Conventional Radiology for Postmortem Imaging

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19.1 Introduction

Immediately after its discovery in 1895, conventional radiography was used in the courts to document and illustrate gunshot wounds and for many years continued to represent the most widely used postmortem radiology technique in (1) determination of identity (when conventional methods such as fingerprinting or DNA analysis are not available or cannot be utilized), (2) traumatic injuries (road traffic fatalities, falls from heights, etc.), (3) gunshot wound fatalities, (4) child abuse, and (5) forensic anthropology.

One of the most famous cases that employed conventional radiography occurred in 1935 in Scotland. Human body parts were discovered in a river and subsequently identified as belonging to two women who were probably dismembered. At the same time, the nurse and the wife of a doctor in Lancaster were reported missing. Radiological examination of the body parts enabled rapid assessment of the age and size of the two victims. Identification was carried out by superposing X-ray images of the skulls with photographs of the alleged victims. The surgical precision used to dismember the two women as well as other information suggested that the perpetrator possessed medical skills.

Introduction of MDCT in forensic practice in the last decades allowed the opportunity to provide a two-dimensional multiplanar and three-dimensional anatomic survey prior to dissection that guides the forensic pathologist to specific abnormalities if necessary; however, due to the common availability of conventional radiography and the specific indications that justify its use, such as the examination of corpses and objects that cannot be examined by CT due to a large volume, conventional radiography still plays an important role in legal medicine and can be considered still useful because of its excellent resolution and absence of artifacts.

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19.2 Conventional Radiology Before Autopsy: Where, How, When

For many years, forensic pathologists have used radiography to acquire a permanent record of part of a deceased person's anatomy and pathology before performing an autopsy. The images, which typically were obtained using conventional radiography or fluoroscopy, helped to document

Table 19.1 Imaging techniques in forensic radiology

	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

fractures, particularly in areas not easily seen during standard autopsy. Images also helped localize foreign material and collections of gases, prepare individual specimens, detect occult injuries, airplane and automobile parts, shrapnel and bomb fragments, etc.

Most forensic institutions possess their own X-ray devices; in other cases radiography can be performed with mobile units. If mobile units are employed and radiography is performed in the autopsy rooms, radiation protection measures should be strictly enforced to protect all personnel. Mobile units may also be used as backup when fixed units are nonoperational or as the primary unit for isolation or contamination cases and in field or temporary morgues.

Radiography is advantageous, as it is simple to perform, rapid, and cost efficient. Radiography is often implemented for infant corpses, for highly putrefied, charred, or otherwise altered bodies, and for bodies of unknown identity (Table 19.1).

Conventional radiology in forensic anthropology, identification, and child abuse are argumented in other chapters of this book.

19.2.1 Focus on Gunshot Wound Injuries

In 2006 the National Association of Medical Examiners recommended that radiographs be obtained as part of the investigation of any gunshot wound fatality and that recovery and documentation of foreign bodies be made for evidentiary purposes. Nowadays, in the investigation of gunshot wounds, conventional radiology is still universally used to locate the bullet, identify the type of ammunition and weapon used, document the path of the bullet, and assist in the retrieval of the bullet, even when MDCT is available as a complement of cross-sectional imaging. Orthogonal radiographic projections (frontal and lateral views) are the most optimal method of precise localization if radiography alone is being used. Lateral views can be added to the protocol to localize abnormalities in three dimensions as needed. Standard conventions for labeling of radiographs with identifying numbers or names and right- or left-sided body markers are necessary to avoid error.

The presence of a bullet is easily determined with conventional radiology by its characteristic shape and high radiographic attenuation. Measurement of its dimensions on radiography may be limited by inherent inaccuracies caused by geometric and physical factors. Radiographs show the borders of a metallic object very clearly but magnification always occurs because of the distance between the X-ray source and the body and bullet and the X-ray detector (Fig. 19.1). The shape and length of the object can be distorted when the object is not positioned perpendicular to the X-ray beam.

Bullets are composed of metals that have different composition and atomic number. Different metals may have unique visual and textural or tactile characteristics, but they are often indistinguishable in radiographic attention. Bullets are often encased in a copper or copper alloy jacket. They may also contain a steel perpetrator at the tip that is designed to enhance the bullet's ability to penetrate its target. The softer copper deforms more readily than the steel penetrator and even

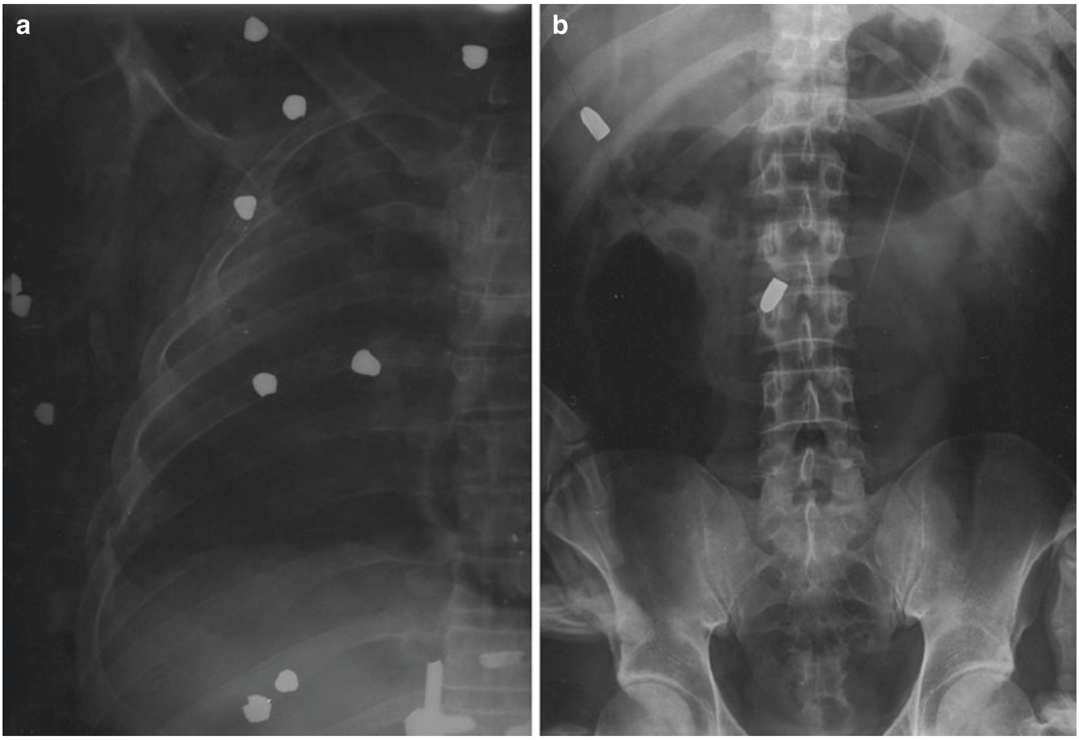

Fig. 19.1 (**a**) Digital radiograph shows 11 ovoid well-defined-in-shape metal pellets, similar in size. The pellets are grouped together, indicating that the shotgun was positioned at close range but did not have contact with the skin. (**b**) The shape and configuration of bullets are identical to the recovered

though they have the same radiographic attenuation, the shape may be a clue to the type of material. In cases where metal fragments exhibit a visible difference in attenuation, such as aluminum versus copper or steel, it is possible to see a difference on radiographs.

In *penetrating* gunshot injuries, bullets enter the body without exiting (Fig. 19.2a, b).

The bullet remains in the body as a single fragment or multiple fragments, depending on the bullet material and the interaction of the bullet with intermediate targets such as bone (Fig. 19.3a, b). If the bullet fragments along its course, metallic fragments will be deposited within the tissue along the course of the gunshot wound track.

In *perforating* gunshot wounds, if the bullet remains intact, there will be no residual metallic fragments in the body. In other cases a bullet may also fragment with portions remaining in the body and others exiting the body (Fig. 19.4).

The determination of the direction for perforating gunshot wounds relies on several features in addition to the characterization of entry and exit wounds. One of the most helpful features is the passage of the bullet through bone. When a bullet enters and exit bone, marginal fracturing creates beveling, with bevel occurring outward in the direction of travel.

Full-body radiography in case of gunshot wound fatalities is mandatory because it allows to document and locate all of the bullet fragments even when the bullet entered the body in one anatomic location; bullets often migrate to unexpected locations in the body and it is really confoundent in the determination of a wound track. This is particularly true when the bullet settles in a body cavity or tubular structure within the body such as the vasculature, trachea and bronchi, neural canal, and urinary and gastrointestinal tract. Bullets may travel to a location far from the wound path after entering a lumen or

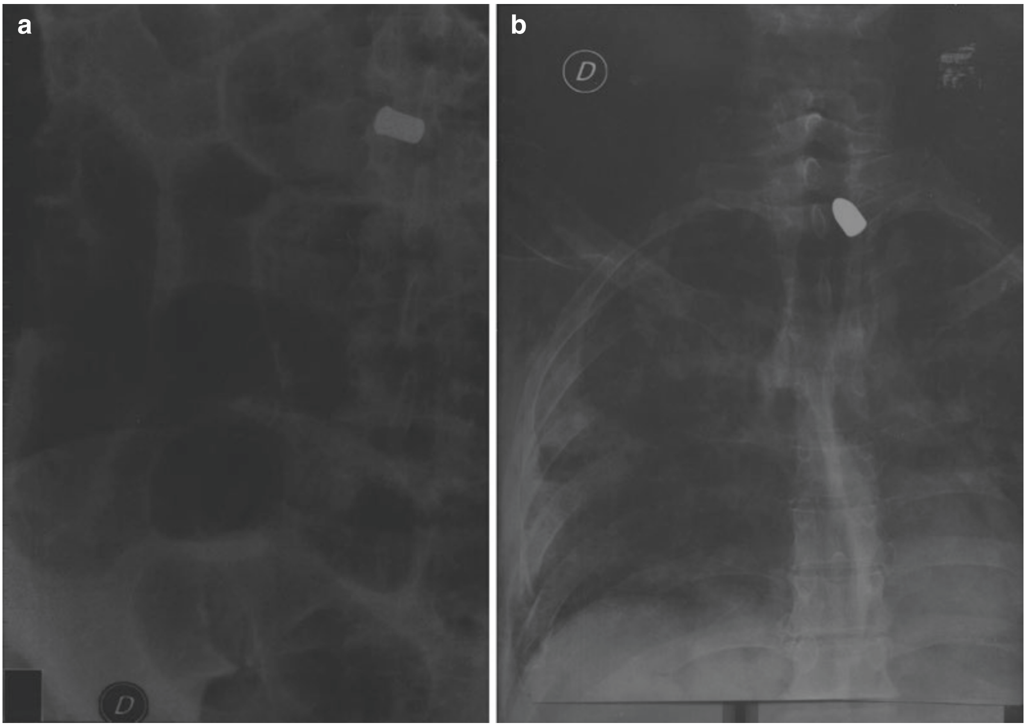

Fig. 19.2 Shotgun wound of the abdomen (**a**) and the thorax (**b**). Bullets with different shape and configuration

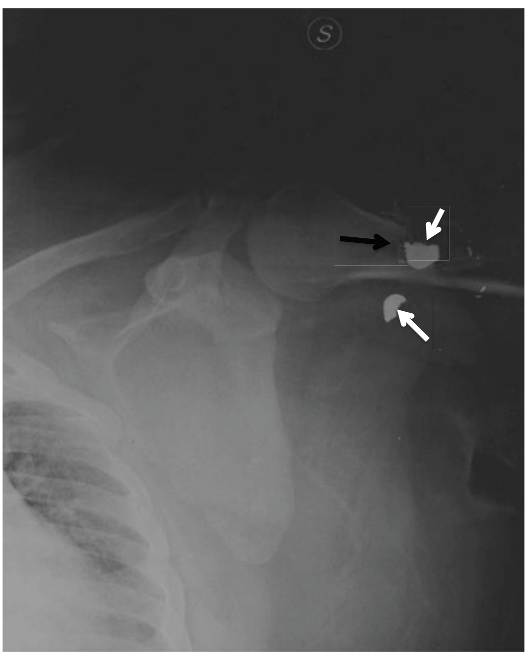

Fig. 19.3 Penetrating gunshot wound to the left arm. The bullet fragmented when impacted the humerus (white arrows). Comminute displaced fractures of the proximal third of the humerus are well documented (black arrow)

cavity. A variety of mechanisms, such as vascular flow, peristalsis, or simply gravity, may affect migration.

Multiple firearm wounds with overlapping anatomical trajectories may hamper individual projectile trajectory identification. These cases benefit from radiographic studies as it allows for identification of bone structure injuries as it traces a firearm projectile's possible trajectory; its most useful feature, however, is enabling the identification of shrapnel left by the projectile along its trajectory. Even if the caliber of the projectile found at the scene or victim is analyzed directly and thoroughly by a ballistics expert, this analysis may find further support in a radiographic study which also helps document evidence and preserve the chain of custody.

19.2.2 High-Energy Trauma

Adequate description and documentation of bone injuries in the study of traffic accident-related deaths are of major importance for the reconstruc-

Fig. 19.4 Perforating gunshot wounds. Few little bullet fragments retained after impact with humerus while major part exited the body

tion of the event. Pedestrians who are victims of traffic accidents frequently display fractures in lower limbs, commonly femur and tibia. The distance from the fracture site to the heel allows for estimation of the most prominent portion of the vehicle involved in the accident. Likewise, long-bone wedge fracture documentation enables to determine the primary impact direction by describing wedge-angle direction (Fig. 19.5).

In motorcycle accidents, cranial fracture description is essential; hinge fractures in particular are observed in motorcyclists after traffic

Fig. 19.5 Lower-leg X-Ray demonstrates high-energy injury

accidents with lateral cranial impact. In car accidents, the driver usually suffers acetabulum fracture with femoral impact, whereas the copilot suffers cranial fractures following ejection through the windshield, with secondary cranio-encephalic trauma. Crushing lesions caused by motor vehicles frequently involve multiple costal fractures and pelvis fractures, as well as solid viscera bursting due to sudden increase in intra-abdominal and intrathoracic pressure. Traumatic diaphragmatic hernias occur along as well. All these lesions are easily documented via conventional radiology.

19.2.3 Pediatrics

Conventional radiology is the mainstay of post-mortem imaging in forensic pediatrics. Emphasis is generally placed on skeletal development, both with regard to the gestational age and the presence of anomalies, such as skeletal dysplasias. In fetuses up to a gestational age of approximately 24 weeks, use of the mammography system is reported, as this has a high resolution and exquisitely depicts the fetal skeleton. In these cases a babygram, which visualizes developmental anomalies of the entire skeletal system in two or more views, is acceptable. In older fetuses and neonates a direct digital radiography system is preferably used. In babies and toddlers postmortem radiography is reserved for cases of sudden infant death syndrome (SIDS) or suspected child abuse. In these cases a full skeletal survey according to either the American College of Radiology or the Royal College of Radiologists should be performed, even if a whole-body CT is obtained. In older children (>4 years of age) postmortem conventional radiology plays a minor role and is only performed on special indications.

19.2.4 Miscellanea

Other applications of radiology in forensic medicine are possible, such as documenting bilateral pulmonary opacity in drowning cases and identifying radiopaque areas in the gastrointestinal tract of human drug couriers.

19.3 Conclusion

Technological advances in the last two decades led to revolutionary changes in imaging. Developments in multidetector computed tomography (MDCT) and magnetic resonance imaging (MRI) technology changed the practice of clinical medicine and radiology. The application of these technologies to forensic medicine changed traditional autoptical approach of pathologist and the use of conventional postmortem radiology which is now requested in few cases. Anyway, high availability and less expensivity make conventional radiology preferable in most situations (gunshot fatalities, high-energy trauma, highly putrefied, charred, or otherwise altered bodies, bodies of unknown identity).

Further Reading

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