Virtual Autopsy using Radiological Imaging

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Abstract

The goal of the transdisciplinary research project Virtopsy is to integrate contemporary imaging tools into pathology and forensic medicine in order to supplement present examination procedures or perhaps provide substitutes. Our project is supported by three pillars: 3D surface scanning for body surface documentation, multislice computed tomography (MSCT), and Magnetic Resonance Imaging (MRI) for inside body visualization. In the past, three-dimensional surface scanning has produced outstanding outcomes for the 3D documentation of patterned injuries, objects of forensic relevance, and complete crime scenes. Using MSCT and/or MRI, the interior of corpses is imaged. Additionally, MRI can be used to examine surviving assault victims, particularly those who have choked, and it aids in seeing internal injuries that cannot be seen during a victim's exterior examination. These approaches enable re-examination of the corpse and the crime scene even decades after burial and release of the scene, in addition to providing the precision and three dimensionality that standard documentations lack. We think that forensic medicine will soon be improved by this virtual, non-invasive, or minimally invasive technique.

Keywords: Forensic imaging • Virtopsy • Computed tomography • Magnetic resonance imaging

Introduction

Numerous forensic science disciplines, including genetics, crime scene investigative techniques, and toxicology, have seen revolutionary developments. Contrarily, forensic pathology continues to use the tried-and-true, evidence-based techniques that were first used centuries ago. These include the dissection of a corpse, as well as an oral account and written documentation of the results, which have recently been supplemented by photography. Forensic pathologists now have more options thanks to the development of medical technologies like computed tomography (CT), which was developed by Hounsfield and Cormack and first used in the early 1970s. As early as 1977, a victim of a gunshot wound to the head underwent a CT scan, and authors like Brogdon and Vogel have discussed the value of radiography in forensic medicine. Traditional X-rays have made their way into everyday forensic practice, while more recent, clinically proven techniques like CT and Magnetic Resonance Imaging (MRI) appear to be falling behind in this regard.

In a field where defense attorneys and prosecutors are frequently willing to test cutting-edge techniques, depending on the specifics of the case, this reluctance to embrace new technologies is startling. Despite these challenges, numerous institutions have started using CT for post-mortem forensic examinations. For instance, a team from the Office of the Armed Forces Medical Examiner, which routinely scans military members killed in action with CT scans, tested the technology's utility in assessing high-velocity gunshot victims and found encouraging results. The CT scanning of corpses has been widely used by teams from the universities of Copenhagen (Denmark) and Linkoping (Sweden), once again with encouraging outcomes. Every corpse brought to the Victorian Institute of Pathology (Sydney, Australia) is subjected to a CT scan before being subjected to an autopsy, according to a personal message. The Society for Autopsy Imaging in Japan was established in 2003 with a similar commitment to this innovative method. Additionally, CT scanning has been applied to forensic anthropology. When comparing anthropological features of the instance of a burnt body to traditional approaches, a French group actually achieved better results. This forensic science revolution in Switzerland had its start in the middle of the 1990s with a joint initiative between the University of Bern's Institute of Forensic Medicine and the Zuerich City Police's Scientific Service. The objective was to capture three-dimensional (3D) surfaces of the body and objects. A few years later, the University of Bern's Institutes of Diagnostic Radiology and Neuroradiology joined forces with the Institute of Forensic Medicine to launch another collaborative research initiative. This project's audacious goal was to use multislice CT (MSCT) and MRI to identify forensic evidence from dead bodies and to compare the findings to those from autopsies. Utilizing the TRITOP program, black-and-white digital photos of the surface of the object of interest taken from various angles with reference marks can be enhanced with color information. This technique can be used to capture true-color surface images of bodies, suspect injury-causing objects, cars, and complete crime scenes. These three-dimensional representations can be compared, enabling the identification of a suspected injury-causing object or structure. The utilization of 3D surface data in complicated traffic incidents is another illustration. Reconstructing the sequence of an accident involves comparing the victim's injuries to the matching vehicle structures.

Detection of osseous lesions

Obvious osseous injuries, whether in the form of fractures, cuts, or bullet wounds, are significant in forensic pathology. Cuts and fractures, as well as the fracture distribution and 3D pattern of dislocation, can be easily visualized and communicated to medical laymen in a non-bloody form to aid in their understanding of the case. Furthermore, it is simple to identify minor fractures at hard-to-reach body parts that can be missed during an autopsy. Another benefit is that nondestructive fracture examinations can be performed on body parts that aren't often dissected, such the face, to spare the next of kin additional psychological distress. X-rays are frequently used to identify foreign objects in corpses, including bullets, knife blades, implants, etc. The added benefit of MSCT is that it can precisely pinpoint these things and show their topographic neighborhood within the body in 3D, greatly easing extraction at autopsy. 3D data can be converted to 2D projections or tomographic views for identifying purposes; one such use is the generation of 2D panoramic dental images that correspond to ante-mortem radiographic records. The fact that MSCT can assess the foreign body's radiological density gives it another edge over traditional X-rays. In CT, Hounsfield Units are used to express this density. Most of these challenges are easily overcome using MSCT. While 3D reconstructions show the distribution of gas in the blood arteries and the heart chambers and can even estimate the precise amount, sectional scans show the presence of gas immediately.

A fundamental benefit of imaging is that putrefaction is maintained to a minimal while the patient is being examined because the decomposing body is enclosed in at least one airtight body bag. The relaxation capabilities of excited mobile hydrogen nuclei in water, tissues, and fat are essential to MRI. Soft tissues, which plainly contain enormous amounts of hydrogen, are thus beautifully portrayed. MRI provides a clear view of the inner organs and the pathology of subcutaneous fatty tissue, one of the preferred places in blunt trauma. Both MRI and CT are capable of detecting fatal hemorrhage. MRI is frequently used within the project for the assessment of surviving victims of blunt trauma, particularly of manual strangulation, as it uses no ionizing radiation and is highly adapted for the presentation of soft tissue disease. The concern with such cases is that while the outward signs may appear to be unimportant, the underlying soft tissues, especially those close to the reflectogenic structures of the throat, may have been badly traumatized, posing a possibly fatal hazard.

Limitation

Basic drawbacks of MRI and MSCT are as follows: While MSCT is quick and provides great spatial resolution for the visualization of the skeleton, foreign objects, and gas, it performs poorly in the soft tissues due to its poor contrast resolution, making it an unsuitable approach for the depiction of soft-tissue and solid organ diseases . Contrarily, MRI shows soft tissues and their pathologies clearly while cortical bone and other hard materials, such as forensically significant foreign substances, are just viewed as artifact-producing gaps in the picture. However, because bullets and other solid metallic objects induce artifacts in both CT and MRI, the immediate area around them may not be sufficiently replicated for diagnosis. Despite these small drawbacks, MRI of gunshot victims typically does not reveal the popularly believed risk of ferromagnetic foreign bodies since projectiles are primarily made of non-ferromagnetic material, such as lead, and do not interfere with imaging procedures. The inspection of a body from the head to the pelvis and occasionally the extremities takes time and may take one to several hours, which is unacceptable in standard forensic procedure because our scanner used for corpses does not enable parallel imaging. Beyond these methodological restrictions, postmortem imaging presents challenges not present in living subjects. Prior to putrification developing, several post-mortem modifications of organs, including the blood, colon, and lung, produce aberrations from typical findings that can be challenging to distinguish from pathologic entities that were present throughout life and from those that caused death. The second and most significant concern is the inability to use intravenous contrast enhancement of tissues and veins, a crucial addition to many clinical exams, due to the absence of a continuous circulation. The inability of radiological imaging techniques to display microscopic pathological alterations is another significant shortcoming of these techniques.

Discussion

According to the authors, post-mortem imaging already serves as a significant complement to autopsies and is steadily expanding in importance in forensic medicine. We think that there may be many applications for this minimally invasive strategy. First, in recent years, acceptance of traditional autopsies has dropped significantly. Triage can be accomplished by scanning the corpses. On the other hand, a broader triage system is now feasible due to the increased acceptability of non-invasive forensic techniques: when evidence of a third party involvement is found during postmortem imaging, the case for an autopsy becomes considerably stronger. One can speculate that screening a larger percentage of the deceased with imaging might aid in identifying more killings. Surface scanning, MSCT, and MRI are minimally invasive techniques that has the potential to replace conventional surgery when used in conjunction with image-guided biopsies and post-mortem angiography autopsy in many instances, so to offer a feasible compromise for cultural post-mortem investigations circles where autopsy is frowned upon. However, there are some limitations, including natural causes of death are elusive, and the most frequent reason is of unexpected and abrupt death, specifically arrhythmogenic Imaging performed after a death cannot identify coronary artery disease. But the same holds true for similar cases' autopsies; in addition to coronary stenoses or occlusions, maybe together with a cardiac hypertrophy and generalized signs such a pulmonary These instances typically don't exhibit macroscopic symptoms of a cardiac ischemia. The determination of an The cause of arrhythmogenic cardiac arrest is pre-existing pathologies, vague findings, ruling out additional causes of death, and potentially (rarely) present histological alterations in the heart muscle. however, autopsy allows for easier tissue specimen sampling, image-guided Biopsies could be a less invasive substitute for allow for histology analyses and aid in identifying the reason for dying. However, even if a number of natural causes of death be adequately detected using post-mortem imaging, this Current shortcomings are only marginally significant in a forensic environment where, in the event of a natural death, The district attorney will typically (with the help of the possible exception of malpractice, etc.) end the case. The third pillar of our research is the examination of living victims. project is moving toward completion thanks to its non-intrusive nature. a benchmark in forensic medicine. Hence, lesions Available but undetectable at external clinical inspection in a visual, observer-independent manner, which satisfy the standards of a contemporary court of law. The data structure of virtual imaging is another benefit. ideally suited for digital storage, including 3D photographs of bodies, tools, and vehicles thought to have created instances may be reexamined in light of injuries and crime scenes Even decades after the body's burial and release the scene of the crime.

Finally, the minimally invasive or non-intrusive a strategy intended via post-mortem surface scanning and MRI and MSCT both provide a number of advantages over current forensic examination methods, specifically: Accurate, unbiased, and transparent documentation of forensic conclusion for the court

- 3D documentation of findings that is calibrated
- Archiving digital data for quality assurance transfer
- Lessening the psychological trauma experienced by the relatives
- Better judicial systems in societies with low autopsy rates

Acceptance.

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Conflicts of Interest

The authors declare that they have no conflicts of interest.

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