

## Review Research Paper

# Digital Autopsy: Moving From Fiction to Reality

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### Abstract

With the technology ruling over each sphere of our modern lives it is no wonder that it is also proving to be a source of great help to the forensic experts who with their work make the dead talk. Technology is fast replacing the manual and mental traditional methods and with the launching of igene and autopsy suites virtual autopsy/digital autopsy / autopsy imaging is indeed moving from fiction to becoming a factual reality. Though forensic radiology has been in use since the discovery of X-rays but the technique which was used to visualize and analyze the mummified remains of people who died thousands of years ago sowed the seed of digital visualization being promoted commercially as digital autopsy. In the setting of Forensic evaluation, 3D surface scanning using multislice CT technology provides excellent visualization of the body and allows re-examination of digital images of the deceased long after the actual time of death.

**Key Words:** Autopsy, Imaging, Technology, Forensic Radiology, Digital

### Introduction:

Autopsy means "Self" (autos) and "I will see" (opsomei) in Greek "to see with one's own eyes." [1] It is the systemic and scientific examination of a dead body to determine or confirm the cause of death. They are of three types namely clinical or pathological, medico-legal and anatomical.

Clinical/ Pathological autopsy is done to determine the disease causing death and a pathologist performs it with the consent of relatives of the deceased.

Medico legal autopsy is done to solve the mysterious unnatural death and is done by a Forensic pathologist or medico-legal expert ideally. Anatomical autopsy is carried out to learn the normal structure of the human body by medical students.

Forensic pathology is a field within which physicians are mainly preoccupied with examining what initially are victims of possible, suspected or obvious violence. Clinical Forensic Medicine essentially does the same but with living victims.

As examinations are typically performed under the legal restraints of investigative authorities such as courts, prosecutors, district attorney or police, there are constraints as to cost, time, objectivity and task specification depending on local law.

Digital Autopsy or Imaging autopsy can be defined as the use of high definition CT and or MRI scan to determine the cause of death in addition to or in lieu of traditional autopsy.

CT is well suited to show foreign objects, bones and air or gas distribution throughout the body, whereas MRI sequences are strong in detaining organ and soft tissue findings. Ultrasonography helps in evaluation of various organs, pleural air, effusions, cardiac and pericardial abnormalities, haemoperitonium and even skeletal injuries.

Resulting data can be archived and reproduced without loss, analyzed elsewhere or distributed to specialists for technically demanding analysis.

### History:

In ancient Egypt and Mesopotamia, post-mortem dissections were frequently performed during the process of embalming. [2] In India, autopsy and dissection were practiced by Sushruta, an early pioneer of ayurveda in the sixth century BC. [3]

In 3<sup>rd</sup> century BC, Greek scholars used autopsy for the purpose of enhancing their understanding of anatomy and disease. [4] Similar approaches emerged in Europe during the middle ages and the Renaissance with the work of Vesalius and others.

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The first organized treatise on pathological finding of autopsy was "The seats & the uses of disease investigated by anatomy", published in 1761 by Giovanni Batista Morgagni. This book describes nearly 700 autopsies performed by the author and is the foundation of modern post-mortem science. [4-6] At the end of 19<sup>th</sup> century, Osler established the autopsy as one of the cornerstones of his approach to both medical training and the clinical method. [7, 8]

In the 1<sup>st</sup> half of the 20<sup>th</sup> century, autopsy rates steadily increased. The 2<sup>nd</sup> half of 20<sup>th</sup> century & beginning of 21<sup>st</sup> century saw continued decline in autopsy rates. [9]

The most commonly attributed factor accounting for this phenomenon included discomfort of the physician in requesting permission from family, cost containment measures and risk of blood borne pathogen transmission, religious and cultural beliefs.

### History of Imaging Autopsy:

Advanced imaging techniques have been in use for quite some time during Forensic investigations. In 1977, Wullenweber et al reported one of the earliest Forensic applications of computed tomography to describe radiographic patterns of gunshot injuries to head. [10] In 1980, Flodmark et al performed a comparison study of premortem CT findings and subsequent autopsy results in neonates who suffered perinatal asphyxia. [11]

Kalender et al in 1990, followed by developing acquisition and processing of 3D digital radiographic imaging data. [12] The 1990's saw the inception of large scale research programmes dedicated to imaging autopsy.

The most prominent programme was the Virtopsy Project headed by Prof. Michael Thali which was initiated by Prof. Richard Dirnhofer at the end of 20<sup>th</sup> century and has been operating out of the Institute of Forensic Medicine at the University of Zurich, Switzerland since 2011. [1, 13]

The aim was to improve the objectivity of findings made in forensic autopsies.

The foundation stone of the commercial concept of digital autopsy was laid during the publicity generated regarding the analysis of the "Virtual Mummy" at the British Museum in year 2004. [14] While manner of death, cause of death, time of death, identification of deceased and a range of practical and reconstructive applications are obviously related to medico-legal investigation of death, Virtopsy methods were ground breaking in that they have established a new high tech tool box into both research and practical aspects of modern Forensic pathology.

### Technology:

The technology currently used for conducting a virtual autopsy comprises of:

- Robot guided surface scanning for three dimensional documentation of the surface of the body, to scale and in colour. [15] This supplements the external post-mortem examination of the body that is done in conventional autopsy.
- Multi-slice spiral CT and MRI. This supplements the internal post-mortem examination of the body in autopsy. [16]
- Post-mortem angiography, which visualizes the cardiovascular system of the deceased with the aid of peristaltic pump and contrast medium. [17]
- Image and robot guided, contamination free sampling for a wide range of supplementary Forensic analysis such as histology, bacteriology, virology, toxicology and diatomology. [15] This procedure replaces the usual collection and storage of sample material from the body.

### Recent Advances:

By connecting a conventional CT or MRI scanner to a 3D imaging software tool developed by Malaysian company iGene, pathologists can display and examine cadavers in a much cleaner fashion than conventional scalpel-based methods allow.

Using a large touch screen to display the body's 3D image, one can zoom into areas of the corpse they want to study in greater detail and remove layers of clothes and tissues without having to cut them. Every time a coroner requires an autopsy to be performed on a body, relatives of the deceased will be given an option of either subjecting the corpse to a conventional procedure free of charge, or opt for the digital autopsy for £500.

### Objectives:

The main objectives of imaging autopsy (IA) include determining of: [13, 18]

- a) Cause of death
- b) Gender identification in difficult Forensic cases;
- c) Body length and individual decedent feature identification;
- d) Identifying distinct foreign bodies like retained bullets, blades, etc.;
- e) identification of injuries and forensic three dimensional reconstructions, bullet tract identification;
- f) Education and clinical performance improvement process; and
- g) For research purposes – from medical to historical (i.e., mummies, etc).

**Advantages:**

1. Post-mortem imaging can demonstrate findings that are not readily recognized during the traditional autopsy such as fast and accurate identification of foreign objects (bullets) in decomposing bodies, documentation and examination of neck muscle hemorrhages in Forensic cases, visualization and quantification of venous air embolism structure.  
IA offers excellent accuracy, including very close estimation of solid organ weights and the ability to match decedent-environment relationships in fatal traumatic injuries. [19, 20] Imaging autopsies provide visualization of soft tissue patterns in cases of severe putrefaction. This is especially important when structural patterns are not otherwise distinguishable on traditional autopsy. [13]
2. Imaging Autopsy produces detailed records that show conclusively the cause or manner of death which can be kept intact and free of human intervention.
3. It eases the burden of determining the identity and cause of death in victims of mass natural disasters, particularly in large number of badly decomposed bodies.
4. Digital bodies can be sent to forensic pathologists who can conduct autopsies remotely.
5. In the wake of a biological contamination or biological terrorist attack, digital autopsy can be extremely valuable in determining further investigation that are necessary to identify the pathogenesis while at the same time protecting forensic pathologist from accidental exposure to biological contaminant.
6. Digital autopsy stream lines communication between forensic experts as well as pathologist to seek professional second opinion with experts abroad through a secured channel digitally.
7. It has the ability to recreate realistic 3D anatomic reconstructions of injuries which is useful when relating the patterns of injury to various environmental factors at the time of death.
8. Interactive visualizations are often easier for juries, lawyers and other court officers with a clearer understanding of the autopsy process, which can be vital when the manner of death must be established in a court case.
9. From the religious point of view, it provides an option to treat the deceased with dignity while at the same time achieve the medico legal requirement. Traditional autopsy may

- be refused because of religious, social, cultural and/or personal beliefs. [21, 22] Imaging autopsy offers a non-invasive alternative of discovering the cause of death in such cases. [22]
10. CT scanning may be more suitable to body packer identification than conventional or plain abdominal X- Rays.
  11. It gives a clean bloodless visualization of the documentation with high precision, contamination free sampling (poisons, infections, tissue etc) accurate to the millimeter.

**Limitations:**

While devastating traumatic injuries may be obvious on a “virtual” autopsy, causes of death due to certain medical conditions (i.e., metabolic disorders) may elude even the most specialized and sensitive imaging techniques. [23] Important questions need to be answered before more widespread use of IA is instituted, including its medico-legal ramifications, medical-economic implications, and issues surrounding IA interpretation.

IA studies involve a number of controversial issues such as who should be responsible for obtaining and interpreting these studies, who will cover the expense of performing and interpreting them, and medico-legally who will be held liable for these autopsies.

The relatively slow acceptance of IA is likely related to certain medico-legal aspects, uncertainty over who should be responsible for interpreting such studies, as well as the cost and reimbursement associated with these studies prevents imaging autopsy from being accepted widely as an alternative to traditional autopsy.

**Conclusion:**

The recent advances in the development of a non invasive technique of visualizing the insides of a person without hurting the cultural, religious and social beliefs ensure a dignified end to a person’s life.

With the installation of the first autopsy suite in a morgue in Sheffield in Britain, one is hopeful for a cheaper, faster and efficient autopsy. Yet there is relatively slow acceptance of IA over traditional autopsy.

While imaging autopsies are unlikely to ever match some of the histological and metabolic information available from traditional autopsies, it may be that for certain diseases radiographic postmortem examination is actually superior. They take only a few minutes and may be viewed remotely without loss of imaging detail with easy sharing of the data among

experts. It does not require specialized facilities other than one time use of the imaging suite.

Image-based autopsy makes the cause-of-death determination process much less invasive and certainly much more “acceptable” to both the decedent’s family and the participating physician or medical trainee.

In addition, the routine performance of Imaging Autopsy could also help build an atmosphere of interdisciplinary cooperation between radiologists, pathologists, and primary physicians involved in clinical care of the decedent prior to his or her death. All too often, the reason for the patient’s demise can only be an “educated guess” which are frequently inaccurate.[24, 26] Information obtained from imaging autopsies offers the potential to do away with such guesswork.

Use of Imaging Autopsy will also prove to be an excellent educational tool that can provide much needed post-mortem information during the era of declining autopsy rates.

Development of Forensic telemedicine consultations will solve many of the problems associated with interpretation of IA studies during odd hours or at locations that do not have the necessary resources to perform such interpretations.

Hence Imaging autopsy or digital autopsy is fast moving away from being a fiction of being used as pre autopsy screening tool or complementary study to an alternative form of traditional post-mortem examination.

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