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Original Article

Imaging Techniques: A New Approach in Forensic Medicine

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Abstract

Forensic radiology is a specialized area of medical imaging using radiological techniques so as to help forensic specialists in matters pertaining to law. Radiological techniques have become more sophisticated with the introduction of CT, MRI and ultrasonography (USG). These are widely being applied by forensic experts and require active intervention of Radiologists. Radiographic images are widely used in identification of foreign bodies, child abuse cases, body identification, age estimation, determination of cause of death and injuries.

Keywords: Forensic radiology; Virtopsy; Identification; Biological age; Necroscopic examination.

Introduction

Radiology has got a significant role in Forensic Medicine and is often used in medicolegal matters in various ways. Radiological studies play a pivotal role in forensic cases for locating foreign bodies within the body like bullets, gas embolism etc., documentation of fractures and other mechanical injuries. Virtual autopsy (Virtopsy), which involves a full body computed tomography and magnetic resonance imaging examination to get two-dimensional and three-dimensional view is developing as an alternative to conventional autopsy. Antemortem and postmortem radiographic comparison is often used in the identification of unknown human remains. The use of radiographs in routine and mass disaster identification is well known and it's usage in necroidentification is an efficient easy method. Age estimation of the living as well as of cadavers relies on dental and skeletal radiographs. The aim of this review is to discuss the various uses of radiology in the clinical forensic medicine.

Necroscopic examinations

Postmortem radiological examination is common in forensic medicine. The permanent nature of x-ray plates makes them available for reevaluation and reinterpretation. Generally, radiographs are taken after the external examination and before the dissection, except in bombings and charred bodies. In natural death cases and assumed medical malpractice, the implementation of various imaging techniques help in spotting pathological features like pneumothorax, pneumo peritoneum, barotrauma injuries and air embolisms. In cases of suspected traumatic subarachnoid hemorrhage, vertebral angiography can be performed after death.[1] When the body to be examined is badly decomposed or exhumed, full body radiographic study help in envisioning hidden injuries and pathological findings.

Radiographs are used in forensic evaluation of gunshot wounds to localize the bullets, to determine the number and caliber of bullets, angle and direction of fire. Bullets often travel to distant sites from entry wound. Hence, radiographic examination should be of the

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whole body. Trajectory of bullet can be traced by characteristic finding of multiple tiny lead fragments referred as lead snowstorm[2] or by sophisticated imaging techniques like computed tomography.[3]

"Virtopsy" (virtual autopsy) has developed as an alternative to conventional autopsy with the merits of removing the hindrances by relatives of the deceased and providing objective, everlasting documentation of postmortem evidence. The technique combines whole-body examination by CT and MRI to obtain two-dimensional and three-dimensional documentation. It has the ability to provide the findings at the moment of the investigation without causing damage and permitting the forensic expert to recapitulate the results afterwards. Further benefits include safe and easy examination of infected dead body minimizing the risks to the forensic specialist.[4,5,6]

Identification of human remains

The identification of human remains is a vital requirement in forensic cases of skeletonized, decomposed, and burnt victims. Radiography is a common diagnostic tool in various dental and medical ailments. Hence, antemortem radiographs can be easily procured for positive identification.[7] Personal identification of human remains is accomplished when specific features noticed on the cadaver match the information documented during the life of individual. The radiographic identification of the deceased is influenced by the similarity in position and intensity conditions of antemortem and postmortem radiographs.[8] Radiographs of skull, dental, chest and abdomen are most commonly employed for positive identification.[9] Positive radiographic identification is accomplished by careful comparison of the details present on the film. The features depicted on radiographs must be unique to each individual, and should remain stable over time despite ongoing life processes and aging. Usually, one to four unique analogous features and no discrepancies are considered enough for a positive identification.[10] Radiographic positive identification of unknown human remains is done by comparison of features present on the antemortem and postmortem plates like old surgical or orthopedic procedures, prosthetic devices, evidences of healed trauma, variation and configuration of the frontal and para nasal sinuses[11], osseous and vascular degenerative changes, congenital malformations.[12] Radiographic techniques for identification are also used in daily forensic cases and mass disaster situations.[13] Panoramic radiographs, which enable the visualization of most structures of the jaws and related areas on a single film, have been advocated for mass screening.[14)]

Digital image processing is of paramount importance in forensic radiology. Contrast enhancement, brightness correction, and segmentation of images are acceptable measures, but any manipulations that alter radiologically visible structures by varying their angular relationship are unacceptable; the use of drawing tools which retouch, accentuate, or fade out contours should be shunned.[15,16]

The potential value of comparison between antemortem and postmortem radiographs in forensic pathology is nowadays fully appreciated. Similar comparisons between antemortem and postmortem CT images can yield successful personal identification.[17] This type of comparison is becoming more feasible as CT equipment is growing to be more available to forensic facilities worldwide.

Age estimation of the living

The estimation of the biological age is obtained from combining clinical and radiological data on dental and osseous development. Dental age is assessed from the degree of mineralization of dental buds, teeth eruption, and the root formation. Skeletal age can be appraised by the sequence of development and fusion of epiphyses of long bone, ossification centers in small bones, hands and knees.[18,19] A CT scan of the clavicle has been suggested as a reliable age indicator

for individuals younger than 21 to 25 years of age.[20] Through radiography, age can be established with considerable accuracy from time of skeletal development at about 20th week of gestation until early adulthood.[19] Most common radiographs used for establishing age up to 16 years are dental and hand radiographs. Postcranial radiographs of specific ossification centers are used for estimating older ages.[21]

Non accidental injury

Radiological technology plays a significant part in establishing physical abuse in children. In cases of suspected nonaccidental injuries, a complete radiographic skeletal examination is required, which should include the entire axial and appendicular skeleton.[22] Skeletal scintigraphy is very sensitive in revealing the rib, spinal, and diaphyseal fractures. This technique is an auxiliary consideration in suspected cases of nonaccidental injuries.[23] Subdural hemorrhages are a common sequel to violent shaking of an infant. Forensic radiologists recommend CT for detection of subarachnoid hemorrhages and MRI for revealing subdural hematomas, concussive and shear injuries. CT and MRI are equally efficient for demonstrating epidural hematoma and CT is favored for fractures.[24] Cranial CT is sensitive and specific in defining acute (recent up to several days old) extracerebral blood collections. MRI is superior to CT in depicting subacute (a few weeks old) and chronic (more than 3 months old) extracerebral bleedings and deep cerebral injuries.[25,26] Posttraumatic brain swelling can be detected on head CT as early as 1 hour and 17 minutes after the injury.[27]

Conclusion

Radiological examination play a significant role in determination of identity, evaluation of injury and death in both accidental and non-accidental cases, in diagnosing medical negligence and physical abuse of children and establishing the biological age. The implementation of imaging techniques, such as MRI and CT has further strengthened the radiographic evaluation. Radiological digital imaging methods are leading to the advent of bloodless and minimally invasive - Virtopsy as an alternative to conventional autopsy.

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