Forensic Imaging

Presented

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Introduction

- Forensic imaging is the use of images to explain and document findings for medico-legal issues.
- It is forensic investigation using advanced technology.
- Forensic imaging is non-invasive method.
- It may be an adjunct or alternative to traditional invasive autopsy.
- Forensic pathologist can determine the cause of death according to imaging without autopsy .
- It is applied before traditional autopsy to locate trauma and pathological changes accurately in cadaver. (fatal motor car accidents).
- There are many used terms for forensic imaging such as virtual autopsy, Necro-radiology, Postmortem imaging, minimal invasive autopsy and forensic radiology.

The Role of Forensic Imaging in Legal Medicine

- It is complementary technique to perform correct diagnosis.
- It is non-invasive or minimal invasive detection of findings that are impossible to discover and diagnose via standard autopsy only .
- Ex . detecting multiple small bleeding sources using PMCT-angiography.
- Digitization of findings is possible through combination of different tools of forensic imaging to solve criminal problems.

Tools of Forensic Imaging

1. X-ray
2. CT (Computed Tomography)
3. MRI (Magnetic Resonance Imaging)
4. PMCT (Postmortem Multi-Slice Computed Tomography)
5. 3D Surface Scanning
6. Augmented minimal invasive techniques through CT and MRI such as:-

   A.Angiography

   B. Biopsy
7. Ultraviolet Forensic Imaging

Conventional Radiography – X Ray

- It is post-mortem investigations via direct exposure to X-rays.
- It is used in anthropology and Identification.
- It evaluates skeletal system in cases of trauma or presence of foreign body.
- Nowadays, conventional radiography is replaced with Multi-Detector Computed Tomography (MDCT).
- MDCT allows 3D representation of any segment of human body as well as better soft-tissue contrast.

PMCT (Post-Mortem Computed Tomography)

- PMCT refers to MDCT (Multi-Detector Computed Tomography). (It is best quality image in forensic imaging).
- It is method of choice for assessing skeletal system
- It visualizes new and old fractures, small ones, in poorly accessible skeletal parts such as posterior parts of ribs, pelvis, and vertebrae.
- It is ideal method for detecting radio-opaque foreign bodies (ex. medical implants, projectiles and fragments, and foreign bodies).
- It investigates traumatic-death and hemorrhagic diseases such as cerebral hemorrhage, subarachnoid hemorrhage, aortic dissection, and aortic aneurismal rupture.
- 3D models are always at risk of artifacts.

PMCT (Cont.)

- It shows calcifications of coronary arteries.
- It does not show patency of vessel's lumen or associated injury to myocardium.
- It does not show stenoses or occlusions because no blood flow is evident on PMCT.
- It shows traumatic events, such as blunt violence, traffic accidents ,and gunshot.
- It detects gas and air embolism, that can be difficult to find during autopsy.
- It detects smallest amounts of gas as well as air embolism.

PMCT- Guided Sampling

It is used in the following:-

- Tissue or liquid sampling of any organ.
- Sterile puncturing for microbiological analyses (small abscesses can be accessed via this method).
- Toxicological screen of human fluids such as urine, bile, gastric contents, and other biological samples.
- Gas collection through minimal invasive puncture performed under PMCT (Chemical analysis of gas via chromatography)
- Diagnosis of ante-mortem air embolism, decompression trauma in diving incidents via determination of the exact composition of gas accumulations.

Postmortem Angiography

- It is minimal invasive two-step angiographic technique.
- First step is bolus injection of oil contrast agent into human cadaver while second step is radiographic imaging.
- It enables detailed examination of vascular system that is difficult to be examined by traditional autopsy method.
- It shows vessel lumen. (corpse vessels are empty and collapsed).
- It localize source of bleeding and stenoses or occlusions.
- It detects vascular injuries due to stabbing or gunshots.
- It can differentiate the causes of hemopericardium (ruptured myocardial infarction or aortic dissection).
- It investigate the causes of natural cardiac death.

MRI

- It distinguishes muscles, fat, parenchyma, and neurological structures.
- It detects soft tissue or organs injuries.
- It complements PMCT that has severe limitations due to lack of discrimination in organ findings.
- MRI has special significance for diagnosis of natural death, traumatic soft-tissue injuries, blunt force, stab wounds, medical errors, age estimation, and foreign bodies.
- MRI is recommended for documenting the cause of death especially in cases of sudden death, and cardiac pathology
- MRI detects infarcted or ischemic regions in heart as well as fibrotic myocardial lesions, enabling early diagnosis of cardiac arrest. (post-mortem cardiac assessment)

3D Surface Scanning

- It is non-invasive method for 3D digitization of objects with high accuracy and resolution.
- It is quick and easy to perform.
- It allows data storage for later use .
- It is a technique that was developed for car industry and reconstruction of traffic accidents.
- It shows correlation of lesion on body and the suspected causative instrument, and comparison of bite marks with dental models of the supposed animal.
- Three-dimensional surface scanning can be combined with other imaging techniques such, PMCT, and MRI.

Ultraviolet Forensic Imaging

- It scan body or crime scene for evidence (wounds or bite marks) not detectable by the naked eye and standard lighting techniques.
- There are two techniques for UV photography:-
  A. Reflective UV imaging.
  B. Fluorescent UV imaging.
- Photographs done with these techniques show wounds in greater detail than would be possible with conventional photographic equipment.
- The resulting images are displayed on a video screen.
- Forensic researcher visualize an ultraviolet image immediately without waiting for film to be developed.

Application of Forensic Imaging in Forensic Medicine

Forensic pathology

Forensic anthropology

Forensic odontology

Forensic ballistics

Forensic Pathology

- **CT is used to diagnose some difficult cases as the followings :-**

1. **Arterial gas embolism in fatal diving accidents.**
2. **Intrahepatic gas.**
3. **Cyanide poisoning death (Cerebral swelling associated loss of gray-white differentiation).**
4. **Perinatal hypoxia in neonates .**

- **CT and MRI are used to assist in the following:-**

1. **Examination of charred bodies.**
2. **Diagnosis of traumatic extra-axial hemorrhage.**
3. **Postmortem weights of liver and spleen accurately.**

- **Imaging is more accurate than autopsy for weighing livers in congestion cases**
- **MRI is more sensitive than CT for detection of subarachnoid hemorrhage**

Forensic Anthropology

- CT is used for the following :-

- **Human identification**

  A. By comparing antemortem and postmortem skull CT scan views.

  B. Facial reconstruction of deceased using computer 3D facial model

  C. Mass disaster victim identification.

  D. Age identification at death based on costal cartilage calcification.

Forensic Odontology

- **CT is used for the followings :-**

1. **Human dental identification and age estimation.**
2. **Dental identification of burned corpse.**
3. **Identification of disaster victims using transportable dental CT scanner via comparison of antemortem and postmortem dental information.**

Forensic Ballistics

- **CT is used for the followings :-**

1- Firearm injuries

A. Study of gunshot residues, shooting distance, foreign body's location, and tracks in living and deceased.

B. Differentiate between contact shot and firing ranges of more than 10 cm in non-destructive method.

- **MRI is used for the followings :-**

1. Ballistic fracture pattern, bullet track and localization, trauma, pathological changes and gunshot residue deposition.
2. Synergy of CT and MRI in study of gunshot wound cases.
3. Postmortem detection of wound and soft tissue injuries.

Method	Advantages	Disadvantages	Field of application
Conventional radiography	Fast examination Easy to handle Simple data storage Relatively low maintenance costs Visualization of the skeletal system Detection of foreign bodies	Radiation (need for specific protection for the personnel) No 3D reconstructions Very limited visualization of soft tissue Superimposed image Quality strongly dependent on acquisition	Detection of foreign bodies Identification Age estimation Changes/lesions of the skeletal system
PMCT	Fast examination Easy to handle Ideal for 3D reconstructions Relatively low maintenance costs Excellent visualization of skeletal system and gas	Radiation (need for specific protection for the personnel) Data storage Limited visualization of soft tissue, organs, vascular system Training needed for correct interpretation	Trauma cases, especially lesions of the skeletal system (accidents, falls from heights, traffic accidents, blunt trauma) Sharp trauma Gunshot trauma Child abuse Detection of foreign bodies Identification

PMCT-angiography	Minimally invasive Good visualization of soft tissue and organs, especially the vascular system Ideal for 3D reconstruction of the vascular system Method of choice to detect lesions of the vascular system	Relatively time-consuming Data storage Special training needed Costs of material	Trauma cases (accidents, falls from heights, traffic accidents) Sharp trauma Gunshot trauma Bleeding, vascular lesions Death after surgical intervention Pathologies of the coronary arteries (evaluation of stenosis) and sudden cardiac death Detection of malformations of the vessels
CT-guided sampling	Minimally invasive Low risk of sample contamination Low risk of artifacts Easy to handle	Relatively time-consuming Special training needed Data storage	Sampling of body fluids and samples of organs for toxicological, microbiological, microscopic, and immunohistochemical examinations Sampling of gas for analyzing cases of putrefied corpses, gas intoxication, gas embolism, etc

MRI	Good visualization of soft tissue, organs, vascular wall No radiation	Time-consuming More difficult to handle High maintenance costs Need specific architectural construction 3D reconstructions need special sequences Data storage Training needed for correct interpretation	Blunt trauma Sharp trauma Strangulation Child abuse Medical errors, death after surgical intervention Detection of foreign bodies Age estimation Identification
3D surface scanning	Good visualization of surface High resolution (mm) Perfect for 3D modeling, reconstructions Very low maintenance costs Mobile	Time-consuming Extensive training for handling necessary No information about inner findings Treatment of data needs a specialist	Trauma cases (traffic accidents, blunt trauma) Reconstruction of traffic accidents Comparison between injury and injury-causing object Comparison of bite marks and denta imprint Digitalization of objects (eg, bones for anthropological examination)

Advantages

- It is suitable alternative of traditional autopsy.
- It prevents direct exposure to infectious disease such as TB and coronavirus.
- It provides objective data to enhance the credibility of results. (reliable reference in age determination by skeleton and dentition).
- It detects original injuries and pathological changes instead of destructing original evidence by surgical procedure.
- It investigates original tracks instead of destructive dissecting of tracks.

Disadvantages

- High costs of instruments, and maintenance.
- It is not commonly used because of its high cost .
- It is difficult to detect some pathological conditions.
- Limitation of CT scanning in detecting soft-tissue injury.
- Limitation in detecting of metal foreign objects.
- It can not detect all hemorrhagic sites in brain injury.
- PMCTA may induce rupture during its performance.

Global Impact of Forensic Imaging

- It is used in forensic practice and research.
- Maryland (USA) utilizes CT as an auxiliary method in autopsy.
- American Radiologic Pathology used CT in gunshot and drown cases.
- University of Southern Denmark used CT scan along with standard autopsy in forensic cases.
- Italians used CT scan as a screening diagnostic test before conducting traditional autopsy.
- in Austria, they utilized forensic imaging technique to detect traces on and within the body of examined person.
- China used postmortem multi-slice computed tomography (PMCT) and thin layer CT scanning and imaging reconstruction to identify age through sternal end of clavicle epiphyseal growth.

Thank you