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# Virtopsy: A Ray of Enlightment into Field Of Forensics

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**ABSTRACT:** We are far ahead in our technologies, non-invasive and minimally invasive techniques are heralding medical innovations and health science technology. In such era, forensic is also a field which demands an empowerment. Virtopsy is virtual autopsy. It is a new-age complimentary documentation approach to identify and analyze the details of demise. Utilizing virtual autopsy for orofacial forensic examination is an emerging specialty which holds a plethora of potential for future trends in forensic science. This article is an overview of this emerging methodology.

**KEYWORDS:**Virtopsy, Virtual autopsy, Noninvasive autopsy, Scalpel-free autopsy

## I. INTRODUCTION

Forensic medicine deals with the examination and identification of relevant medical data in both the living and deceased and presentation of the same with exhaustive scientific matter for judicial proceedings.[1.] Forensic science is a multidisciplinary science integrating criminalistics, engineering science, general jurisprudence, odontology, pathology/biology, psychiatry and behavioral science, questioned documents, toxicology, and physical anthropology.[2.]

Forensic pathology is a discipline of Forensic science which deals with pathologic and physiologic changes of a body before and after death wherein autopsy plays a significant role.[3.]

Virtopsy is a minimally invasive, observer-independent new-age technique which can restructure the field of forensic examination.

### Autopsy

Autopsy derived its meaning from the Greek terminologies, auto meaning "self" and opsomie, "I will see". [4]The Dictionary of Legal Medicine proposed by Manif and Elias Zacharias, says that the implementation of autopsy includes examination of the body, externally i.e on the surface and internally i.e body cavities, taking into consideration that the main goal to diagnose is thanatology. The scientific examination of bodies after death, where whole surface of the body as well as all the body cavities are explored to record the findings.[2.]

### History

Autopsy is a method dating from ancient times. The first in this field were the Chinese, who examined the animals' internal organs.[3] 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.[6] For medical and clinical purpose, Osler established autopsy as an important tool at the end of nineteenth century.[3]

### PAVING WAY TO VIRTOPSY

The traditional internal autopsy procedure consists of body mutilating techniques. Major objection against autopsies are the emotional aspects of the victim's relatives. Also some religious and cultural sects present serious objections for the autopsy procedure like in Judaism, the process of autopsy is strictly prohibited.[3] Sacrificing body's integrity after death is considered as a mark of disrespect from cultural aspect.[3]In the current scenario, where newer infecting agents are coming in, mortuary staff as well as general public is at high risk of hazardous infection during the conventional autopsy procedure as the infectivity from the body is unknown and infection can spread from a fresh dead body as well as a highly putrefied body.[7] Also during procedure all the organs are removed and examined. If the body need to be subjected to subsequent autopsy, it becomes a very tough job for the second autopsy surgeon to conclude with all the dislodged and dissected organs where the normal architecture is lost.

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Most valuable gift of technology to science is the non-invasive or minimally invasive diagnostic methods belonging to imagistic domain. The development of advanced and highly sensitive CT and MRI techniques led to the idea of using them for postmortem investigations.[3]

**Imaging technology of radiologists in field of forensics**

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.[6]Richard Dirnhofer, former Director of Forensic Medicine, Berne gets the credit of developing the science of Virtopsy, or "virtual autopsy", which was later continued by his successor, Michel Thali and his colleagues at the University of Berne's Institute of Forensic Medicine, Switzerland.[3]

**VIRTOPSY**

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[6]

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**Equipment for Virtopsy**

**Virtopsy includes the following tools:**

- 3D surface scan using 3D photogrammetry-based optical surface scanner-Surface analysis
- Postmortem CT (PMCT) & Postmortem MRI (pm-MRI) -Hard and soft tissue analysis
- PMCT-guided biopsy (PM-biopsy and PMCT-guided angiography-Biochemical analysis)[8]


**Equipment for Virtopsy**

**Virtibot**

Recent Advancement in Virtopsy.Virtibot is a Robotic technology that carries out Virtopsies. Virtibot is a 6-axis industrial robot , that is mounted onto an external axis along with the CT couch, so it can access the entire scannable volume. It has a changeable end effector and can, therefore, mount different tools. The system incorporates a surgical navigation system to allow for a closed loop robot control.[9]


**Vitribot**

**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

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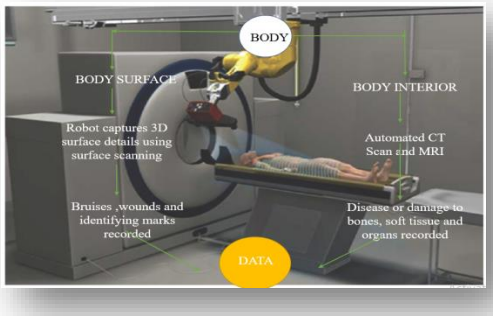
to calibrate the exterior scan of the corpse and match with internal imaging processes.[10]

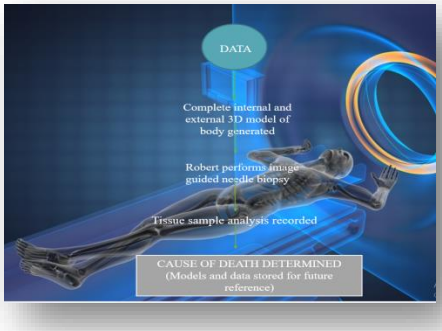
After the markers are placed by the virtibot, it creates a 3D color model of the corpse. The scan utilizes stereoscopic cameras to capture the color image, and a projector is used to cast a mesh pattern on the body. These cameras have a resolution of 0.02 mm. The robot moves over the body creating a 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 MRI spectroscopy 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 non forensic personnel in the room.[10]

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.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. After analysis of the 3D model, internal and surface scans, a needle biopsy can be done if internal body samples are needed.[10] All the data scanned are then captured and saved on compact discs.[10]




**Procedure of virtopsy**

**Uses of Virtopsy**

1. Timing of death

The timing of death can be determined by virtopsy using changes seen in both MSCT (Multi Slice Computed Tomography) and MRI (Magnetic Resonance Imaging) in head injury cases[11]

2. For identification of individuals

Smith et al. described a case report on positive identification of a deceased individual. CT scan on an unidentified cranium and comparing multiple landmarks, images with corresponding features in an ante mortem CT scan of a missing man, confirmed the identity of the missing person[12]

3. For toxicological examination

A tool to determine the death of a person in cases of drug abuse[13]

4. 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[14]

5. 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[15]

6. 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. MSCT and MRI revealed strangulation signs concordantly with forensic pathology findings[16]

7. 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)[17]

8. Gunshot wounds

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[18]

To assess the direction from which gunshot wounds were created, different characteristics are used. 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.[6].For example, in bone injuries, cone-shaped (outward beveling) defects show the direction in which the projectile passed through the bone.

9. In drowning deaths

Plattner reported a case report of virtual autopsy due to drowning, massive vital decompression with pulmonary barotrauma and lethal gas embolism were identified in the radiological images[19]

10. For age and sex determination

PMCT scan provides an easy and fast method for depicting and measuring bone structures include pelvic bones such as the sacrum

**ADVANTAGES [2,20]**

1. Non invasive imaging technology
2. More ethical ,religious sentiments are not hurt
3. Body is not mutilated so no hazard of infection
4. Less time consuming and body can be handed over fast to the relatives
5. It provides ability to examine bodies contaminated by infection, toxic substances, radionuclides, or other biohazards (i.e., bioterrorism)
6. No fear of spread of infection during procedure as in conventional autopsy
7. Can be digitally stored and exported to all parts of world for a review of opinion, reexamination of evidences
8. Facility of 3D illustration and reconstruction providing a detailed insight into the crime and crime scene

**DISADVANTAGES [7]**

1. Insufficient data base for comparative study.
2. Cannot give the infection status
3. Fear of missing small injuries
4. Difficult to appreciate the color changes
5. Postmortem artifacts are difficult to appreciate.
6. All the pathological conditions cannot be distinguished.
7. Antemortem or the postmortem wounds are difficult to differentiate

**Indian Context[21]**

X rays have been used in the field of Forensic Medicine in our country since long. One of the landmark cases where X ray examination was used in the "2nd autopsy" was the Naina Sahni murder case or the 'Tandoor Murder' case. Naina Sahni was murdered on the night of 2-3/7/1995 by her husband Sunil Sharma, who allegedly tried to dispose off her body by burning it in the Tandoor of Ashok Yatri Niwas Hotel, New Delhi.[21,23]

The body was taken to the mortuary of Lady Harding Medical College mortuary where the 1st autopsy was conducted. The forensic expert noted various "chop wounds' and amputations on the body and found "no evidence of firearm discharge from internal examination" even though police recovered cartridges, bullet and air pistol from the scene. Cause of death was given as "hemorrhage and shock consequent to various antemortem injuries on the body. [21,23]

The second postmortem examination was conducted by a Board which got the body X rayed before the start of the dissection. X ray revealed the presence of 2 bullets, one in the skull and the other in the neck region. These were retreived and handed over to the police for ballastic examination. Cause of death was given as "Coma consequent upon firearm injuries to the head which were sufficient to cause death in the ordinary course of nature". The Sessions Court severly repraminded the first doctor.[21,23]

Since then, it has become a norm to get whole body X ray done at least in cases of Firearm injuries and in 100% burns. It is now being

advocated that at least in tertiary care hospital mortuaries, Digital X ray unit should be made an integral part of the mortuary complex. [21,23]

According to Roy of the Times of India, Mumbai,27 "Seventy nine health workers from mortuaries at Bhagwati hospital in Borivli, JJ in Byculla, Cooper in Juhu and Rajawadi in Ghatkopar have narrated their daily struggle to work in conditions where, at every step, they risk contracting biological hazards like bloodborne viruses and other infections, including HIV, hepatitis and TB.[21,23]

## CONCLUSION

Virtopsy along with its scientific rationale and practical merits, salutes and respects the religious and emotional sentiments of various ethnic groups. Immensely helpful for future correlations as it involves preserving the records and holds great promise for the future of forensic science.In the days of COVID 19 , virtopsy has an unavoidable role. ICMR has said in a draft document that Invasive techniques should not be adopted for forensic autopsy in COVID-19 death cases as doctors and other mortuary staff will expose to potentially dangerous health risks due to organ fluids and secretions. As per the procedure of conducting forensic autopsy, the "dissection of bones and tissues will generate aerosol which may lead to spread of infection.In this scenario virtopsy is an boon where we are struggling for maintaining an infection free environment.

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