

# Importance of Radiology in Forensic Medicine

## Review Article

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The importance of imaging techniques in forensic medicine is widely recognized. Forensic anthropologists and odontologists routinely rely on the comparison of ante-mortem and postmortem radiographic plates to establish identity. The location of foreign bodies and gas emboli, and the documentation of fractures and other types of injuries make x-rays an integral element of most medicolegal procedures. Radiographic studies of the body are crucial in early recognition of hazardous objects because exploding bullets that penetrated the body unactivated, undetonated explosive material, and retained shrapnel's (foreign bodies) can cause severe injuries to the forensic investigators if undetected before the autopsy. Clinical radiological examination plays a significant role in the diagnosis of non accidental injury in children and adults, in establishing medical negligence, and estimating biological age in disputed cases. Finally, there is an increasing demand for noninvasive techniques to replace the conventional autopsy in cases in which cultural and religious demands ban on invasive postmortem procedures. The aim of this review is to describe the various uses of radiology within the medicolegal realm.

Postmortem radiological examination is fairly common in forensic facilities. The permanent nature of x-ray plates made available to forensic expert for reevaluation and reinterpretation as additional evidence. The objective and non invasive character of radiographic records makes them a valuable tool for presenting evidence in court. The stage at which radiology is implemented during autopsy will vary according to the circumstances involved in a particular case. Generally, radiographs will be taken after the external examination and before the dissection, except in medicolegal investigation of bombings and charred bodies. In natural death cases as well as in investigations of assumed medical malpractice, the implementation of various imaging techniques is the most adequate method for detecting pathological features such as pneumothorax, pneumoperitoneum, barotrauma injuries, and air embolisms. Moreover, when traumatic subarachnoid

hemorrhage is suspected, vertebral angiography, if available, is recommended. When the body to be examined is badly decomposed, for instance, in exhumed cadavers, it is highly recommended to conduct a full body radiographic study that might help to visualize otherwise hidden injuries and pathological findings [1].

As a rule, in all gunshot wound cases it is strongly recommended that x-rays are to be taken. This includes instances where the bullet is known to be in the body, as well as those in which it has allegedly been exited. This relatively easy task can sometimes fails--a bullet can be overlooked even by experienced radiologists, because of "professional blinkers phenomenon" in localizing bullets. It is important to remember that bullet may even migrate; thus, the radiographic examination should include the whole body. The path of the bullet can be observed as a cloud of minute metallic particles detached from the projectile, the so-called "lead snowstorm", or by using more sophisticated imaging techniques such as computed tomography [1].

Radiography is useful not only to locate a projectile but also in determining whether metallic fragments are present, within the body, because even very small fragments of a bullet's jacket may suffice for a ballistic identification. The presence of "souvenirs" within the body can be revealed through radiographic examination of the body before autopsy. The precise location of a foreign body is better visualized in multiple radiographic planes, including antero-posterior and lateral ones [1].

The estimation of age at death of unidentified victims also can be achieved through radiographic evaluation of epiphyseal closure, for different reasons, which otherwise in an autopsy is not feasible. The poor visualization on x-ray of certain articular phases like the pubic symphysis makes radiographic age determination in case of adult non advisable [1].

For certain cultures and religions, conventionally autopsy is

stigmatized or even forbidden; various imaging techniques, like ultrasound, CT, and magnetic resonance imaging (MRI) may be allowed for conducting medicolegal investigations, respecting the sentiments of the victim's next of kin [2].

During the 1990s, a variety of alternative noninvasive procedures were proposed as substitute for conventional autopsy. The concept of "virtopsy" (virtual autopsy) was born out of the desire to overcome the obstacles posed by relatives of the deceased and to provide objective and indestructible documentation of postmortem evidence. The technique combines whole-body examination by CT and MRI to obtain two-dimensional and three-dimensional documentation. The advantages of virtopsy lie in the ability to "freeze" the findings at the moment of the investigation without causing damage and allowing the investigator to recapitulate the results later on, either for presentation in court, teaching, consultation through telemedicine, and/or quality control. Additional advantages of radiologic necropsy include, safe and easy examination of infected cadavers, minimizing the hazards to the practitioner [2].

The identification of human remains is one of the most essential aspects of forensic pathology. Unidentified human remains constitute approx 10% of the caseload of most forensic practitioners. This fraction includes skeletonized, decomposed, and burnt victims along with cases of extensive mechanical trauma to the face. Personal identification of human remains is achieved when specific features detected on the cadaver match data recorded during the life of the individual. Radiographic identification can be accomplished when there is a lead as to the possible identity of the victim; usually, this is the result of comparing an anthropological profile (gender, age, stature, and ethnic affinity) with police or military "missing persons" reports. The correct radiographic identification of the deceased greatly depends on the similarity of the conditions in which the ante mortem and postmortem radiographs were taken, that is, position and intensity. Radiographic positive identification of unknown human remains is often attained by comparison of some markers present on the ante mortem and postmortem plates, for example, signs of previous medical intervention such as old surgical or orthopedic procedures as well as prosthetic devices, evidence of healed trauma, normal anatomical variation like the variation and configuration of the frontal and paranasal sinuses, osseous and vascular degenerative changes, congenital malformations, and certain slow growing neoplasm's that might be evident within the remains [2].

Age determination of living individuals is crucial in many legal issues. In developing countries, where many a birth takes place in rural venues with deficient record keeping, when the suspicion of fraudulent registration arises-- especially in light of the recent increasing illegal emigration from third-world countries and the lack of proper official documentation of these individuals-- the forensic practitioner's expert opinion plays a key role in legal rulings [2].

In general, every country has an official age limit underneath which an individual will be considered a minor and will be granted certain leniency, for example, will be judged in juvenile court in cases of criminal charges, will not be enrolled into military service, or will be excluded from certain labors on the one hand, however, the individual who has not reached this official age limit will be denied

certain financial and legal rights, such as the right to legal binding contracts, marry, the right to have sexual intercourse with an adult, and so on [3].

Skeletal age can be evaluated by the sequence of development and fusion of epiphyses of long bones and development of centers of ossification in small bones. The point in time of each epiphysis' fusion varies greatly according to their anatomy and physiology. The pace of growth and development differs between the sexes and between various ethnic groups, and the onset of the diverse age indicators is affected by genetic and environmental factors; thus, they should be taken into consideration, at least for various stages of development for hands and knees. Other radiological developmental techniques include the careful estimation of bone-by-bone development of the hand [2].

Radiological technology plays an important role in diagnosing non-accidental injury (physical abuse). Some techniques such as skeletal scintigraphy are highly sensitive in the detection of rib, spinal, and diaphyseal fractures and have a low sensitivity for cranial fractures. This procedure should be considered as a supplemental examination in suspected cases of non accidental injuries. All these are considered diagnostic of non accidental injury because the forces necessary to produce such fractures cannot be generated from simple falls or other accidents [2].

Imaging techniques are a powerful tool in forensic sciences. Medical examiners and forensic anthropologists are less versed in the finer points of roentgenology than are radiologists; nevertheless, they are required to interpret findings from imaging studies to further medicolegal investigations. Often, the forensic investigator calls on the radiologist whose expertise might prove invaluable in forensic consultations. Radiological investigation during autopsy is priceless not only in gunshot wound cases, but in all instances when the practitioner might be required to locate foreign bodies, within the cadaver, like in suicidal bombing victims. The implementation of other imaging techniques, such as MRI and CT, are strongly advocated for cases of suspected air embolisms and for abuse victims. In the last decade of the 20<sup>th</sup> century, investigators have suggested the use of "virtopsy" (virtual autopsy) as the best tool to be used in conjunction with conventional postmortem examination to reveal the greatest amount of details pertinent to the case at hand [2].

The importance of complete radiological examination for postmortem as well as clinical cases of suspected abuse cannot be overestimated. Radiological evidence of skeletal trauma commonly is found in abused children aged 18 months and younger; the location, nature, and multifocal aspect of these injuries are considered specific for non accidental injuries. Radiological imaging plays a crucial role in evaluating cranio spinal injury, and the implementation of CT and MRI is advised in all cases of suspected non accidental cranial injuries [4].

In forensic anthropology and odeontology, radiographic examination plays a key role in positive identification of unknown human remains. This often is attained by comparison of ante mortem and postmortem radiographs. Some of the markers frequently collected in the plates are signs of medical intervention, normal

anatomical variation, and evidence of healed trauma. There are numerous accounts of cranial, dental, and postcranial radiographic features useful for identification. The correct radiographic identification of the deceased depends greatly on the similarity between the ante mortem and postmortem films. Positioning of the questioned anatomical specimens prior to radiograph is of paramount importance for comparison since the investigator strives to duplicate as closely as possible the ante mortem object-film angulation [2].

Biological age estimation of living individuals, an undertaking that is becoming more common worldwide in most forensic anthropology practices, is mostly supported by radiographic evaluation of dental and skeletal maturation [1].

The importance of careful record keeping in medical facilities and

private practices for as long as feasible cannot be over emphasized. In most countries, radiographs pertaining to inactive patient's files are stored at least for 5 years. The radiographic information can be stored on a magnetic media when facing space constrains, thus allowing one to save data for 20 years.

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