Review Article

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Radiology as a Tool in Forensic Practice

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Abstract

The present paper highlights the importance of radiology in forensic practice, which is applicable to the living as well as the dead. The interaction between the two disciplines is considerable, as forensic problems ranging from personal identification to age estimation have been solved radiologically. Through the years, radiology has proved to be an invaluable tool in the investigation of violent and unnatural deaths. A recent development in this field is the concept of a 'virtual' or 'digital' autopsy that seeks to replace the scalpel with a scanner to determine the cause of death. Modern imaging techniques may be more acceptable to society than conventional postmortem examination-viewed by laymen as mutilating and disfiguring.

Keywords: Forensic; Radiology; Virtual Autopsy.

Introduction

Forensic radiology uses medical imaging to answer a variety of legal questions, including those about suspicious and violent deaths [1]. In developed countries of the world, radiology is being increasingly employed as a tool in the investigation of medicolegal cases[2]. However, in our local set up, it is used only for special purposes.

The field of radiology comes in contact with the law whenever radiological methods assist in solving a forensic problem. One of the main areas where it is applied clinically is in age estimation of individuals, and almost every Forensic Department in the country has an age clinic attached to it.

In the years since Wilhelm Roentgen's discovery of x-rays, the use of radiography and other medical imaging specialities to aid in investigating civil and criminal matters has increased as radiologic technology can yield information that otherwise is unavailable [3].

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The present paper gives an overview of the various applications of radiological techniques, such as radiographs, Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) in different medico-legal situations, in both the living and the dead.

Clinical (in the Living)

In the examination of clinical forensic cases, usually in the Emergency or Forensic Department of the hospital, plain x-rays provide information for formulating an opinion regarding simple or grievous injuries in doubtful situations. They also help in age estimation of individuals in civil and criminal cases. The application of imaging procedures in living patients are enumerated in detail below:-

Cases of Trauma with Medico-Legal Implications

Routine Trauma Cases in Casualty

During the medical examination of cases of road traffic accident, fall from height or physical assault, which could lead to legal proceedings at a later date, x-rays aid in determining location, extent and nature of skeletal injuries, and in dating of fractures for medicolegal purposes. While preparing the wound certificate, casualty medical officers often rely on x-rays for diagnosing closed fractures, in order to give an opinion as to whether an injury is simple or

grievous in nature. According to Section 320 of the Indian Penal Code, fracture of a bone or tooth amounts to grievous injury, for which punishment of the offender is prescribed under Sections 325 and 326 of the Indian Penal Code [4].

Magnetic Resonance Imaging (MRI) has been found to be well suited to the examination of surviving victims of assault, and helps visualise internal injuries not seen at external examination of the victim [5].

Cases of Suspected Child Abuse

In our centre, such cases are few and far between. However, with moral degeneration in society and prevalence of social evils, they are on the rise, as is evident from the cases reported to the district child welfare committee (CWC). A child who has been physically abused may be brought to the hospital by the caretaker (abuser) with an inaccurate history that is inconsistent with the clinical findings. For instance, a 7 year old girl may present with alleged history of fall from height two hours ago, whereas the clinical examination reveals several fresh as well as healed injuries. Further, x-ray of the chest shows multiple rib fractures in various stages of healing. Thus, radiographs aid in recognition of rib and long bone fractures which may be clinically silent in children. According to Brogdon, oblique diaphyseal long bone fractures are highly suggestive of abuse, particularly in infants [6]. These fractures apparently result from twisting and torsion forces which cannot be generated from simple falls and accidents. Hence, the pattern and age of injuries along with findings that do not tally with the history should raise the suspicion of the medical officer to the possibility of child abuse.

Age Estimation

This is one of the most commonly performed examinations in forensic practice. Dental radiographs clearly demonstrate the development of teeth, eruption status and degree of root completion, which may be useful when tooth eruption is not visualised on inspection of the oral cavity. The appearance and fusion of ossification centres, in different parts of the body, may be observed on a good X-ray film, using antero-posterior and lateral views. The usual x-rays taken for this purpose are those of the wrist joint, elbow joint, shoulder joint, knee joint and pelvis. These serve as a very useful tool for the forensic specialist when giving an opinion regarding the age of an individual in potential sports competitors, alleged juvenile offenders and suspected child labourers. However, biological age of the living cannot be correctly estimated in adult individuals older than 25 years[7]. In older individuals, fusion of cranial sutures is taken into account.

Poisoning and Drug Trafficking

Metallic Poisoning e.g. Lead, Arsenic

Lead lines may be seen as opaque densities at the metaphyses of long bones and along margins of iliac crest in children, which are useful in the diagnosis of chronic lead poisoning [8]. Radio-opaque poisons like arsenic can be visualised in the GIT on a plain Abdominal X-Ray. In the present day and age, the incidence of chronic lead poisoning has declined, perhaps because lead water pipes are no longer used and unleaded petrol has been introduced. Chronic arsenic poisoning still occurs in parts of West Bengal and Bangladesh due to contaminated ground water[9].

Body Packing

A 'body packer' is a human drug carrier who swallows specially prepared drug packets in order to evade detection of illicit narcotic drugs while smuggling them across borders in the gastrointestinal tract. The commonly used drug packets are conventional "condom packages' or newer "pellets" with multiple layers of polyethylene food wrapping, tape and plastic bags with an average length of 4.5 cm and mean diameter of 1-2 cm.[6] These packets can be identified on a Plain Abdominal Radiograph or Computed Tomography (CT) Scan by an experienced radiologist.

Post-Mortem (in the Dead)

Radiological and imaging techniques are a valuable resource in the forensic diagnosis of cause of death. A comparison of antemortem and postmortem radiographs can aid in personal identification of the deceased, especially in mass disasters. In some situations, the trauma or disease which resulted in death may be visualised even before an autopsy is done. A whole body x-ray can be performed in cases of firearm injuries to localise the anatomical region where bullets/pellets are lodged.

Identification of Human Remains

Radiological procedures often assist in identification of individuals when visual recognition

may be next to impossible (in traumatised, dismembered or disfigured bodies). In cases of severe tissue damage and mutilation, radiology may become the primary and often the only means of positive identification. However, in most victims, antemortem radiographs must be available for direct comparison [6]. The usual practice is to compare pre-existing films from a potential matching subject with post-mortem films of the deceased unknown person taken during autopsy[10].

Correlation of Ante-Mortem and Post-Mortem X-Rays is Based on

- Individual anatomical variations, e.g. skull, spine, frontal sinuses
- Specific abnormalities, e.g. old fractures, deformities, callus formation, congenital anomalies or infective changes
- Foreign bodies seen radiologically, e.g. joint prosthesis, femoral pins or plates, metal sutures and surgical clips.

Radiographic Measurements like cephalometry and pelvimetry also assist in identification[11]. In one case, the dental radiographs of an alleged missing person were obtained from her dentist and matched those of a deceased female whose body was found buried on a hillside. This led to the conclusion that both the x-rays belonged to the same individual.

Cause of Death

Detection of Trauma and Haemorrhage

In forensic postmortem practice, the bulk of cases comprise road traffic accidents, falls from height and assaults with sharp/blunt weapons, all of which can result in extensive bodily injuries. Fractures and dislocations of bones and teeth are clearly visible on a good x-ray film. Hairline fractures, which may be missed during autopsy, are well delineated by imaging techniques. This assists in accurate documentation of trauma and cause of death. Intracranial haemorrhage in the extradural, subdural and subarachnoid spaces, as well as internal haemorrhage in the pleural, pericardial and peritoneal cavities can be detected with the aid of a CT scan[12]. MRI, on the other hand, is more useful for identifying soft tissue injuries, for example in a case of hanging or strangulation, to visualise underlying damage to the soft tissues of the neck. In fatalities due to choking, the foreign body may be visible in the larynx on a lateral view of a plain radiograph of the neck region. In some cases of electrocution, typical round density foci called 'bone pearls' or 'wax drippings' may be observed radiologically[13]. These are caused due to melting of Ca_3PO_4 by heat generated from the current. Evidence of air embolism consequent to suicidal or homicidal cut throat injury can be appreciated on x-ray as bubbles in the venous system, great veins of neck, inferior vena cava and heart. Fractures of the hyoid bone or thyroid cartilage in violent asphyxial deaths are also similarly demonstrated.

Death Due to Firearm Injuries and Missiles

In firearm injuries, missiles in the body (being radio-opaque) can be accurately localised with the help of X-Rays. This saves time, effort and tissue damage due to extensive dissection while searching for the bullet, which can be a tedious task[8]. The number of bullets within the body must be correctly recorded as the forensic specialist may have to give an explanation if it does not correspond with the number of entry wounds noted in the postmortem report. Moreover, bullets and pellets carefully recovered and preserved can be produced as evidence in subsequent legal proceedings. Explosives and parts of the bomb mechanism embedded deep within tissues can be detected on X-Ray in the case of blast injuries.

Radiological procedures may unravel concealed crimes and causes of death not initially suspected. For instance, a mutilated body discovered at the crime scene had actually sustained gunshot wounds, as the pre-autopsy radiographs revealed. In an incident in Shillong, a charred body was found inside a car with the suspicion that the deceased individual had been killed prior to being set on fire. In such a case, radiology helps to confirm or exclude possible causes of death like firearm and other mechanical injuries.

The detection of metallic substances at the site of injection or at their final place of lodgement e.g. gastro-intestinal tract is aided by imaging techniques[8]. In a sensational case, a metallic sphere 0.3mm in diameter containing the poison "RICIN" was introduced into the tissues of a Bulgarian newsreader in France, which proved to be fatal. The autopsy revealed a tiny pellet in the thigh with two small holes bored into its casing[14].

Sudden Natural Death

CT and MRI are helpful in the diagnosis of natural causes of death such as myocardial infarction, ischaemic heart disease, coronary atherosclerosis,

pulmonary embolism and pneumonic consolidation [12]. Subarachnoid haemorrhage due to natural causes (rupture of a berry aneurysm), infarcts and clots may show up on a scan of the affected region (head, thorax, abdomen, or extremities). In a suspected case of pneumothorax, the presence and extent of air in the pleural cavities can be seen on a pre-autopsy radiograph. Although the gold standard for diagnosis of most causes of sudden natural death is gross and histopathological examination, e.g. myocardial infarction, imaging methods could have a supportive role if done prior to the autopsy.

Virtual Autopsy (Virtopsy)

This refers to the use of modern imaging technology such as multislice computed tomography (MSCT) and magnetic resonance imaging (MRI) to establish an examiner-independent, three dimensional (3D), objective and reproducible forensic assessment method, eventually leading to minimally invasive "virtual" forensic autopsy[15].

'Virtopsy' could be a possible (futuristic) option when family members or public object to the conventional autopsy for cultural or religious reasons. In Shillong, a good number of medicolegal deaths, including road traffic accidents, are exempted from postmortem examination by the Deputy Commissioner of the district, at the request of the relatives. In such situations, a procedure which causes little disfigurement or mutilation may receive more public acceptance. It is a rapid identification tool in mass disasters. Moreover, it could receive better compliance for cases involving children or infants. As it is minimally invasive, it would also cut down exposure of dissectors to infection while dealing with deceased victims of tuberculosis or AIDS.

The main disadvantage of utilising this technology on a regular basis is the high cost and specialised training involved. There may be ethical issues when the same CT/MRI machine is used for living patients and dead bodies. A centre like ours with constrained infrastructural resources can ill afford to have a dedicated forensic imaging unit. At best, portable x-ray equipment could be utilised for medicolegal purposes.

Virtual autopsy has its limitations in cases of poisoning and natural death, when tissue samples have to be obtained for chemical or histopathological analysis. Postmortem changes such as putrefaction can present specific difficulties for imaging diagnosis [16]. As yet, it cannot replace a classical autopsy, but could serve as a complementary investigation,

Fig. 1: Radiograph showing epiphyseal union at the shoulder joint (448 x 336 px)

Fig. 2: Radiograph showing fracture of shaft of humerus, a grievous injury (448 x 336 px)

Fig. 3: This antemortem x-ray can be compared with a postmortem film to fix/exclude identity (448x 336 px)

combined with all normal surgical or pathological techniques. In select cases, it may be used as a pre-autopsy screening tool to reduce the number of unnecessary and invasive postmortem examinations.

Summary

Radiology has often aided in solving forensic problems in both clinical and postmortem situations. X-rays are particularly helpful in age estimation of living individuals and in determining cause of death due to firearms. Radiologists and forensic specialists have to work hand in hand while forming the opinion in medicolegal cases where imaging techniques have been employed. Records of forensic x-ray, CT and MRI films, preferably in digital format, are to be retained indefinitely, or until the case is finalised in court. In recent years, the idea of a 'virtual autopsy' has been conceived and could pave the way for minimally invasive postmortems of the future.

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