

CASE REPORT

Fabrice Dedouit,^{1,2} M.D.; Norbert Telmon,¹ M.D., Ph.D.; Céline Guilbeau-Frugier,³ M.D.; David Gainza,¹ M.D.; Philippe Otaï,² M.D., Ph.D.; Francis Joffre,² M.D., Ph.D.; and Daniel Rougé,¹ M.D., Ph.D.

Virtual Autopsy and Forensic Identification— Practical Application: A Report of One Case

ABSTRACT: The body of an unidentified elderly woman was found trapped in a floodgate. Prior to autopsy, full-body multislice computed tomography (MSCT) was performed for study of bone lesions and cause of death. Age was estimated by analysis of the sternal end of the fourth rib and of the pubic symphyseal medial articular surfaces. The results were then compared with the autopsy findings. MSCT was superior to autopsy in diagnosis of traumatic bone lesions and also revealed dental anomalies and signs of drowning. Age estimation gave a similar result for both methods. This case report illustrates the potential value of MSCT for medico-legal investigations of death: diagnosis of injuries, possibility of determining the cause of death, and anthropological study in order to estimate age or to visualize features likely to enable identification of a corpse.

KEYWORDS: forensic science, bones, computed tomography, drowning, identification

Postmortem investigation is increasingly assisted by multislice computed tomography (MSCT) and magnetic resonance imaging (MRI) (1–5). Preliminary results led to consider implementing a noninvasive or minimally invasive autopsy technique as an alternative to forensic autopsy in selected cases. MSCT and MRI have numerous advantages over conventional autopsy: the techniques are noninvasive and the data can be visualized *in situ*, stored and fully reinterpreted at any time.

We present a case which illustrates some of the possibilities of postmortem MSCT: for medico-legal investigation of death to determine the cause of death and to diagnose injuries, but also in medico-legal anthropology to assess the age of an unidentified victim and to reveal features potentially useful for identification.

Material and Methods

Case

The body of an elderly woman was found trapped in a floodgate. After it had been removed from the water, external examination found several cutaneous head injuries. The body was unidentified. A medico-legal autopsy was ordered.

Imaging

The anonymity of the deceased was preserved by wrapping the corpse in two artefact-free body bags. Full-body MSCT exploration was performed on the day of recovery in the radiology

department. Axial MSCT was performed with 16×0.75 mm collimation on a Sensation 16 unit (Siemens, Erlangen, Germany). Anthropological study was performed based on dry bone criteria only for age estimation. Indeed, the age, sex, stature, and the race were determinable because of well preservation of the body. The pubic symphysis was virtually dissected and both medial surfaces of the symphyseal faces were examined. Reconstructions of the extremity of the right fourth rib were also obtained. Age was estimated using the Suchey-Brooks method for the pubic symphysis and Iscan's method for ossification of the sternal end of the fourth right rib (6,7). Two- (2D) and three-dimensional (3D) reconstructions were obtained on a Leonardo workstation (Siemens, Germany). 2D reconstructions were obtained using multiplanar reconstruction (MPR). 3D reconstructions were obtained using volume rendering technique (VRT) mode and maximum intensity projection (MIP) modes. The time of acquisition for a full body exploration was 10 min and time for 2D, 3D reconstructions and interpretation of the images was 1 h. The images were interpreted by board-certified radiologists.

Autopsy and Anthropological Study

Autopsy was performed by board-certified forensic pathologists and forensic anthropologists. All three body cavities (cranium, thorax, and abdomen) were examined. The pubic symphysis and the sternal extremity of the right fourth rib were dissected and carefully cleaned in hot water. The aim of this anthropological study was to estimate the age of the deceased. The results of radiological investigation and autopsy were compared.

Results

External Examination

The body was an elderly caucasoid female, of medium stout build and normally dressed. Two bruise injuries were noted at the posterior part of the head. Macroscopically they were not

¹Service de Médecine Légale, Hôpital de Rangueil, Avenue du Professeur Jean Poulhès, 31403 Toulouse Cedex 4, France.

²Service de Radiologie Générale, Hôpital de Rangueil, Avenue du Professeur Jean Poulhès, 31403 Toulouse Cedex 4, France.

³Service d'Anatomo-pathologie, Hôpital de Rangueil, Avenue du Professeur Jean Poulhès, 31403 Toulouse Cedex 4, France.

Received 11 Aug. 2006; and in revised form 24 Feb. 2007; accepted 24 Feb. 2007; published 4 June 2007.

hemorrhagic and appeared to be postmortem. An old scar was observed on the anterior part of the right leg.

Imaging Using Fluoroscopy and MSCT

Screening of the corpse using fluoroscopy revealed metallic fixation devices in the right tibia. Such features are important for identification if ante-mortem radiographs exist and are recovered.

The MSCT investigation detected many traumatic bone fractures: fractures of the posterior segment of the first left and second right ribs, the left occipital condyle, the anterior part of the first cervical vertebra (Fig. 1a), and both pedicles of the second cervical vertebra (Fig. 1b). Subluxation of both apophyseal joints between the second and the third vertebrae were noted (Fig. 1c). The cervical spine lesions were not surrounded by soft tissue infiltration and were consequently considered as postmortem injuries. Comminuted fractures of the sternum were diagnosed, with infiltration of the soft tissues surrounding the fractures. This aspect suggested vital injuries. Scalp injuries and an old fracture of the eighth thoracic vertebra were also observed.

The MSCT findings suggested a diagnosis of drowning. Fluid was visible within the esophagus, trachea, and bronchi (Fig. 2a). The pulmonary parenchyma had a “crazy paving” appearance with thickened inter- and intra-alveolar septa and alveolar congestion (Fig. 2b). Furthermore, air-fluid levels were noted in the frontal, maxillary, ethmoidal, and sphenoidal sinuses (Fig. 2c).

Autopsy

After reflecting the scalp, no hemorrhagic infiltration was seen. No injury of the skull or the brain was observed. Examination of the neck found only abnormal mobility between the first and the second cervical vertebrae. No hemorrhagic infiltration was noted around the cervical spine, in particular within the cervical muscles surrounding the spine.

In the thorax, the lungs were edematous and congestive. The bronchial lumen was filled with water. The sternum was fractured with peripheral hematoma; this fracture appeared to be vital. No other injury was observed. All organs were macroscopically unremarkable except for a congestive appearance.

Virtual Anthropological Examination Using MSCT

Pubic Symphysis—According to the Suchey-Brooks female pubic symphyseal phases, the pubic symphysis was estimated to be phase V (6) (Fig. 3a). This represents a mean age of 48.1 years, with a standard deviation of 14.6 years, and an estimated age range of 25–83 years in 95% of cases.

Fourth Right Rib—Bony projections were visible arising from both the rim and floor of the pit, along with evident deterioration of the bone itself (Fig. 3b). The rim was very sharp and irregular. The pit was large and of a wide U-shape. Ossification of the sternal end of the fourth rib according to the Iscan female phases was analyzed and assigned to phase VII (7). This represents a mean age of 65.2 years, with a standard deviation of 11.24 years, and an estimated age range of 42.7–87.7 years in 95% of cases.

Teeth—Analysis of the teeth by MSCT provided interesting possibilities for identification (Fig. 3e). Determination of the dental

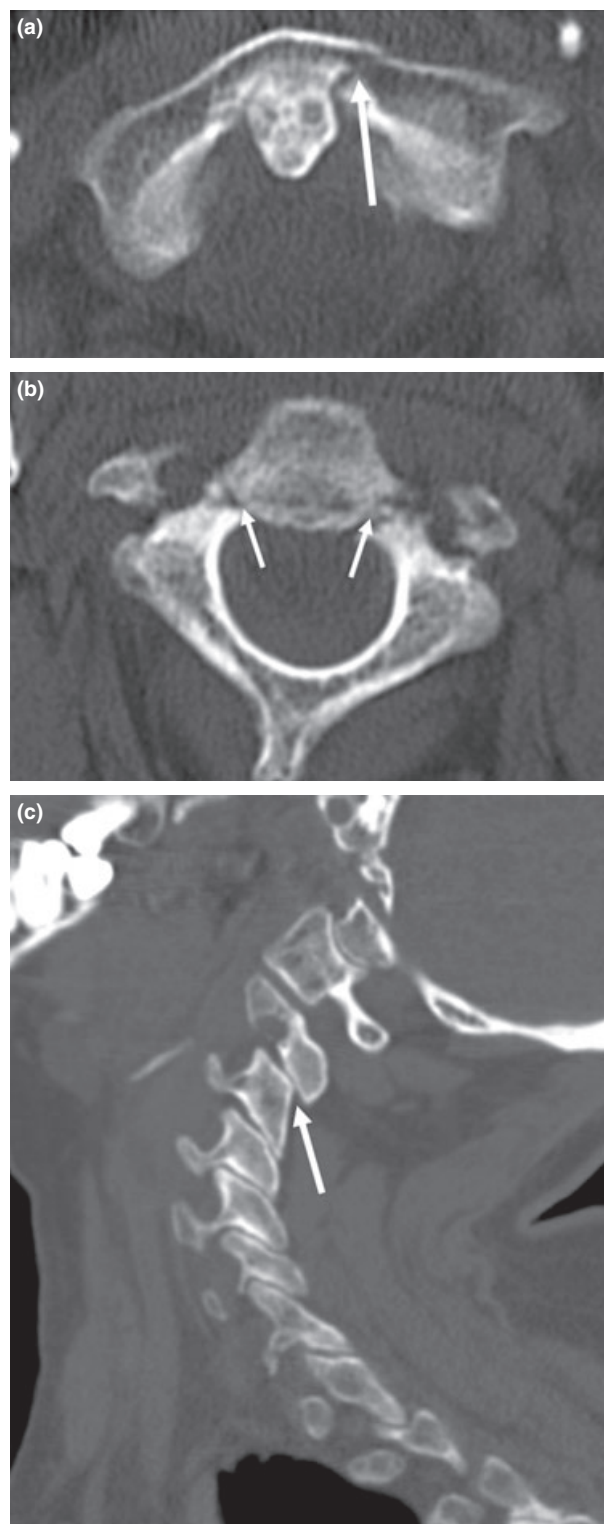


FIG. 1—Skeletal fractures revealed by postmortem multislice computed tomography (MSCT). (a) Axial image: fracture of the anterior arch of the first cervical vertebra (arrow). (b) Axial image: bilateral pedicular fractures of the second cervical vertebra (arrows). (c) Sagittal 2D MSCT cervical spine reconstruction [maximum intensity projection (MIP) mode]: subluxation of both apophyseal joints between the second and the third vertebrae (arrow).

identity card was possible. Multiple metal and composite fillings were seen and many teeth were missing because of ante-mortem

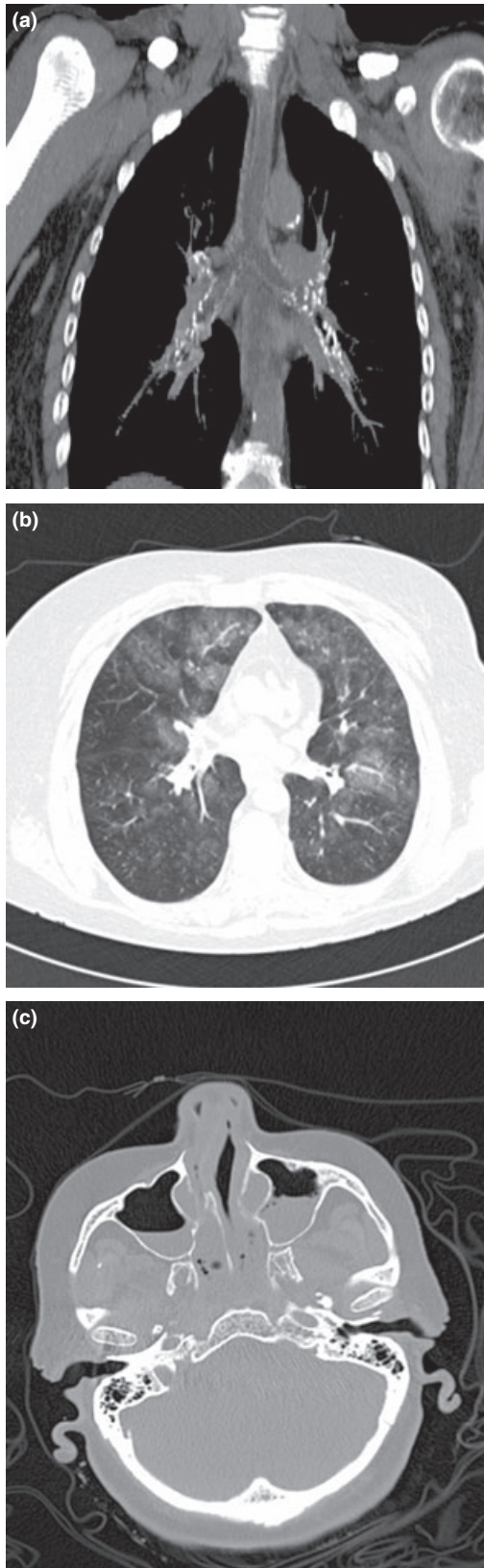


FIG. 2—Visceral abnormalities revealed by postmortem multislice computed tomography (MSCT). (a) Frontal 2D chest CT reconstruction [maximum intensity projection (MIP) mode]: the tracheobronchial tree is filled with fluid. (b) Axial image, chest: bilateral alveolar congestions with thickened intra- and inter-alveolar septa. (c) Axial image, face: bilateral air-fluid levels in the maxillary sinuses.

extraction. Tooth 23 presented an anatomic abnormality because it had not erupted. Tooth 24 had an abnormal position.

Anthropological Studies on Dry Bone

Pubic Symphysis—According to the Suchey-Brooks female pubic symphyseal phases, the pubic symphysis was estimated to be phase V (6) (Fig. 3c).

Fourth Right Rib—According to the Iscan female phases, ossification of the sternal end of the fourth rib was estimated to be phase VI (7) (Fig. 3d).

Teeth

The dental identity card was performed. Multiple metal and composite fillings were noted and many teeth were missing because of ante-mortem extraction. Tooth 23 was missing and thought to have been extracted; tooth 24 had an abnormal position.

Epilogue: Confirmation of Positive Identification

A search notice with a photograph of the victim was published in local newspapers but was unsuccessful. Five months later, police investigations revealed that a 71-year-old woman had disappeared 5 months earlier. It was known by the woman's family that she had undergone surgery after right tibial fracture 2 years before. Her last dentist had no dental radiography of the victim, but she had undergone right leg radiography in November 2002. This radiograph was examined and compared with the radioscopy image obtained before autopsy (Figs. 3f and g). Positive identification was possible. A metal plate was fixed to the inferior part of the right tibia with two coronal inferior screws, one medium sagittal screw, and four coronal superior screws. All the screws traversed the bone and their extremities extended well beyond the bone. The most inferior screw was larger than the others and penetrated the inferior extremity of the right fibula.

Discussion

Rare reports have already assessed postmortem imaging in cases of drowning (1,3,8). Radiological imaging reveals findings typical of drowning, such as fluids in the paranasal sinuses, stomach and duodenum, and mosaic pattern and over-inflation of the lungs. The “crazy-paving” appearance of the lung parenchyma is interesting because it may be seen in cases of near-drowning (9). It seems to be a good indicator of vital reaction in drowning, attesting inhalation of water and a short survival time which is necessary to produce these parenchymatous changes. Water regurgitation and pulmonary inhalation are also signs of vital reaction.

The blunt injuries due to trapping of the body in the floodgate, namely the cervical spine, sternum, and rib fractures, were detected and well documented with MSCT. It was possible to distinguish vital from nonvital fractures through the presence or absence of soft tissue infiltration around the fracture site. This aspect was also verified during the autopsy. In this case, the cervical spine fractures were more precisely evaluated by MSCT than by autopsy. Autopsy was able to detect abnormal mobility of the cervical spine, but missed fractures of the first and the second vertebrae and of the left occipital condyle, probably because these injuries were postmortem

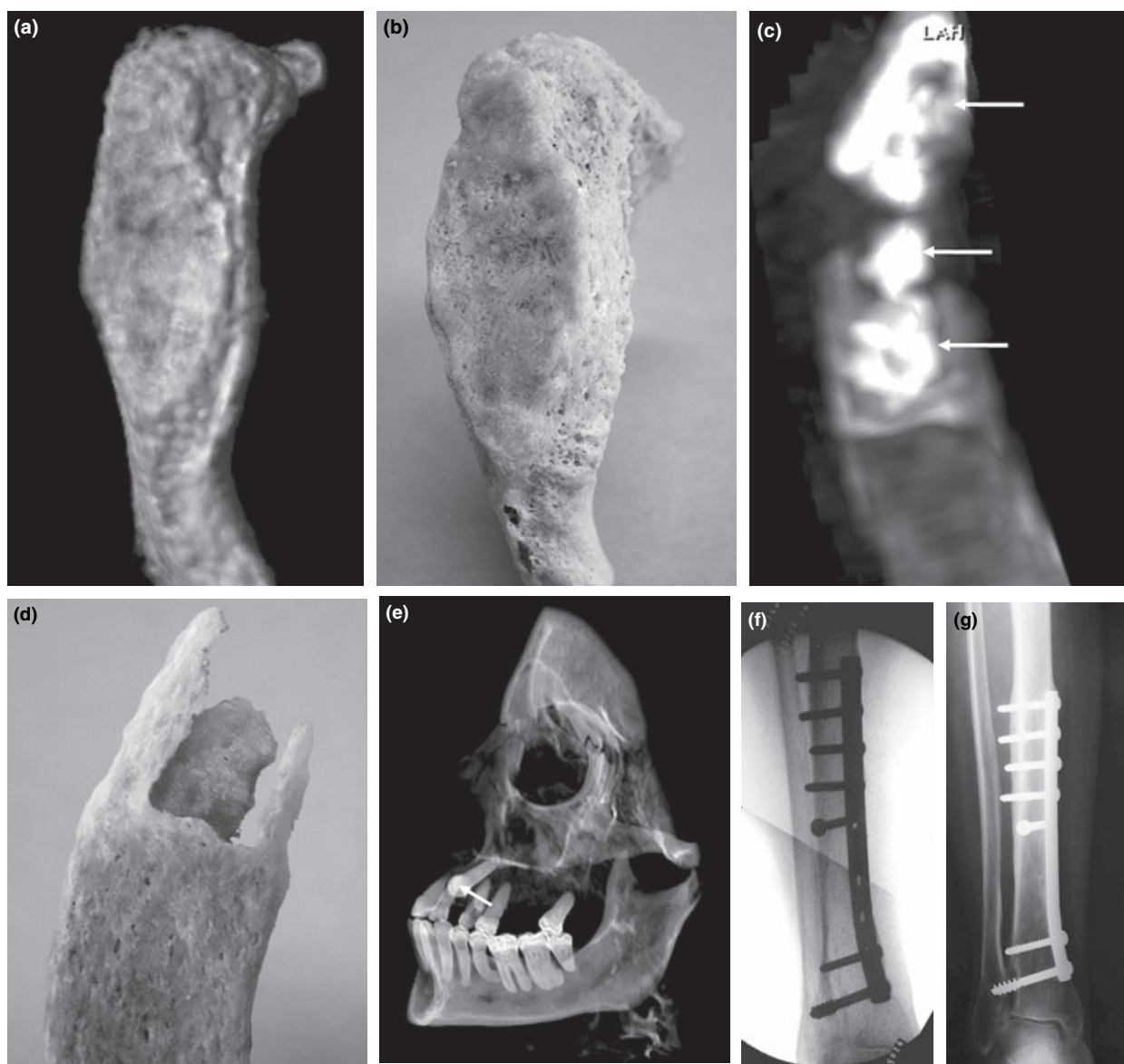


FIG. 3—Medico-legal anthropological study. (a) 3D multislice computed tomography (MSCT) reconstruction of the medial articular surface of the left pubic symphysis virtually dissected before the autopsy, medial view [volume rendering technique (VRT) mode]: phase V according to the Suchey-Brooks classification. (b) Dry medial articular surface of the left pubic symphysis, medial view: phase V according to the Suchey-Brooks classification. (c) 3D MSCT reconstruction of the sternal end extremity of the right fourth rib, lateral view (VRT mode); analysis revealed a phase VII according to Iscan's classification. Note the multiple calcifications within the costal cartilage (arrows). (d) Dry bone: sternal end extremity of the right fourth rib; the analysis revealed a phase VII according to Iscan's classification. (e) 3D MSCT reconstruction of the left jaws, lateral view (VRT mode): nonerupted tooth (arrow), abnormal position of the adjacent tooth. (f) Postmortem fluoroscopy of the right leg: presence of radio-opaque metallic fixation devices. A metal plate was screwed into the inferior part of the right tibia, with two coronal inferior screws, one medium sagittal screw and four coronal superior screws. All the screws traversed the bone and had extremities largely out of the bone. The most inferior screw was larger than the others and entered the inferior extremity of the right fibula. (g) Ante-mortem radiography of the right leg: presence of radio-opaque metallic fixation devices strictly similar to Fig. 3f.

and not surrounded by hematomas. The excellent detection of spine fractures on postmortem MSCT has already been described (10).

Multislice computed tomography offers new potential for post-mortem imaging and identification in medico-legal anthropology (11–14). In the case we present, osteoscopic methods were successfully transposed to estimate the age of an unidentified corpse, giving similar results to those of dry bone study. However, the acquisition of axial images must be millimetric, otherwise the spatial resolution is insufficient and it is impossible to analyze the region of interest. A drawback of MSCT is the need for a powerful reconstruction station, including a variety of software for specific reconstructions (bone, soft tissue, metal, dental reconstruction, etc.).

It is also evident that analysis of the articular surfaces to determine phases used in anthropology is better in dynamic evaluation, which allows vision from many angles, than on static and printed images. The same is true of dry bones, which are better analyzed by touching and rotating them than by photographs. Transposition of osteoscopic methods seems to give accurate results, but transpositions of osteometric methods require further assessment. Positive identification of the woman's body enabled us to confirm the estimated age. Analysis of the medial articular surface of the pubic symphysis and the sternal end of the fourth right rib led to correct age estimations, because the victim's known age was within the estimated age range. Of course, the ranges of age's estimations on MSCT

reconstructions are as wide as dry bones estimations because their estimation corresponds to a simple transposition of the well-known osteoscopic methods.

Furthermore, postmortem MSCT is valuable for medico-legal odontology study (15,16). In this case, a nonerupted tooth was identified, accompanied by an abnormal position of the adjacent tooth. If a tooth is missing, plain external examination cannot always determine whether this is because of noneruption or whether the tooth had been previously extracted. In our case, it was possible to answer this question. Postmortem panoramic radiographs can of course be obtained, but MSCT enables exhaustive full-body investigation with a single rapid acquisition. Of course, the time required for interpretation is longer than acquisition time, because of the numerous reconstructions which have to be performed.

After virtual autopsy, virtual anthropology will probably expand, making possible a new type of collection: the virtual bone collection. The images and reconstructions obtained can be transferred through the Internet. This opens new horizons for anthropology in terms of world-wide diffusion of bone collections which cannot be transported physically. Our case illustrates the possibilities of post-mortem MSCT for medico-legal investigation of death to determine the cause of death and to detect lethal or nonlethal injuries, and also in medico-legal anthropology to estimate the age of unidentified victims and to reveal potential elements of identification.

Acknowledgment

Sincere appreciation is expressed to Nina Crowte for her assistance in the preparation of this manuscript.

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Additional information and reprint requests:

Fabrice Dedouit, M.D.
Service de Médecine Légale
Hôpital de Rangueil
1 avenue du Professeur Jean Poulhès
TSA 50032
31059 Toulouse Cedex 9
France
E-mail: fabded2@hotmail.com