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Virtopsy: The Digital Era of Autopsy

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Abstract

Virtopsy (virtual autopsy) is the new age complimentary documentation approach to identify and analyze the details of the demised. With the evolution of digitalization, techniques like computed tomography and magnetic resonance imaging can supplement or even partially replace traditional autopsy. Apart from the fact that this can be done both in living and dead individuals, the documentation and analysis and autopsy findings are investigator independent, objective and noninvasive, leading to qualitative improvement in the forensic investigation and precision of results. In forensic odontology, virtospy helps in facial reconstruction, bite-mark registration and analysis, lip print and rugae analysis, comparative ante mortem and post mortem analysis and patient identification and age and sex determination in virtual skeletons. With the advent of preventive dentistry leading to minimal restorations, correlative dental analysis is now showing a paradigm shift to digital analysis and virtual autopsy will assist in this aspect.

Keywords: Autopsy; Computed Tomography; Magnetic Resonance Imaging; Virtopsy; Virtopsy Table.

Introduction

Medico-legal autopsy or medico-legal necropsy is an inevitable part of forensic medicine. It is an area of forensic expertise. Dictionary of Legal Medicine proposed by Manif and Elias Zacharias define medico-legal autopsy as the execution includes the examination of the body, externally and internally, considering the thanatology as the main goal to diagnose [1].

Traditional autopsy methods includes: *dissecting, describing and documenting*. Traditional internal autopsy procedure consists of body mutilating techniques which also effects emotional and religious aspects of the victim's relatives. This called for alternative aids and techniques to replace conventional autopsy like radiographic methods and virtual methods.

Virtual autopsy

Virtual autopsy is the concept of the objective and noninvasive documentation of the body consists in the observation of the anatomical structures through computed tomography (CT), magnetic resonance (MRI) and micro radiology devices.

Virtopsy project was put forth in the department of forensic medicine, diagnostic radiology and neuroradiology in the University Of Bern, Switzerland by Richard *Dirnhofer and Michel Thali*.

This method causes no damage to the existing evidence. It allows for 3D reconstructions of the computed tomography images from the observed structures and the body surface recording is performed by forensic photogrammetric and 3D optical scanning [2].

Virtopsy basically consists of

(a) Body volume documentation and analysis using CT, MR imaging, and microradiology,

(b) 3D body surface documentation using forensic photogrammetry and 3D optical scanning.

The whole procedure of virtual autopsy takes approximately 30 minutes and it is based on the principle of triangulation. The precision of virtopsy on detailing anatomical structures depends on a) the equipment used and b) the settings used.

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General scheme of virtopsy

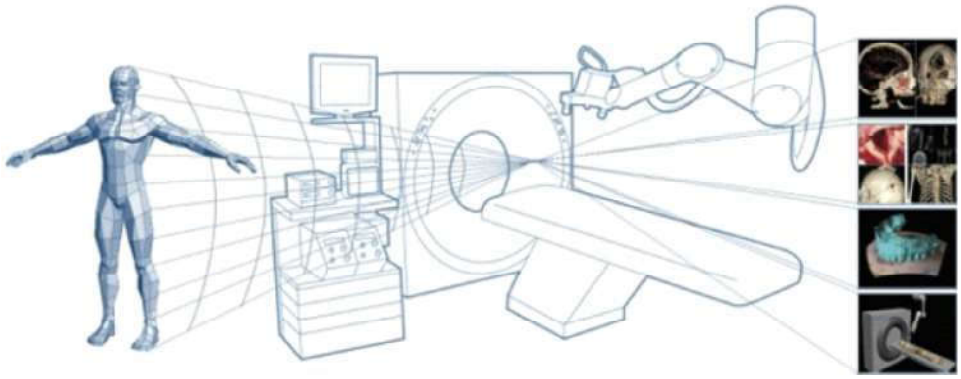


Fig. 1:

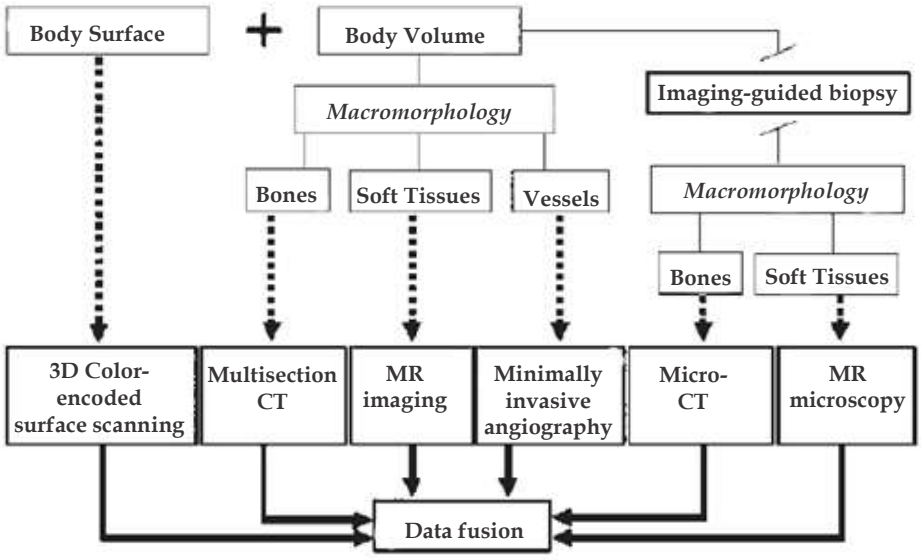


Fig. 2:

Virtopsy includes the following tools [3]:

- 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)/MRS (magnetic resonance spectroscopy).
- 3D facial reconstruction.

1. *Prepare the corpse for autopsy*

- 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.
- Virtobot - interpersonal inaccuracies can be avoided.
- The markers are used by the computer processors to calibrate the exterior scan of the corpse and match with internal imaging processes.

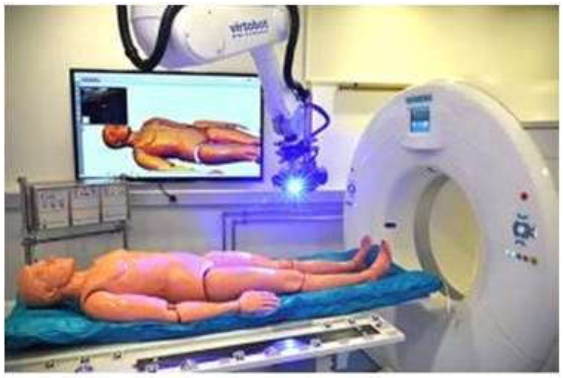


Fig. 3:

- Virtobotwas also developed at university of Bern.
  - It scans around the dead tissue with light radiation and takes photos with high quality.
- Some pictures are provided by CT scan at the same room.
- Virtobot + CT = 3D images
- Virtobot is also able to do CT guided biopsy.

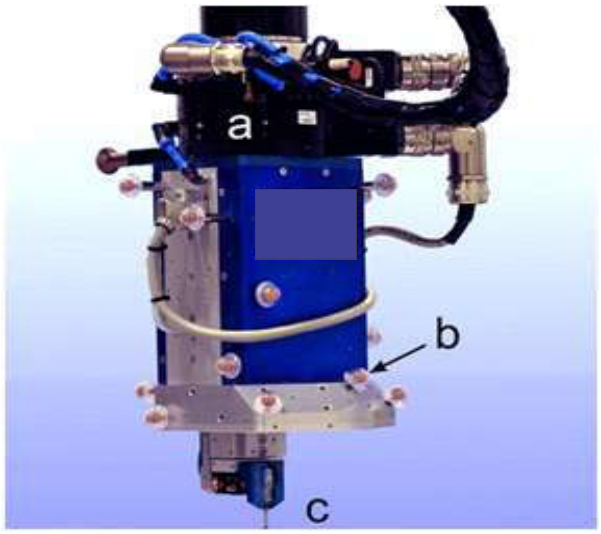


Fig. 4:

Fig. 5:

2. 3 D 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.

The ATOS II scanner.

Fig. 6:

Fig. 7:

3. After surface scanning- preparing for CT/MRI [10]

- 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, to respect privacy of the dead, maintain hygiene of the surroundings and to remain undisturbed by any non-forensic personnel in the room.

Fig. 8:

4. CT and MRI/MRS

- 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.

- Further, the corpse is also subjected to MRI and MRS scans.

Fig. 9:

5. Combining the data

- 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.
- 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.

6. 3D Forensic Facial Reconstruction

- Computerized 3D FFR: 3D computerized models are made using manual clay model techniques.
- Computerized systems
  - -- 3D animation software: to model the face onto the skull
  - -- Virtual sculpture system with haptic feedback
  - -- Phantom Desktop TM Haptic Device
  - -- Sensable Technologies

Virtopsytable

Fig. 10:

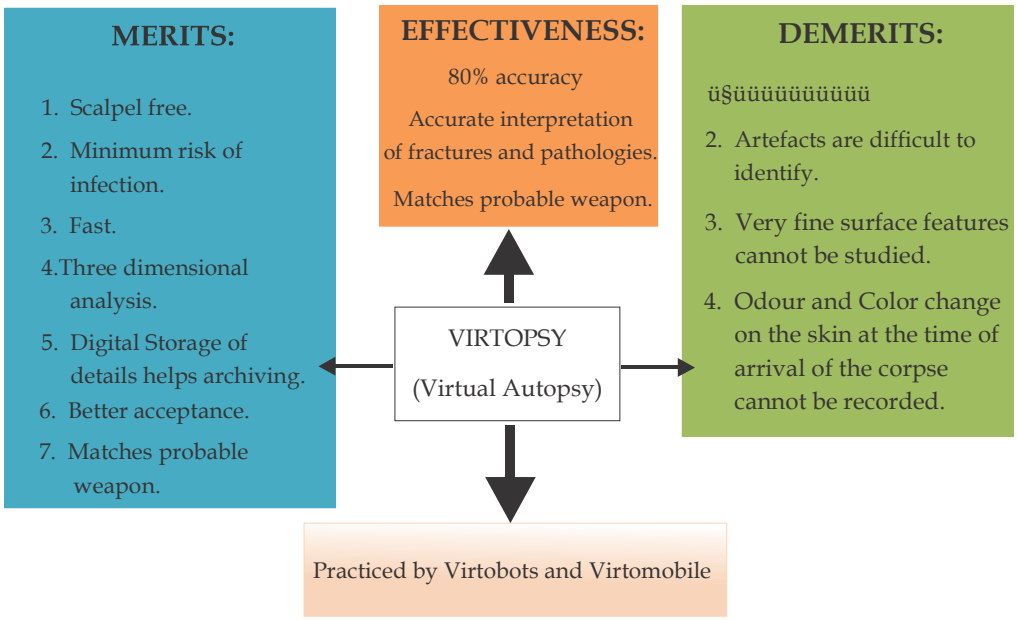
This was developed by Dr. Anders Persson. A large touch-sensitive liquid-crystal display screen represents the operating table displaying the image of the body (Figure 10).

Applications of virtopsy [5]

- To determine cause of death
- Gender identification in difficult Forensic cases;
- Body length and individual decedent feature identification;
- Identifying distinct foreign bodies like retained bullets, blades, etc.;
- Identification of injuries and forensic three dimensional reconstructions, bullet tract identification;
- Education and clinical performance improvement process; and
- For research purposes – from medical to historical (i.e., mummies, etc).
- Vitality of sustained injuries
- Bite mark investigations
- Forensic assessment of living persons
- Dental age estimation based on tooth development- include or exclude individuals based on age criteria

Advantages [6]

Effective visualization and localization of the fracture lines.



- Depth of the foreign body
- primary and secondary traumas
- no risk of cadaver contamination or damage
- Observer independent results

Disadvantages

- High equipment cost
- Cannot determine pathological changes like inflammation, changes of color or odor.
- Irregulatiry of body shape may affect scanning.
- Merging of data might cause some loss of details.

Conclusion

With the advent of the digitalization in dentistry, virtopsy can open up a new stream for emotionally biased cases. But however advanced the technique might seem, it holds its share of disadvantages too. The feel of touch, the change in color of the tissues and the smell from the deceased helps in the assessment of some crucial points during a normal autopsy which is not possible with virtopsy. Economical point of view also triggers a negative impact for the same.

Nevertheless, it is advanced in many better ways and if put to proper use with proper funding, it can be a great adjunct for the forensic team.

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