Postmortem Telebiopsy. *J Forensic Sci* 2012;57:2

performing a CT scan on an unidentified cranium and comparing multiple landmarks, images with corresponding features in an ante mortem CT scan of a missing man. The result showed that they were exactly the same on both CT scans, confirming the identity of the missing person.^[13]

Dental identification procedures often include the comparison between postmortem and ante mortem data, dental deoxyribonucleic acid techniques and development of dental postmortem victim details. Postmortem dental data are compulsory for dental identification, which is obtained principally by visual examination. But visual examination is very difficult in victims with charred bodies and damaged oral cavities. In these cases, virtopsy becomes a very quick, reliable way for getting postmortem records; 3D imaging in postmortem victims is effectively performed using the principle of triangulation.^[14]

For toxicological examination

Virtopsy can be used as a tool to determine the death of a person in cases of drug abuse.^[15]

Virtopsy in road traffic accident

Aghayev documented a case series of three cases of fatal blunt head injury using postmortem MSCT and MRI that showed extensive hard and soft tissue injuries of the head and signs of high intracranial pressure with herniation of the cerebellar tonsils. Similar findings were found in clinical autopsy, which was performed after the digital autopsy.^[16]

Virtopsy in cardiorespiratory failure from nontraumatic origin

Sohail *et al.* determined the utility of PMCT examination in establishing the cause of death among male prisoners dying in Karachi jails, and it was concluded that PMCT is as effective as dissection autopsy in identifying pulmonary infections and natural causes of death. Furthermore, it was more effective in identifying vertebral fractures, which may exclude corroborate trauma to spine and hanging.^[17]

Virtopsy in hanging or manual strangulation

Yen reported a case series of postmortem MSCT and MRI of nine persons who died from hanging or manual strangulation. The neck findings were compared with those discovered during forensic autopsy. In addition, two living patients underwent imaging and clinical examination following severe manual strangulation and near-hanging, respectively. The report concluded that MSCT and MRI revealed strangulation signs concordantly with forensic pathology findings.^[18]

Virtopsy in death due to burns

Thali *et al.* reported a completely charred body case of a single motor vehicle/fixed object collision with a postcrash fire. The radiological methods of MSCT and MRI made it possible to document the injuries caused by burn as well as

the forensic relevant vital reactions (air embolism and blood aspiration) and concluded that postmortem imaging is a good forensic visualization tool with a great potential for the forensic documentation and examination of completely charred bodies.^[19]

Gunshot wounds and virtopsy

A case series of eight gunshot victims were scanned by MSCT and MRI; the data from these imaging techniques were postprocessed on a workstation, interpreted with subsequent correlation of findings from classical autopsy. The spiral CT and MRI examinations with the subsequent two-dimensional multi-planar reformation and 3D shaded surface display reconstruction the entire gunshot created complex skull fractures and brain injuries (deeply-driven bone splinters and wound channels) could be documented in complete graphic detail.^[20]

Virtopsy in drowning deaths

Plattner reported a case report of virtual autopsy due to drowning, whereby the findings of a massive vital decompression with pulmonary barotrauma and lethal gas embolism were identified in the radiological images.^[21]

Virtopsy for age and sex determination

Sex determination in forensic practice is performed mostly on sexually dimorphic bones that include pelvic bones such as the os sacrum. PMCT scan provides an easy and fast method for depicting and measuring bone structures prior to eloborative autopsy preparations.

Advantages of virtopsy

Advantages include 3D illustration, easy accessibility, allows a digital re-examination of the body after liberation of the crime scene and burial or rot of the corpse even decades later, exhumations can often be unnecessary, can be used for telemedicine/teleforensic/telepathology.^[11,22]

Disadvantages

Disadvantages include the touch, feel, and smell senses of forensic personnel that are absent.

Conclusion

Traditional autopsy has its own mark on the postmortem table, so does the virtual 3D image of a decomposed body as it lends its futuristic advancements to maintain the privacy of a dead person and end the last chapter of life with perfection.

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Conflicts of interest

There are no conflicts of interest.

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