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X-RAY STUDIES IN ESTABLISHING IDENTITY AND MANNER OF DEATH

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Recent textbooks on forensic medicine and crime investigation agree that x-rays are an indispensable tool of the crime detection laboratory. It is the purpose of this paper to point out the applications of x-rays in the field of forensic medicine. The usefulness of the roentgen rays is based on their ability to penetrate structures which are impervious to light and to make them visible on the x-ray film after the latter has been properly processed in the darkroom. Thus, to choose an example from the field of criminology, rather than dismantle a suspected box or package it might be advisable to roentgenograph it for the demonstration of a bomb.

It is, of course, understood that roentgen study in no way replaces thorough inspection and exploration of the body in the autopsy room, but is supplementary to this approach. The advantage of the roentgenographic method is that it allows a speedy and clean investigation of the skeleton without destruction of the soft tissues. Thus, an overall radiographic search for traumatic injuries to the skeleton and for foreign bodies, particularly bullets, may greatly facilitate and should precede the detailed investigation by the pathologist. As far as the soft tissues are concerned, the pathologist, by his dissection, may have to destroy vital evidence in order to obtain direct information on the skeleton. By contrast, x-ray study leaves the body intact.

The x-ray procedure may be the only means of investigation in a small community where there is no pathology laboratory available in which to study the skeleton for identification purposes. The pathologist, in his search for evidence to establish the manner of death, may overlook bullets or fragments of projectiles, that are buried in the soft tissues, or he may not detect vital fractures that

are easily revealed by x-ray, such as fractures of the hyoid bone. Glaister recalls a case in which the missile was ultimately shown to be located in the hip joint although the entrance wound was in the chest.

The first question that arises in identification, particularly of putrified fragments of meat is: is the part in question actually human? It is not as important to identify the animal species as it is to verify or exclude the human origin of the questionable tissues. We, ourselves, have had portions of a carcass brought to our anatomy laboratory which could have been human, but which turned out to have originated from a horse. Others have had the same experience with the paws of a bear or large dog (Quiring, Dutra). There are often striking resemblances, particularly in the extremities.

The next question is the determination of age. Here, x-ray studies are most valuable, particularly in the younger age groups below 25. In order to understand the usefulness of the roentgenographic methods for the determination of age, we have to review briefly bone growth and development.

Ossification, i.e., the deposition of calcium in bone, starts during fetal development. Bone formation is preceded by a stage where the skeleton is preformed in cartilage. Cartilage is invisible to x-rays. At 6 weeks of fetal life the first bone appears replacing cartilage. Small bony deposits are embedded in the cartilage in certain places such as the center of the humerus in the upper arm. These bony deposits are called primary centers. They appear in proper sequence which is known and which helps to determine the age of the fetus. At the time of birth most of the primary centers of the long bones of the extremities are present. A few are absent in hands and feet, where they appear in proper sequence during the first years of life. Additional

secondary centers make their appearance at the end of the long bones, again in a well established order during infancy and childhood. Charts have been designed which allow us to determine from the roentgenogram the approximate age of a child by the presence or absence of these secondary centers. As age progresses, both primary and secondary centers enlarge, but are separated from each other by cartilage. They finally fuse with each other. This is the stage when growth ceases. Again fusion of primary and secondary centers, just as their appearance, takes place at known ages and is concluded not before 25 years of age. Thus, up to this date, we have numerous clues which help us in age determination. It should be realized that severe illnesses and hormonal and nutritional disturbances will delay the ossification process and thus retard bony development.

To give a few examples: if the heel bone is developed in the fetus, it indicates that the fetus is past the 5th month which, for legal purposes, means a viable age (Dutra). Thus, this is forensically an important stage in bone development. The presence of secondary centers at the end of the thigh bone in the knee joint means that the baby is just full term. There are characteristic skeletal features in the hand that coincide with the beginning of the menstrual period, an age which we call menarche in the adolescent girl. From the roentgenogram we often can predict within a range of 6 months the arrival of menarche (Greulich and Pyle).

It should be mentioned in passing that the stage of tooth development is an additional means of determining age. The study of dentition in a subject of questionable age should be left to the dentist who is an expert in this field.

After 25, determination of age is not as exact and definite as in the younger age groups, but there are still important clues to be gained from the study of the skeleton. As one indicator we have the character of the sutures of the skull which gradually fuse as age progresses. The presence or absence of the teeth, progressive calcifications in the rib cartilages as individuals grow older, and wear and tear on our skeletons are all depicted on the x-ray film. In the older age groups the joint cartilages are eroded with secondary changes in the joints. The bones creak as a sign of this wear and tear, and these degenerative changes show up on the film. By means of x-ray films we can narrow down the age within 5 to 10 year age groups.

Further significance of x-ray study of the skele-

ton lies in the possibility of identification of the individual. Just as a face or finger prints have individual characteristics that are usable for identification purposes, so the roentgenogram of the skeleton displays many features that are typical for a given individual. The paranasal sinuses, such as the frontal or maxillary sinuses, differ in different individuals, so that, if old roentgenograms are available, they can be used for identification purposes (Culbert and Law). To the expert every bone tells its own story and can be utilized. Particularly helpful in this respect are congenital deformities, old fractures which have been demonstrated previously during life time, curvatures of the spinal column and residues of nutritional disturbances and illnesses that affected bones in the past and left a permanent scar.

The remains of a man were found in a car that had been burned completely, and it turned out not to be the owner of the car. A key was found in his pocket, that fitted the lock to a boarding house where there was a report of a person missing. An old x-ray film of this person was available which showed a fracture that was treated at a local hospital. The burned body was x-rayed and the same fracture in the same location was found. This was the main means of identification, particularly since finger printing of the burned body was not possible (Dutra).

The "Noronic" disaster in Canada in 1949 was a great challenge to any agency or laboratory that undertook identification of the victims. (Singleton; Brown, Delaney, and Robinson). The "Noronic" was a pleasure boat which undertook excursion trips on the lakes near Toronto. On one of these trips the boat caught fire and burned with 120 dead and many injured. Tremendous identification problems on the dead arose, particularly since the fire occurred in the early morning hours, with many people being caught in their night clothes and often without their dentures. Identification papers or keys were frequently absent from the bodies of the victims. In the panic people were running around the boat and were burned wherever they happened to be. Civil law requires definite proof of death for insurance purposes. Thus, positive identification had to be undertaken and here the x-ray method really came of age. A broad organization was set up requiring the participation of pathologists, radiologists, dentists, and police officers, as well as representatives of the Red Cross. One of the first tasks was to canvass the hospitals all over the area for x-ray films of people that had or were

suspected to have died on the ship. An average of 13 x-ray films of every one of the dead were taken, and these films were compared with the available x-ray films from the hospitals.

Of course, some cases were easily identified by other means, but about 78 bodies were left where absolute identification was not possible and where identification by circumstantial evidence from the x-ray films had to be resorted to. One victim, a woman, had an old fracture of the pelvis and x-ray films taken during life and one taken after death had the same identifying feature.

Another person was missing and was not found among the victims for weeks. An x-ray film of this missing person was available showing one characteristic feature, a marked abnormal curvature of the spine. Curvatures of the spine are rather common, but not to such a degree as in this case. The investigators tried to match the film showing the curvature with every available body, but with negative results. It was months later, that they found the body in a compartment that was locked and under water. When the body was recovered, it showed just that curvature of the spine which identified it.

As to the determination of the manner of death, depressed skull fractures in which the skull is caved in, e.g., by a hammer blow, are easily revealed on the x-ray film while the pathologist may have to search for them throughout the bruised skull. In this case the film is an easy method of revealing the location of the injury and the cause of death.

Police officers are familiar with the identification of bullets and the determination of the direction which a bullet took through the body of the victim. Radiographically we can trace and identify the point of entrance of the bullet, as compared to the exit, by the fine metal dust which is deposited at the site of entrance but not of exit. Even the direction that the bullet took can be reconstructed from the film, in addition to the location and type of bullet. Sometimes a pathologist might have to look a long time before he would find all fragments which are so easily demonstrated on the film.

Another interesting case illustrating the importance of the radiologic method for investigative purposes, was described by Morgan and Harris.

A 57 year old owner of a hog farm who employed a tenant for feeding of the hogs, was found dead in a hogpen which housed 75 hogs. His body was covered with mire and was badly mutilated by the hogs. The victim was known to suffer from severe heart disease. Thus it was assumed that he had been working around the hogpen, had had a heart attack and lost consciousness or died. He was then presumed to have fallen into the pen where the hogs had eaten all protruding parts. Gross inspection seemed to bear out the assumption of natural death. The examiner, in an effort to study the extent of the injuries to extremities and face, first fluoroscoped and then took a number of x-ray films of these regions. Surprisingly the wounds on the hands were compound fractures, not caused by hogs, but by buckshot that had penetrated the hands. On radiographing the skull, it also was found to contain numerous buckshot. The explanation was that the tenant who had not been suspected at all previously had shot the victim. The x-ray evidence aided materially in the presentation of the case in Criminal Court.

This paper illustrates briefly the usefulness of the radiologic method in identification of persons and determination of the manner of death.

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