**Virtopsy: Lifting the Veil**

Supriya Keisham, Soibam Neha, Kh. Pradipkumar

Department of Forensic Medicine & Toxicology

Regional Institute of Medical Sciences

Imphal, Manipur

[supriya\_kei@yahoo.co.in](mailto:supriya_kei@yahoo.co.in)

**ABSTRACT**

A coventional autopsy is an invasive approach where an external examination is first conducted to document any findings alongwith 2D photography. Then all the organs are removed, inspected, measured and sampled for histology, in order to identify pathologies that lie within the organs. If required additional samples are collected and sent for cultures. In contrast virtopsy can boast in its ability to be almost completely noninvasive which can supplement or may even replace conventional autopsy. In deceased persons, the main goals are to determine the cause and manner of death, to evaluate the vitality of the sustained injuries, and to develop a forensic reconstruction based on the findings. The documentation and analysis of postmortem findings with techniques of virtopsy is investigator independent, objective, and noninvasive and will lead to qualitative improvements in forensic investigation. Future applications of this approach include the assessment of morbidity and mortality in the general population and, perhaps, routine screening of bodies prior to burial.

**Key words:** Virtopsy; Forensic Medicine; Autopsy; Imaging techniques; Postmortem computed tomography

1. **INTRODUCTION**
2. **Preliminary considerations**

Forensic medicine, in the past decades, has seen many strides in terms of new techniques and procedures. Among these a revolutionary one is the innovation of virtual autopsy. 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” which means “I will see”, 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. In virtopsy, 3D imaging techniques and 3D surface scans are used to map the external surface as well as the internal structure of the body[1].

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1. **Scope for virtopsy**

Findings in conventional autopsy are documented in an unintentionally subjective (observer-dependent) manner, and any findings that have not been documented are destroyed irrevocably if the body is sent for cremation or the integrity of the evidence is compromised, if not destroyed, when the body is buried. Virtopsy provides objective nondestructive documentation where the digitally acquired data can later be consulted with subject experts to answer any new questions even after the body has been legally disposed off.

Conventional autopsy are often rejected by family members or not tolerated on religious grounds. Virtopsy might replace conventional autopsy and, when required, minimally invasive imaging-guided tissue sampling and angiography can be applied to address vascular questions.

Scope of virtopsy also include research with focus on postmortem interval estimation, identification of individuals, age and sex determination, imaging in toxicology, road traffic accidents, hanging or manual strangulation, gun shots, sharp and blunt force trauma, burns and hypothermia, injury or organic lesions of heart and brain and other organs with emphasis on embolisms, and 3D surface pattern matching.

1. **IMAGING MODALITIES AND TECHNIQUES**

Virtopsy includes the following tools:

* 3D surface scan using 3D photogrammetry‑based optical surface scanner
* Postmortem computed tomography (PMCT) with adjuvants such as post-mortem computed tomography angiography (PMCTA), and minimally invasive tissue and liquid sampling
* Postmortem magnetic resonance imaging (PMMR) and Magnetic resonance spectroscopy (MRS)[1,2].

1. **Virtobot system**

Virtobot is a 6-axes industrial robot mounted onto an external axis along with the computed tomography couch (CT couch). It has a changeable end-effector to mount different tools. The virtobot removes any interpersonal inaccuracies and results in consistency and high accuracy[3].

1. **Photogrammetry and Surface Scanning**

The virtobot moves over the body creating a 3D color model of the corpse taking as little as 10 seconds. Stereoscopic cameras, with a resolution of 0.02mm, are used to capture the color image alongwith a projector to cast a mesh pattern on the body. Small discs are placed along the body to properly align the surface scan and the interior scans for rendering the images into a single cohesive image. The computer processors use these markers to calibrate the exterior scan and match with the internal imaging processes. To avoid any interpersonal inaccuracies, the virtobot places these markers on the surface of the body providing standardized and accurate results[3,4,5].

After the surface scan, the corpse double covered in plastic bags, to prevent any contamination, is brought and laid on the sliding table of the CT, MRI, and MRS equipment simultaneously.

1. **Post-mortem Computer Tomography (PMCT)**

A Computed tomography (CT) scanner makes measurements of the x-ray attenuation through a predefined plane of a cross section of the body. The resulting dataset is a 3D volume in volume pixels (voxels). These voxels contain the information about the attenuation of x-ray displayed as density which is measured in Hounsfield units (HU). 0 HU have been defined to be equivalent to the density of water, –1000 HU (i.e., one thousand below zero) to the density of air. The density of all other organic and inorganic materials vary individually and are used to distinguish between different tissues. The comparison of individual HU (Hounsfield Units) values of different foreign bodies may assist to identify if a given foreign body is metallic or non-metallic[3]. PMCT allows excellent identification of osseous lesions, foreign bodies, pathological gas formation, and organ trauma with higher precision over conventional autopsy[6,7] .

PMCT also helps in identification of a corpse by comparison with antemortem records, as it is a commonly performed investigation clinically. Prominent landmarks for comparison include the paranasal sinuses, bony deformities, medical implants such as dental implants, bone screws and plates, pacemakers and others. These techniques are reliable, even if the body has damages due to trauma or putrefaction. Speed, reliability, and low costs compared to other means of identification such as DNA analysis is one of its advantages[8,9].

1. **Postmortem Magnetic Resonance Imaging (PMMR)**

Magnetic resonance imaging (MRI) is a medical imaging technique. In contrast to CT, MRI is not based on x-rays but uses a strong magnetic field. The strength of the magnetic field is measured in Tesla [T], and current MR units work with 1.5 T or 3 T magnets, creating a magnetic field that is roughly 50,000–100,000 times more powerful than the magnetic field of the earth. MRI provides greater contrast for soft tissues than CT and is therefore useful for neurological, cardiovascular, and musculoskeletal imaging. In the post-mortem setting, MRI is a powerful adjunct to CT, its ability to visualize soft tissue organs complements the ability of CT to visualize osseous lesions. The absence of motion in the corpses is an advantage which eliminates the motion artifacts allowing better visualization of anatomical details. One of the drawbacks is that the relaxation times T1 and T2 are temperature dependent which leads to changes in the image contrast with decreasing body temperature [10,11].

Other shortcomings or limitations are MRI is more time consuming than a CT and is limited to cases that do not have any metallic fragments or implants, which is ruled out with a prior CT[3].

1. **Postmortem CT Angiography**

In the post-mortem setting, a non-dynamic CT angiography is done using the roller pump of a modified heart-lung machine to distribute the contrast medium through the vascular system. Vascular access is gained through a cut-down at the level of the femoral vessels.

* The arterial system is visualized by a tube inserted into the femoral artery and contrast medium is injected at a constant pressure. A second tube in the femoral vein, drains the overflowing blood. Imaging is performed immediately after the instillation of the contrast medium.
* For visualization of the venous system, the injection and drainage tube are simply switched and the procedure and imaging are repeated[3].

Vascular injuries and extravasation of contrast medium can thereby be diagnosed based solely on imaging. Intraabdominal or thoracic hemorrhages can be traced back to the lacerated vessel/s. Small vascular lesions that can be difficult to visualize during autopsy, may be identified after CT-angiography. However angiography is not suitable to determine the findings in the heart muscles immediately after an ischemic attack which can be demonstrated in the conventional autopsy[3,12].

1. **Tissue/Liquid Sampling**

With the use of CT or MRI organs of interest or specific pathologies can be visualized which helps in taking limited and minimally invasive biopsies with the use of CT guidance and a biopsy gun. In a similar way tissue and fluid samples can also be collected for toxicological and microbiological examinations[13]. This provides an added advantage as compared to conventional autopsy where, due to its invasiveness, the quality of sample is poor as it gets contaminated with other tissues or body fluids.

1. **Magnetic resonance spectroscopy (MRS)**

Another technique in virtopsy, is the MRS, which helps in determining the metabolic concentrations in the tissues, thus helping in estimating the time of death. MR microscopy is a microimaging technique which is used to study the soft tissue injuries like retinal hemorrhage, electric injury to the skin, etc. Microtomography is used to study the weapon involved and its injury patterns[1].

**3. FEASIBILITY OF VIRTUAL AUTOPSY**

Virtual autopsy is feasible upto a great extent as it provides 3D illustration which are easy to interpret and easily accessible. It allows a digital re-examination of the body and even of putrefied corpse decades later. It takes much less time (almost in few seconds) than the traditional autopsy and hence gives better diagnosis by providing respect to religious sentiments. These make it a reliable technique to get forensic records. The results provided are highly sensitive, specific and accurate.[12] It is non-invasive and non-destructive in nature. It simplifies the work as it identifies the identity, detects foreign bodies and easy demonstration for the court of law.

Though it has many modifications but it does has its own loopholes which needs to be fixed such as the lack of physiological senses of anatomical pathologist like touch, feel, texture and smell senses[14]. The concerned personnel are restricted as there is no direct contact with the dead body. Moreover the high cost of setting up a Virtopsy center makes it less feasible in the underdeveloped and developing countries.

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