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Radiologic Identification of Unknown Human Remains

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ABSTRACT: During the 15 months from April 1978 through July 1979, 3964 cases were referred to the City of St. Louis, Office of the Medical Examiner. Of these, 71 (1.8%) required investigation to establish identification (ID). All cases were rigorously investigated to establish the most scientifically sound ID possible. In addition to evidence from the scene, fingerprint, dental, and X-ray studies were attempted. Fifty (80.4%) individuals were scientifically identified, 17 (24%) were circumstantially identified, and 4 (5.6%) remain unidentified.

Thirty (60%) of the 50 scientific IDs were by comparison of premortem and postmortem radiographs. Positive ID was accomplished in 22 cases of decomposition, 4 fire victims, 2 inadvertent body misidentifications, 1 submersion victim, and 1 suicide. Although all regions of the body were useful for ID, chest, skull, and abdominal radiographs were most frequently helpful. Anatomic, disease, and postsurgical features provided the unique features necessary for identification.

KEY WORDS: pathology and biology, human identification, postmortem examinations, radiography, X-ray, musculoskeletal system

It is the responsibility of medical examiner or coroner systems to determine the cause and manner of death of persons within its jurisdiction. During the completion of this task, it may be necessary to identify human remains. Such scientific identification (ID) may be important for the satisfactory conclusion of both civil and criminal proceedings. When identification can not be confirmed by visual inspection, then fingerprint, dental, anthropologic, and radiologic examination may complete the scientific ID. Each of these, except radiology, has been used extensively and found good acceptance. Through the presentation of our recent experience, we hope to show that routine application of scientific radiologic identification to the daily problems of forensic medicine is effective, timely, and relatively easy.

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Methods

At the beginning of this study period, we decided to make an effort to scientifically identify all human remains to the best of our ability. A log of all cases needing such an ID was kept and an effort made to fully exhaust fingerprint, dental, and radiologic possibilities for each individual. No conscious bias in favor of a particular method was introduced.

In general, a medical history was obtained as soon after presumptive ID as possible. Routine search for X-ray and dental records ensued. Postmortem X-rays were obtained before autopsy in nearly all cases and consisted of a total body survey in the anterior projection. As radiologic identification progressed, selected additional radiographic projections were obtained in several cases. Forensic odontologic investigation was performed by an interested member of our dental school. Fingerprints were processed by the usual law enforcement method.

The study lasted 15 months, from April 1978 through July 1979, during which time 3964 cases were investigated by the City of St. Louis, Office of the Medical Examiner.

Results

Of the 3964 cases processed, 71 (1.8%) required investigation to establish identity (Table 1). Satisfactory scientific identification was accomplished for 50 (70.4%) individuals, 17 (24%) were circumstantially identified, and 4 (5.6%) remain unidentified.

Of the 50 scientific identifications, 30 (60%) were accomplished by comparison of premortem and postmortem radiologic information. Fingerprints confirmed identity in 11 (22%) cases, dental investigation in 6 (12%), and acceptable visual criteria in 3 (6%). Identification by medical radiography was most successful for decomposed human remains found on land and for victims of residential fires (Table 2). It confirmed correct identity

TABLE 1—*General results of a 15-month prospective study of medical X-ray contribution to ID of unknown human remains.*

3964	cases	
71	ID problems (1.8%)	
4	no ID made	
17	circumstantial ID	
50	scientific ID	
30	(60.0%)	medical X-ray
11	(22.0%)	fingerprints
6	(12.0%)	dental
3	(6.0%)	visual

TABLE 2—*Human remains identified by medical X-ray.*

Condition of Remains	Human Remains by Category, *n*	Identified by Medical X-Ray, *n*
Dry floater	40	22
Wet floater	11	1
Fire	11	4
Dismemberment	2	0
Misidentified body	2	2
Other	5	1

when two bodies were inadvertently mislabeled. Medical radiography also identified one submersion victim and one suicide.

The radiographs found most useful were those of the chest (Fig. 1), skull (Fig. 2), abdomen (Fig. 3), extremities, and spine (Table 3). Findings on these radiographs, which provided unique features and allowed positive ID, included calcifications (Fig. 1), normal anatomic variations, evidence of previous surgery (Figs. 2 and 3), and fractures (Table 4).

Generally, more than 24 h was required between the initiation of the investigation and the confirmation of identity (Table 5). Scientific ID by medical X-ray required the most time (average, 7.9 days), while fingerprint and dental IDs were very similar, requiring an average of almost five days. Circumstantial ID, the least scientific modality, required approximately two days.

Finally, medical radiography excluded two presumptive identifications developed for a torso recovered from the water (Fig. 3).

Discussion

Identification of human remains by comparison of postmortem and premortem radiographs is not new. However, experience is limited to a few individual case reports (Table 6), a retrospective study in Rhode Island [*1*], and one summary of the experience gained following a mass disaster [*2*]. Contrary to this limited usage, our prospective study demonstrates that medical X-rays may be effectively used for scientific human ID during routine medicolegal investigation.

Although IDs by fingerprint and dental techniques are well established and proven effective, in our study ID by radiologic techniques compared very favorably. In fact, radiologic ID was three times more effective than fingerprints and five times more effective than dental methods. We have found only two other studies that compare modalities. Of 3005 cases examined retrospectively in Rhode Island, 1.6% required identification, of which fingerprint and dental procedures each identified 12% and medical radiographs, 6% [*1*]. For the *Noronic* steamship disaster, medical radiographs were four times more effective than fingerprints, mostly because of severe tissue damage from fire [*2*].

For a modality to be effective and accepted, it must prove its usefulness and must not delay the workings of a busy office. In our hands, medical radiography has proven effectiveness, and though on the average it takes longer to confirm an identity by this modality, it has not hampered the timely completion of our service responsibilities.

Medical radiography has many advantages, not the least of which is the number of medical X-rays generated each year. The federal government estimated that there were 129.1 million medical X-ray examinations performed in 1970, when the noninstitutional population was estimated to be 200 million [*3*]. Between 1961 and 1970 the number of medical X-ray visits per 100 persons increased from 47.9 to 55.9. Although more recent statistics are not available, it seems safe to assume that the number of examinations has not diminished. Furthermore, medical X-rays are considered a part of a person's medical record and are generally maintained in files for at least five years, and then often microfilmed. Therefore, medical X-rays exist for nearly every American and should be available with appropriate investigation.

The skeleton usually survives natural and unnatural processes and hence nearly always can be examined radiographically. Similarly, radiographs obtained for almost any reason will include parts of the skeleton. Therefore, it is commonly possible to have premortem and postmortem studies of the skeleton for comparison.

Most important, like fingerprints and dental characteristics, medical radiographs contain details that are individual enough to provide scientific ID through comparison [*4–11*]. Many areas of the skeleton are sufficiently different from individual to individual to have been suggested as tools for ID of the general population or segments thereof. Greulich [*12*] pointed

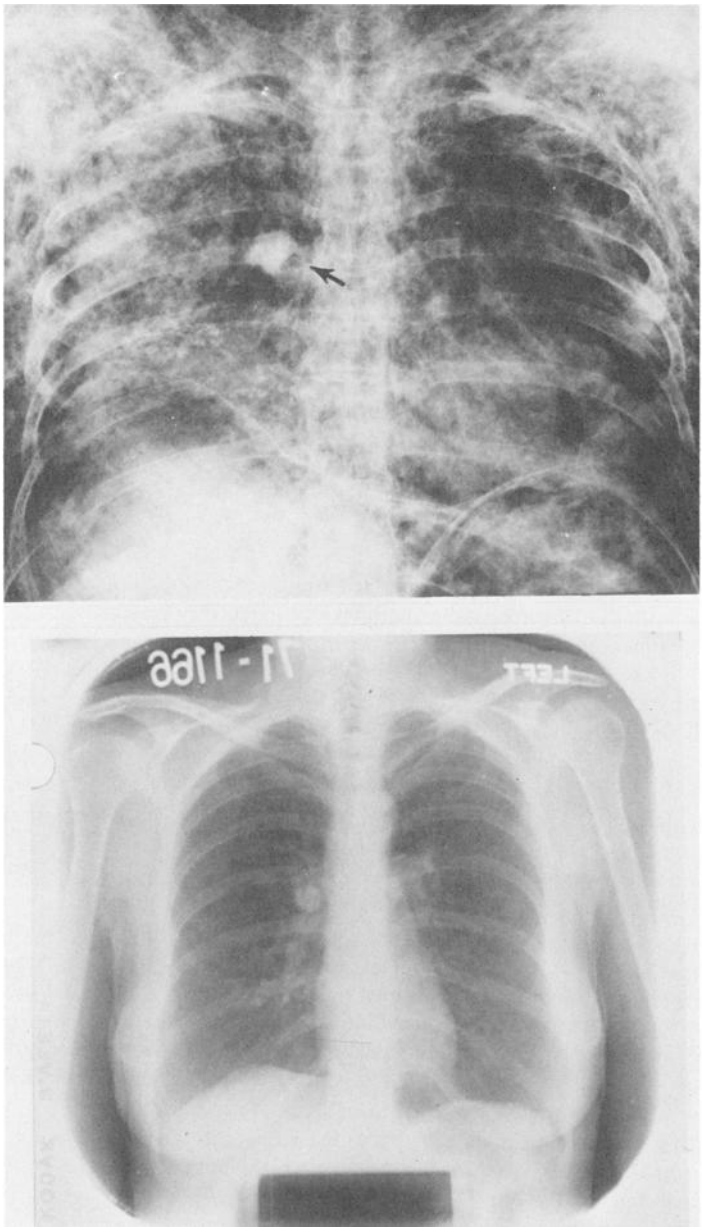

FIG. 1—*A woman was found dead at home in an advanced stage of decomposition.* (Top) *Postmortem X-ray of the thorax showed diffuse subcutaneous gas from decomposition and a large calcification* (arrow) *in the right hilar region from previous granulomatous disease.* (Bottom) *A premortem 105-mm survey chest film, obtained from a local mental hospital, showed identical skeletal features as well as the characteristic calcified granulomatous lymph node.*

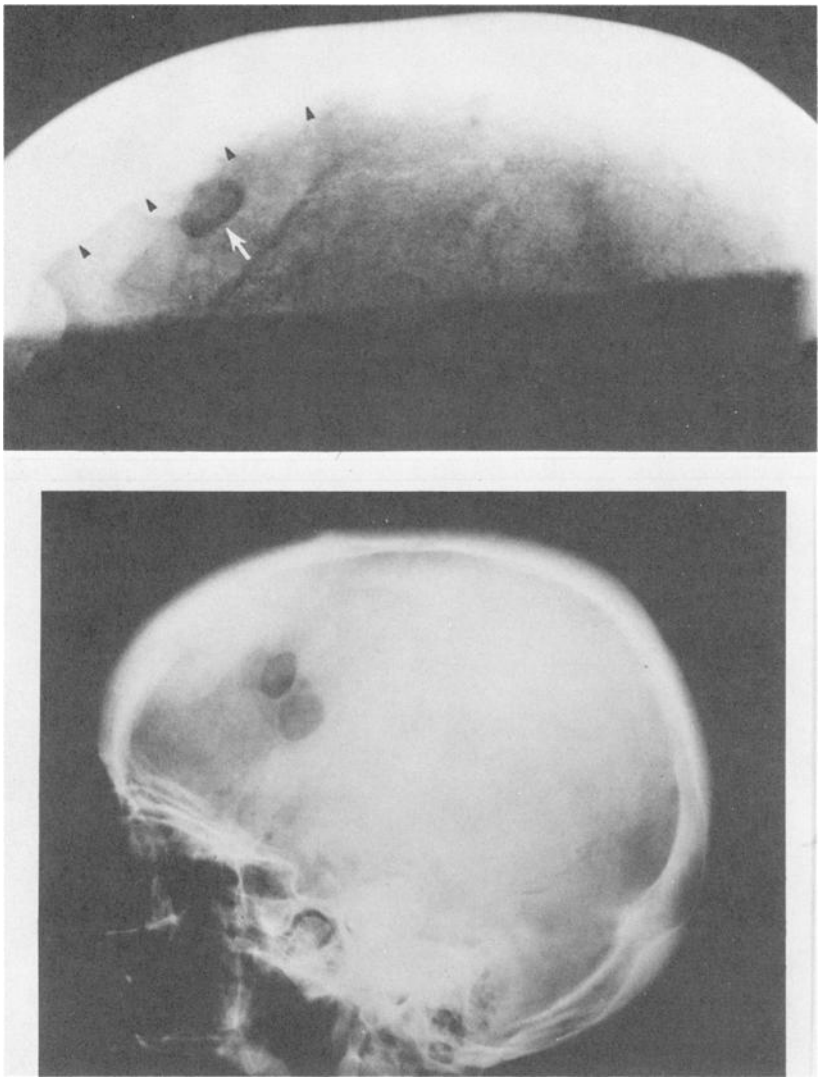

FIG. 2—*A woman was found dead after an apartment fire.* (Top) *Postmortem X-ray of the skull cap taken after autopsy showed frontal burr holes* (arrow) *from previous neurosurgery. Benign cranial thickening known as hyperostosis frontalis interna* (arrowheads) *is also present.* (Bottom) *A premortem lateral skull film from a state hospital showed identical burr holes and cranial thickening.*

out that hand and wrist X-rays were characteristic, even among most twin pairs. Voluter [*13*] suggested radiographs of the sphenoid sinus and base of the skull, and Law [*14*] favored frontal sinus examinations for general ID purposes. Sanders et al [*9*] convincingly demonstrated ID by radiography of a left clavicle, the only remaining bone found seven months after an automobile accident. Thus, skeletal details are often sufficient to provide scientific ID of human remains.

It is not always necessary to scrutinize the skeleton for minute details of normal anatomic variation. While anatomic shape may be sufficient for confirmation of an ID, characteristic

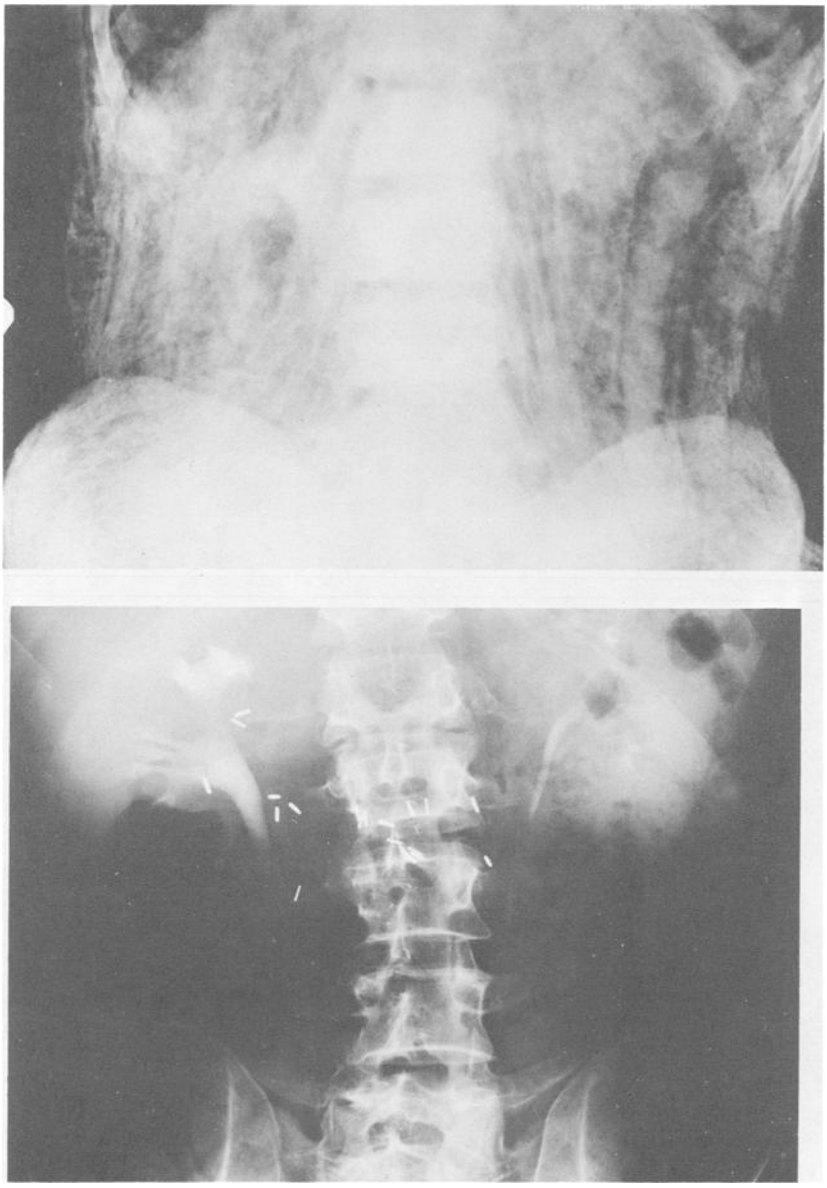

FIG. 3—*A male torso with femora was recovered from Mississippi River.* (Top) *Postmortem X-ray of abdomen showed no characteristic abnormalities.* (Bottom) *A premortem radiograph from an intravenous pyelogram of a possible match showed metallic clips from previous abdominal surgery and skeletal details of the lumbar spine different from those of the torso. The identification was excluded.*

TABLE 3—*Positive ID by anatomic region.*

16	chest
6	skull
6	extremities
5	lumbar spine
3	cervical spine
1	pelvis

TABLE 4—*Radiological observations useful for ID.*

11	chest calcifications
9	normal anatomic variation
7	evidence of surgery
5	fractures
2	congenital anomaly
2	abdominal calcification
2	arthritis

TABLE 5—*Average days until ID confirmed.*

Average	Range	Technique
7.9	2-20	medical X-ray
4.9	1-32	fingerprint
4.8	1-16	dental
2.2	1-8	circumstantial

TABLE 6—*Case reports of ID by comparison of premortem and postmortem radiographs.*

Reference	Year	Body Part	Unique Anatomic Detail
Culbert and Law [*4*]	1927	skull	frontal sinus shape, mastoid air cells
Dutra [*5*]	1944	femur	fracture
Kade et al [*7*]	1967	calcaneus	trabecular pattern
Camps [*8*]	1969	skull	frontal sinus shape
Sanders et al [*9*]	1972	clavicle	trabecular pattern
Martel et al [*10*]	1977	ribs	cartilage calcification
Atkins and Potsaid [*11*]	1978	skull	frontal sinus shape
		hand and wrist	trabecular pattern

skeletal or soft tissue changes caused by disease or surgery may be present. In our study, these landmarks were more important than matching normal anatomic features. In fact, a single characteristic calcification, surgical change, or orthopedic appliance confirmed identity in many of our cases. Therefore, comparison of premortem and postmortem radiographs must include careful evaluation of the remaining soft tissues and attention must be directed towards telltale evidence of disease and surgical intervention. No body part should remain unexamined.

As much as medical radiography may help in confirming human identity, it may also serve to exclude an identity. We had developed two presumptive IDs for a torso recovered from the Mississippi River. In both cases, radiological assessment excluded the possible match. One was excluded by arthritic changes observed in the cervical spine and the other by evidence of abdominal surgery (Fig. 3).

Of course, confirmation or exclusion of identity rests on establishment of a presumptive ID. Following this, a medical history is obtained and the medicolegal investigator must locate the medical radiographs or whatever record remains of them. In our experience, two cases were identified by microfilmed radiographs, one by a match between an old X-ray report of skeletal configuration and the postmortem X-ray study, and another by a very characteristic medical history of fracture and osteomyelitis that matched the postmortem X-ray findings precisely.

We think that human ID by medical radiographs is optimized by consultation with an interested radiologist. Radiologic training helps avoid technical traps caused by positioning and exposure, and conversely facilitates comparison when technical factors are not similar. A radiologist is trained in the evaluation of radiographic studies for normal anatomy, its variants, and the effect of disease and surgical intervention. It has been adequately demonstrated that a radiologist can match as many as 100 paired radiographic studies when they are presented as unknowns, even though the examinations are very similar [*10,11*]. Testimony in support of this skill has been cited in a homicide trial [*11*]. This expertise is readily available throughout the country, and radiological consultation can potentially help a medicolegal death investigation effort.

Summary

Scientific ID of human remains can be completed with medical radiographs after the establishment of presumptive identity. Because most Americans have diagnostic X-ray examinations, and because these examinations are generally maintained as part of the medical record, premortem radiographs are commonly available for comparison with postmortem studies. Since the skeleton usually survives most insults and is characteristic for each human being, its features as displayed on radiographs may be used for ID, much as are fingerprint or dental attributes. If soft tissues persist, they will likewise yield specific radiographic information concerning the effects of aging, disease, and surgery. Scientific comparison of premortem and postmortem X-ray studies is enhanced by consultation with a radiologist. Radiological ID of otherwise unconfirmed human remains can be accomplished in a timely and efficacious fashion.

Acknowledgments

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