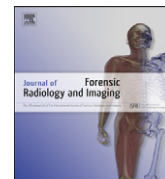




ELSEVIER

Contents lists available at SciVerse ScienceDirect

## Journal of Forensic Radiology and Imaging

journal homepage: [www.elsevier.com/locate/jofri](http://www.elsevier.com/locate/jofri)

## 2nd Congress of the ISFRI: Scientific Sessions

### Determining the temperature-dependence of tissue relaxation times (T1 and T2) for prospective optimization of post-mortem magnetic resonance (PMMR) image contrast

Natalie Adolphi<sup>a</sup>, Chandra Gerrard<sup>a</sup>, Gary Hatch<sup>a</sup>,  
Norbert Takacs<sup>b</sup>, Kurt Nolte<sup>a</sup>

<sup>a</sup> University of New Mexico Center for Forensic Imaging, 1101 Camino de Salud, 87102 Albuquerque, NM, USA

<sup>b</sup> New Mexico Department of Agriculture Veterinary Diagnostic Services, 1101 Camino de Salud, 87102 Albuquerque, NM, USA

**Abstract:** Due to the excellent sensitivity of Magnetic Resonance (MR) imaging to subtle differences in soft tissues, MR enables non-invasive anatomical imaging with superior soft tissue contrast relative to X-ray computed tomography (CT). Soft tissue contrast in MR is not determined primarily by density (as in X-ray imaging) but instead by T1 and T2, tissue-specific parameters that characterize the temporal behavior of the MR signal. However, in the post-mortem setting, the sensitivity of MR to subtle changes in tissue properties presents both opportunities and challenges. Recent reports in the literature demonstrate changes in MR image contrast as a function of subject temperature for a given MRI protocol (e.g., T1-w, T2-2, FLAIR). These normal temperature-dependent changes in MR image contrast, not encountered in clinical MR of live subjects, have the potential to confound the identification of pathology or injury. Tofts et al. have demonstrated that FLAIR image contrast can be corrected by adjusting the protocol, specifically the inversion time (TI), based on knowledge of the temperature-dependence of the apparent diffusion coefficient (ADC) and T1 in brain tissues. Here we present a generalized method for (A) non-invasively determining subject temperature and (B) computing the values of the image acquisition parameters, TR and TE, required to obtain the desired image contrast for a given subject temperature, based on the temperature-dependence of tissue T1 and T2 values. Measurements of the temperature-dependence of T1 and T2 values from various unfixed, ex vivo mammalian tissues and organs will be presented.

**Author disclosures:** National Institute of Justice Award 2012-DN-BX-K019 is gratefully acknowledged.

<http://dx.doi.org/10.1016/j.jofri.2013.03.002>

### Introducing virtopsy into a country religiously opposed to autopsy

Nadav Berkovitz<sup>a</sup>, Sigal Tal<sup>a</sup>, Paul Gottlieb<sup>a</sup>, Yehuda Hiss<sup>b</sup>,  
Konstantin Zaitsev<sup>b</sup>

<sup>a</sup> Assaf Harofeh Medical Center, Zerifin, 70300 Zerifin, Israel

<sup>b</sup> National Center of Forensic Medicine, Ben Zvi 67, 61085 Tel-Aviv, Israel

**Purpose:** To evaluate accomplishments and challenges in introducing virtopsy to the pediatric forensic post-mortem examination. This in a country (Israel) requiring family consent, with religious opposition from most of the population (Jewish, Muslim, Christian and Druze) to autopsies and even to shipping the body from one location to another before final interment. What lessons can be learnt applicable to similar communities.

**Materials and methods:** Data was collected from the National Center of Forensic Medicine in Israel during the 18 month period introducing post-mortem imaging (Group A) carried out in a medical center located miles away from the Forensic Center. There was limited daytime access to imaging devices, resulting in interment delay. The data was compared to the previous 18 months (Group B). The examined parameters were cases submitted, those examined, autopsied or imaged depending on family consent.

**Results:** Out of all cases consent to autopsy was similar (A=56% vs. B=54%). Of all cases in Group A, consent for imaging was 24%. Of those imaged, 77% underwent autopsy. Of those examined externally only, 16% consented to imaging. For 7% of total cases in Group A, estimation of cause of death was based on virtopsy alone.

**Conclusion:** In a country with high religious opposition to post-mortem forensic procedure, there are challenges to making virtopsy an integral part of the pediatric forensic post-mortem protocol. At this point those consenting to post-mortem imaging are more likely to agree to the performance of autopsies. Even with the difficulties, some we have identified, there was an immediate increase of 7% of cases where a possible cause of death would not otherwise be given. Virtopsy does not breach religious doctrine in Israel, and might partially substitute autopsy.

<http://dx.doi.org/10.1016/j.jofri.2013.03.003>

### Detection of bodypacks: Accuracy of abdominal radiography versus very low dose CT

Jürgen Fornaro<sup>a</sup>, Sebastian Leschka<sup>a</sup>, Dennis Hibbeln<sup>a</sup>,  
Simon Blum<sup>b</sup>, Roland Hausmann<sup>b</sup>, Simon Wildermuth<sup>a</sup>,  
Patrick Laberke<sup>b</sup>

<sup>a</sup> Institut für Radiologie, Kantonsspital St. Gallen, 9007 St. Gallen, Switzerland

<sup>b</sup> Institut für Rechtsmedizin, Kantonsspital St. Gallen, 9007 St. Gallen, Switzerland

**Purpose:** The aim of this study was to investigate the detectability of bodypacks in low dose computed tomography (CT) in comparison to abdominal radiography (AR).

**Materials and method:** Bodypacks ( $n=13$  to  $n=20$  per body) were placed into the small intestines of 9 human corpses. In each case AR and CT at different dose levels were performed: standard dose for abdominal CT scans (CTDI=8.5 mGy/cm), 1/2 dose (CTDI=4.3 mGy/cm), 1/4 dose (CTDI=2.1 mGy/cm), 1/8 dose (CTDI=1.1 mGy/cm), 1/16 dose (CTDI=0.6 mGy/cm), and technical minimal dose of 1/60 (CTDI=0.14 mGy/cm). Two independent observers counted the number of bodypacks in each CT dataset and in the AR. Radiation exposure was estimated for CT using the dose-length-product and for AR using the area-dose-product.

**Results:** Intra- and interobserver agreement was good. Image noise at CT ranged between 17 HU (at standard dose) and 300 HU (at technical minimal dose). At AR, the accuracy for the detection of bodypacks had a sensitivity of 59% and a specificity of 97% at an average radiation exposure of 1.0 mSv. In CT, all bodypacks were detected at every dose level (sensitivity and specificity: 100%). The calculated radiation exposure ranged from 10.9 mSv (at standard dose) to 0.2 mSv (at technical minimal dose).

**Discussion:** CT permits detection of all bodypacks even at minimal dose levels of 0.2 mSv. Therefore, the use of very low-dose CT is recommendable for the detection of bodypacks in suspected traffickers as low-dose CT provides a superior accuracy and a lower radiation exposure than AR.

<http://dx.doi.org/10.1016/j.jofri.2013.03.004>

## Estimation of age by ultrasonography of radius and ulna

Jatin Bodwal<sup>a</sup>, Anil Aggrawal<sup>a</sup>, Satbir Singh<sup>b</sup>, S.K. Khanna Khanna<sup>a</sup>

<sup>a</sup> Maulana Azad Medical College, Bahadur Shah Zafar Marg, 110002 Delhi, India

<sup>b</sup> G.B. Pant Hospital, Bahadur Shah Zafar Marg, 110002 Delhi, India

**Background:** Age estimation is very important task for the forensic practitioner in criminal and civil cases. X-rays of different joint to see the ossification centers is routinely used, to assess the age and at the same patient exposes to radiation. On the other hand ultrasonography is scarcely used for this purpose and is radiation free. Keeping this in mind we undertook this study.

**Aims:** To compare the usefulness of ultrasonography and X-rays in estimation of age up to 18 years and to find the advantages and disadvantages of ultrasonography over X-rays in estimation of age.

**Methods:** 53 Children of the age, new born to the 18 years of both sexes, underwent X-rays and Ultrasonography of “distal end of radius and ulna, and proximal of end of radius”. X-rays was done in the anterior posterior view and, ultrasonography was done in sagittal and transverse view. Age was deduced separately by X-rays films and Ultrasonography. Observer was blind to the actual age of the subjects.

**Results:** We found, there was a “fair” degree of the agreement between X-rays and ultrasonography. Sensitivity and specificity of ultrasonography was 74.3% and 70% respectively. Both X-rays and ultrasonography showed excellent correlation.

**Conclusion:** We recommend ultrasonography can be used to estimate age without undue risk of radiations; however X-rays are still the conventional method for age estimation. By conducting more studies by ultrasonography on different ossification centers and on larger population, USG can be made a valid alternative of X-rays.

<http://dx.doi.org/10.1016/j.jofri.2013.03.005>

## Multi-detector computed tomography—A ‘one stop shop’ for anthropological examination of juvenile remains? A study of reliability

Alison L. Brough<sup>a</sup>, Bruno Morgan<sup>b</sup>, Sue Black<sup>c</sup>,  
Craig Cunningham<sup>c</sup>, Catherine Adams<sup>d</sup>, Guy N. Ruttly<sup>a</sup>

<sup>a</sup> East Midlands Forensic Pathology Unit, University of Leicester, Leicester Royal Infirmary, Robert Kilpatrick Building, Leicester LE2 7LX, UK

<sup>b</sup> Radiology Department, Leicester Royal Infirmary, University of Leicester, Leicester LE1 5WW, UK

<sup>c</sup> Center for Anatomy and Human Identification, College of Life Sciences, University of Dundee, Dow Street, Dundee Dd1 5EH, UK

<sup>d</sup> Foren Dent, ILTM, Cardiff Medicentre, Health Park, Cardiff CE74 4UJ, UK

**Abstract:** This investigation provides vital data which supports the implementation of a virtual/near virtual anthropological examination for the identification of juvenile remains. Determining the accuracy and repeatability of age, sex, stature and ethnicity estimations made using only MDCT data, by comparison with documented demographics, would be a vital preliminary step in validating the utility of MDCT analysis in special situations such as forensic and disaster victim investigations (DVI). This would accelerate the process of anthropological assessment and remove the necessity to de-flesh remains, which may also be more ethically and morally acceptable, particularly when dealing with young victims and offers significant health and safety benefits for practitioners. This study uses the measurements previously validated by the Developing Human Research Group and information from the current DVI INTERPOL form to construct a ‘one stop’ identification form for juvenile remains. 30 Juvenile forensic cases that had undergone a MDCT post-mortem scan were randomly selected and anonymised by an independent practitioner. The MDCT data was then used to create an identification form for each case. Age, sex, stature and ethnicity estimations made using only the ID forms were compared to the known demographics for each individual to determine the accuracy of this virtual method. This identification process is currently under blind review by a number of independent practitioners and the final results will be presented at the conference.

<http://dx.doi.org/10.1016/j.jofri.2013.03.006>

## Forensic imaging and more...

Walter Coudyzer<sup>a</sup>, Federica Zanca<sup>a</sup>, Wim Develter<sup>a</sup>,  
Joke Wuestenbergs<sup>a</sup>, Bart De Dobbelaer<sup>b</sup>

<sup>a</sup> University Hospitals Leuven, Herestraat 49, 3000 Leuven, Belgium

<sup>b</sup> University Hospitals Leuven, MIRC, Herestraat 49, 3000 Leuven, Belgium

**Abstract:** Our radiology department started in 2006 with advanced forensic imaging (virtual autopsies). Soon, after we build up some experience in scanning bodies, we realized that forensic evidence was not the only information a corps could reveal. For instance, a lot of data generated by a CT scan can be used for dosimetric purposes. As presented at the RSNA in 2010, “Evidence for X-ray exposure parameters selection in CT of the brain and petrous bone from comparative measurements on deceased bodies.” This study was part of a global image quality assessment study for post-mortem virtual autopsy scans. The results from this study were used to improve the scanning techniques for the living patients and resulted also in an important decrease of the radiation dose for some regions of the body. Especially at present, reducing radiation dose is a worldwide hot topic. But there is more. Since in 2010 dual energy scans and iterative algorithms were globally introduced, it gave us also the opportunity to explore and improve these data sets and this in close collaboration with our medical imaging and research center (MIRC) <https://mirc.uzleuven.be/MedicalImagingCenter/about.php?lang=en>. We started to develop metal artifact reduction software, crime scene analysis tools, IV contrast administration improvement and reduction and tried to increase image resolution by using existing and new methods while scanning and reconstructing the images. All the data collected during the past years resulted in a “treasure” of information and became therefore also interesting for other medical and non-medical disciplines: forensic orthodontists, anthropologists, geologists, engineers, etc. The obtained data was always created with non-invasive imaging techniques and only after the approval of the forensic pathologist and the deceased's family consent.

<http://dx.doi.org/10.1016/j.jofri.2013.03.007>

## The anatomical variations of the hyoid–larynx complex

Bernadette S de Bakker<sup>a</sup>, Henri M. de Bakker<sup>b</sup>

<sup>a</sup> Department of Anatomy, Embryology & Physiology, Academic Medical Center, Meibergdreef 15, 1105 AZ Amsterdam, The Netherlands

<sup>b</sup> Department of Radiology, Groene Hart Hospital, Bleulandweg 10, 2803 HH Gouda, The Netherlands

**Introduction:** Pressure on the neck in cases of hanging or strangulation could lead to fracturing of the hyoid bone and/or the calcified laryngeal cartilages. During forensic examination by the pathologist and radiologist, these fractures have to be discerned from anatomical variations. Therefore, proper understanding of the complex embryonic development of the hyoid bone and larynx is essential to interpret the etiology of variations within this complex. The aim of our research is to combine embryological knowledge with forensic practice concerning the hyoid–larynx complex.

**Methods:** Serial sections of 34 human embryos were used to examine the development of the hyoid–larynx complex. Every structure was manually annotated in order to create 3-dimensional (3D) reconstructions. A total of 284 excised hyoid–larynx complexes were radiologically examined for anatomical variations by the use of standardized X-ray.

**Results:** Of the 284 radiologically examined cases, 38% showed single or combined variations in the hyoid and/or larynx. Often noted were variable degrees of existing accessory bones or cartilages present in the tract of the obliterated pharyngeal arch cartilages, the existence of a median process of the corpus and hyperplastic, hypoplastic or aplastic parts of the hyoid or larynx.

**Conclusions:** The hyoid–larynx complex derives in part from the pharyngeal arch cartilages, but the development appeared to differ from current knowledge in embryology books and literature. Therefore we are now able to explain the etiology of hitherto inexplicable variations such as the existence of a median process of the hyoid bone corpus. Anatomical variations often occur and mistakes in distinguishing a fracture from for example an accessory bone is of great impact in this field. Therefore we emphasize the importance of using solid embryological background knowledge during forensic examination of a hyoid or larynx.

<http://dx.doi.org/10.1016/j.jofri.2013.03.008>

## Accuracy and reliability of soft tissue depth measurements from CT for forensic facial reconstruction

Summer Decker<sup>a</sup>, Jonathan Ford<sup>b</sup>

<sup>a</sup> University of South Florida College of Medicine, 12901 Bruce B Downs Blvd, MDC75, 33612 Tampa, FL, USA

<sup>b</sup> University of South Florida College of Engineering, 12901 Bruce B Downs Blvd, MDC75, 33612 Tampa, FL, USA

**Introduction:** Facial approximation (FA) is used when other methods of forensic identification, such as DNA, are not available or applicable. FA, in the clay methods and virtual methods, all rely on populational soft tissue (ST) depths from limited data sets. Much of the known facial indices originate from cadaver ST studies. This study, using three-dimensional (3D) computer modeling, tested the accuracy and reliability of cadaveric facial studies as they apply to forensic cases.

**Methods:** A series of embalmed cadaveric heads were scanned with computed tomography (CT). The head's bone and ST were 3D modeled using Mimics 15.0. Measurements of ST landmarks were collected from the 3D models. After scanning, ST measurements were taken manually from the cadavers. Photographs were taken to document the tissue depth markers'

location. These physical measurements were compared to the virtual data. A series of clinical head scans of living individuals were collected and modeled for the comparison of scanning cadaveric and clinical tissue.

**Results:** ST measurements demonstrate that cadavers are often distorted in the facial region. The distortions from embalming skew ST measurements. The landmarks used in ST data collection are chiefly defined by bony features and not the skin surface.

**Discussion:** It is a concern as these features are not visible during data collection, the researcher must approximate where they believe the feature to be. The utilization of CT and 3D reconstruction allows for a more reliable location for ST measurement. Due to cadaver limitations, the use of clinical facial CT data proved to be the ideal data set for modern living individuals.

**Conclusion:** If FA is to remain a tool in human identification then more clinically relevant data is needed. With advances in medical imaging, the embalmed cadaver, unfortunately, is no longer the optimal model for facial reconstruction studies.

<http://dx.doi.org/10.1016/j.jofri.2013.03.009>

## Multiphase post-mortem computed tomography angiography in seven lethal cases of great height falls: Preliminary results of a French experience

Fabrice Dedouit<sup>a</sup>, Fathima Zohra Mokrane<sup>b</sup>, Camille Rerolle<sup>a</sup>, Frédéric Savall<sup>a</sup>, Daniel Rouge<sup>a</sup>, Hervé Rousseau<sup>b</sup>, Norbert Telmon<sup>a</sup>

<sup>a</sup> Service de Médecine Légale, CHU Rangueil 1, Avenue du Professeur Jean Poulhès, 31059 Toulouse, France

<sup>b</sup> Service de Radiologie, CHU Rangueil, 1 Avenue du Professeur Jean Poulhès, 31059 Toulouse, France

**Background:** The use of enhanced multislice computed tomography (MSCT) in forensic sciences has been recently developed in order to improve radiological vascular and organs injuries detection.

**Methods:** Seven suicidal cases of great height falls (4 women, and 3 men) underwent a multiphase post-mortem computed tomography angiography (MPMCTA) before medico-legal autopsy. The estimated height falls varied from 5 to 15 m. All corpses were prepared with a surgical cannulation of femoral vessels. After a non-MSCT exploration, a controlled perfusion device (Virtangio<sup>®</sup> machine) was used with paraffin oil mixed with specific contrast agent (Angiofil<sup>®</sup>), allowing three time-different acquisitions (arterial, venous, dynamic). Two radiologists proceeded to images analysis. The forensic pathologist undergoing autopsies knew preliminary imaging results.

**Results:** The results of MPMCTA explorations and autopsies differed concerning detection of gas, bone fractures, and vascular ruptures (mainly cerebral), with a superiority of the MPMCTA. Autopsies were superior to MPMCTA for detection of some superficial skin lesions, which were easily accessible to external examination.

**Discussion:** Both techniques were able to diagnose some classical and typical bone, visceral and vascular lesions. Additionally, some rare injuries were found like coronary desinsertion, double thoracic aortic ruptures, inferior vena cava laceration extended to the right atrium, and pulmonary vein disruption. These findings were found with both techniques, but MPMCTA permitted better in situ lesions' illustration and documentation. Furthermore, realization of different-time acquisitions was essential for detection and comprehension of abnormal traumatic communication between cardiac cavities.

**Conclusion:** This study illustrates the complementarity of MPMCTA and autopsy in traumatic cases, and especially for cases of lethal great height falls.

<http://dx.doi.org/10.1016/j.jofri.2013.03.010>

## Semi-automated digital bullet trajectory reconstruction in craniofacial ballistic trauma

Wim Develter<sup>a</sup>, Joke Wuestenbergs<sup>a</sup>, Wim Van de Voorde<sup>a</sup>, Walter Coudyzer<sup>b</sup>, Bart De Dobbelaer<sup>c</sup>, Dirk Vandermeulen<sup>c</sup>, Jonatan Snyders<sup>c</sup>

<sup>a</sup> Department of Forensic Medicine, University Hospitals Leuven, Kapucijnenvoer 33, 3000 Leuven, Belgium

<sup>b</sup> Radiology Department, University Hospitals Leuven, Herestraat 59, 3000 Leuven, Belgium

<sup>c</sup> Medical Imaging and Research Centre, KULeuven–UZ Leuven, Herestraat 59, 3000 Leuven, Belgium

**Introduction:** Ballistic trauma demands a close collaboration between the forensic pathologist and the ballistic expert to reconstruct bullet trajectories. These reconstructed trajectories are a result of the measurements obtained during autopsy and the relevant ballistic findings on the crime scene. Low velocity ammunition, unfortunately the most applied ammunition in homicides in our regions, tends to change direction when encountering resistance, the so called ‘ricochet-effect’. During autopsy, those aberrant trajectories can be misleading and difficult to reconstruct especially in multiple hits with interfering trajectories.

**Methods:** Post-mortem imaging is performed on each ballistic trauma in our forensic department. In extension, as guidance in the reconstruction of (skull) shot trajectories, we developed a software tool combining the defects seen on the 2D CT data with an automated software program based on a semi-rigid model to extract leading features in the reconstruction of the most probable trajectory. To speed up the manual time-consuming search of these hallmarks (entrance wound, free air and bone particles, gunshot residue in and around the trajectory and the final location of the projectile or the exit wound) an automated software program was created using a semi-rigid model and applying an image registration to extract the leading features and reconstruct the bullet trajectory in an automated way. The data to “teach” the automated recognition was obtained under predetermined controlled conditions with several ammunitions under various fire angles using sheep heads.

**Conclusions:** Using 3D visualization these results can help the pathologist during the autopsy in determining the trajectory and the ballistic coordinates of the trajectory and can later be shown as documentation in court.

<http://dx.doi.org/10.1016/j.jofri.2013.03.011>

## Low dose dual-energy computed tomography in suspected body packers and body stuffers—Preliminary clinical experience

Jürgen Fornaro<sup>a</sup>, Sebastian Leschka<sup>a</sup>, Denis Hibbeln<sup>a</sup>, Simon Blum<sup>b</sup>, Roland Hausmann<sup>b</sup>, Simon Wildermuth<sup>a</sup>, Patrick Laberke<sup>b</sup>

<sup>a</sup> Institute of Radiology, General Hospital, 9007 St. Gallen, Switzerland

<sup>b</sup> Institut für Rechtsmedizin, General Hospital, 9007 St. Gallen, Switzerland

**Background:** The detectability of drug packages with abdominal plain film radiography is limited by sophisticated packaging methods and overlying stool, organs and bones. The aim of this study was to investigate the accuracy and practicability of dual-energy CT in body packers and stuffers, and the discernibility of cocaine from heroine.

**Materials and methods:** From May to December 2012 two suspected body packers and six suspected body stuffers (mean age of 30 years, range 20–43 years) were referred to our institution. A low dose native dual-energy CT of the abdomen and pelvis was performed in each case with tube currents of 14 mA s at 140 kV and 72 mA s at 80 kV. The data sets

were reviewed for drug packages in a soft tissue and bone window as well as on color-encoded reformations of the dual energy index (DEI). Three-dimensional renderings of the DEI (cocaine material in green, heroine material in red) were produced to demonstrate findings to the police.

**Results:** In two body packers and three body stuffers an average of five drug packages were detected (range 1–11) with a mean size of 19 mm (range 9–39 mm). The mean attenuation of the packages was 151 HU (range 93–215 HU) at 80 kVp with an average decrease in attenuation of –92 HU (range –27 to –139 HU) at 140 kVp, suspicious of cocaine content in all cases. These results have been confirmed by chemical analysis of the defecated drug packages. The mean effective dose was 2.1 mSv (range 1.9–2.2 mSv), comparable to abdominal plain film radiographs with a typical effective dose of 1.3 mSv.

**Conclusion:** Dual-energy CT is a promising novel technique in detecting and characterizing drug packages in suspected body packers and stuffers. As most of these traffickers are of young age, the application of a low dose protocol is essential to limit the harm of ionizing irradiation.

<http://dx.doi.org/10.1016/j.jofri.2013.03.012>

## Do we really need a dedicated equipment to achieve a multiphase post-mortem CT angiography?

Marianne Jolibert, Christophe Bartoli, Pierre-Eloi Laurent, Catherine Boval, Vincent Vidal, Marie-Dominique Piercecchi, Frederic Cohen, George Leonetti, Jean-Michel Bartoli, Guillaume Gorincour

La Timone Hospital, 264 Rue Saint Pierre, 13005 Marseille, France

**Objective:** To show the feasibility of full multiphase post-mortem CT angiography using the technique of ultrasound-guided femoral arterial puncture and a standard CT injector.

**Methods:** Three acquisitions were made in a case of unexplained death in a woman of 50 years. Each used a mixture of 50% water p.p.i. and 50% of iodinated contrast; the first and the last were made in the supine position, while the second was made in the prone position

**Results:** We were able to establish the normality of the entire vascular system, including the right coronary artery and venous system, which has eliminated the main causes of death. The autopsy was conducted subsequently, without being disturbed in any way by the post-mortem vascular injection, and confirmed the radiological findings.

**Conclusion:** This description, the first of a complete minimally invasive post-mortem angiography, strengthens the performance and utility of a simpler technique performed without special equipment.

<http://dx.doi.org/10.1016/j.jofri.2013.03.013>

## Identification of a jawless skull by superimposing AM and PM CT images

Morio Iino<sup>a</sup>, Hideko Fujimoto<sup>a</sup>, Motonori Yoshida<sup>a</sup>, Hiroshi Matsumoto<sup>a</sup>, Ryoji Matoba<sup>b</sup>

<sup>a</sup> Department of Legal Medicine, Osaka University Graduate School of Medicine, 2-2-F3 Yamadaoka, Suita, 565-0871 Osaka, Japan

<sup>b</sup> Osaka Medical Examiner's Office, 1-6 Bambacho, Chuoku, 540-0007 Osaka, Japan

**Introduction:** A victim of killing for life insurance. A jawless skull was found in the mountain area after the offender's testimony. The skull was thought to belong to the male victim who had been killed and buried in the mountain 2 years before. Before burying him the offender had cut his both wrists off and destroyed the jaws with a shovel not to be identified

from the fingerprints or the dental records. Two years before the murder, the offender had attempted to murder the victim by running over to get money from a life insurance policy. Despite being unsuccessful, he still got some insurance coverage since the victim became vegetative after the false accident. The offender murdered him because of his expensive medical care. The issue was if the skull belongs to the victim. We tried to identify the victim with the ante mortem (AM) CT images of the missing person and the post-mortem (PM) CT data of the skull since it is known that the shape of frontal sinus is unique.

**Methods:** The AM CT images were obtained from the hospital, which were scanned when he had been run over. The skull was scanned with 4-slice MDCT scanner and reconstructed with the 3D image serving system (Aquarius NET) at our department. These two data sets were superimposed by the software function called “fusion”.

**Results:** Two data sets of the AM and PM CT images of the skull were nearly identical in the shape and the size in both multi planer reconstruction (MPR) and 3D volume rendering (VR). More specifically, the sizes and the shapes of parietal and temporal bones, the shapes, region, and the sizes of the orbit, and the shapes of the skull base are identical.

**Conclusions:** The results suggest that two data sets belong to the same person. We have done personal identifications by using PM CT data of the skull without jaws comparing with AM CT data of the head.

<http://dx.doi.org/10.1016/j.jofri.2013.03.014>

## CT appearance of gas collections can predict the cause of death in scuba diving accidents

Pierre-Eloi Laurent<sup>a</sup>, Mathieu Coulange<sup>b</sup>, Julien Mancini<sup>c</sup>,  
Christophe Bartoli<sup>d</sup>, Jacques Desfeux<sup>d</sup>, Pierre Perich<sup>d</sup>,  
Marie-Dominique Piercecchi-Marti<sup>d</sup>, Vincent Vidal<sup>a</sup>,  
Jean-Michel Bartoli<sup>a</sup>, Georges Leonetti<sup>d</sup>, Guillaume Gorincour<sup>a</sup>

<sup>a</sup> LIIE, Aix-Marseille Université, Bd Jean Moulin, 13005 Marseille, France

<sup>b</sup> Service de Médecine Hyperbare, Pôle RUSH, Hôpital Ste Marguerite, Avenue de Ste Marguerite, 13009 Marseille, France

<sup>c</sup> Lertim, Aix-Marseille Université, Bd Jean Moulin, 13005 Marseille, France

<sup>d</sup> Service de Médecine Légale et Droit à la Santé, Assistance Publique des Hôpitaux de Marseille, Bd Jean Moulin, 13005 Marseille, France

**Objectives:** To define the computed tomography (CT) semiology of post-mortem gas collections linked to putrefaction, post-mortem “off-gassing” and decompression illness (DI) after fatal diving accidents and to establish CT diagnostic criteria for different causes of death in diving.

**Materials and methods:** A 4-year prospective study was conducted including cases of death diving referred to our center. For each subject a hyperbaric physician analyzed the circumstances of death and interviewed rescue crews and witnesses. A post-mortem full body CT scan was conducted followed by an autopsy. The following criteria were examined: intra-arterial gas, intravenous gas, complete pneumatization of supra-aortic trunks, complete pneumatization of the right ventricle, presence of subcutaneous emphysema limited to the thoracic area, and presence of a pneumothorax.

**Results:** Eighteen subjects were included in the study. The presence of intra-arterial gas associated with death by DI had a negative predictive value (NPV) of 100% but the positive predictive value (PPV) was only 54% because of post-mortem off-gassing. The PPV reached 70% when considering pneumatization of the supra-aortic trunks. Pneumothorax had a poor PPV (53%) for DI. Putrefaction gas is not visible in the arteries for the first 24 h after death.

**Conclusion:** Pneumothorax, subcutaneous emphysema, and/or intra-arterial gas, all of which are classical criteria for DI diagnosis, are not specific to a DI. Complete pneumatization of supra-aortic trunks and of the right ventricle are the best CT criteria to detect a fatal DI when the scanner is conducted within 24 h after death.

<http://dx.doi.org/10.1016/j.jofri.2013.03.015>

## Forensic radiology at the New York City office of the chief medical examiner (NYC OCME): Current US forensic radiology practices and reflections on the future

Zoe Miller

Department of Radiology, New York Presbyterian Hospital,  
Weill Cornell Medical Center, New York, NY, USA

**Introduction:** Forensic sciences must adhere to high quality standards in order to present their evidence in court. However, no standards currently exist regarding qualification and certification in Forensic Radiology. At the NYC OCME, medical examiners (ME) decide on a case-by-case basis whether or not post-mortem radiographs should be performed. Radiology technicians take the requested images of either specific areas or the whole body. The ME then interprets the images for use in identification or forensic investigation. There are currently no staff radiologists employed by the NYC OCME. Therefore, if the MEs find images challenging to interpret, they will call in a consultant radiologist for further evaluation.

**Method:** This study will retrospectively analyze all cases over the past 5 years to which consultant radiologists have been called. We will gather information on when, how often, and in what types of cases the decision is made to call in a radiology consultant. We will also evaluate what subspecialties within diagnostic radiology were involved and determine if radiologic evidence was given in a court case.

**Results:** The expected result is that the use of forensic radiologists is non-standardized within the NYC OCME. There are likely no set criteria for when a radiologist is to be consulted for a case. It is unlikely that radiologists with special training in forensic and post-mortem radiology are consulted. The cases for which the radiologists are most often consulted involve identification of individuals and child abuse. Either an oral or a written report may be submitted. Radiologists may give evidence in court in a small number of cases but most likely the forensic pathologists relay the information.

**Conclusion:** Forensic radiology is not standardized as seen in the NYC OCME. Future research should be geared towards establishing when and how Forensic Radiologic assessment should be performed. A drive towards publication of specialty guidelines, credentialing and certification will advance the quality of radiologic assessments in the forensic context.

<http://dx.doi.org/10.1016/j.jofri.2013.03.016>

## When it goes wrong: Complications of post-mortem CT angiography (PMCTA) as performed at VIFM

Chris O'Donnell

Victorian Institute of Forensic Medicine, 57 Kavanagh St, 3006  
Southbank, Australia

**Introduction:** PMCTA is performed at VIFM for detection of bleeding sites. This presentation examines our PMCTA technique and analyses the reasons for incomplete performance and complications.

**Methods:** Review of all PMCTA records. CT images were compared with autopsy reports. Failure of PMCTA was defined as inadequate contrast filling of visceral and cerebral vessels including the site of suspected pathology. Complication was defined as iatrogenic vascular abnormality.

**Results:** 136 PMCTA performed since May 2010. Indications were subarachnoid hemorrhage (SAH) 39 (29%), haemopericardium 25 (18%), suspected GI hemorrhage (HGE) 17 (13%), intra-abdominal HGE 16 (12%), suspected pulmonary embolism 15 (11%) and other HGE 23 (17%). Autopsies were performed in 119 (88%). Failed and complicated PMCTA was observed in 53 cases (39%). These included inadequate filling of cerebral arteries 41 (30%), incorrect vessel cannulation 3 (2%), traumatic rupture of cannulated femoral vessel 3 (2%), iatrogenic arterial rupture due to over distension 3 (2%) and traumatic dissection of aorta. In 27 of 41 (66%) incomplete cerebral arterial filling occurred in cases of SAH.

**Discussion:** The inability to adequately fill intracranial arteries is an important deficiency in our technique especially given that SAH was a major indication in those cases. This failure seems to be a function of the raised intracranial pressure associated with SAH. Complications were considered largely technical and may have reflected inexperience of operators responsible for groin dissection or local variation in groin anatomy.

**Conclusion:** PMCTA as practiced at VIFM under performs especially in the cranial cavity for detecting causes of SAH possibly due to raised intracranial pressure. Meticulous dissection technique is required at the groin in order to avoid cannulation site complication.

<http://dx.doi.org/10.1016/j.jofri.2013.03.017>

## Post-mortem multislice CT implementation for routine added value to classic autopsy in selected cases: A starter-kit for a 350,000-inhabitants Swiss Canton population

Marco Palmesino, Ermidio Rezzonico

*Radiologia EOC Lugano, Via Tesserete 46, 6900 Lugano, Switzerland*

**Abstract:** The design and the implementation steps to bring a routine post-mortem-CT project for selected cases in the Swiss Canton of Ticino will be presented. Special emphasis will be directed on the strategies chosen to adapt local pre-existing medical, forensic and police facilities to the multidisciplinary project. The project involves the Collaboration of the valuable transnational forensic team from Italy, the Cantonal Justice and Police Department, the Radiology Department of the regional Hospital of Lugano in the Southern part of the Canton Ticino, as well as a complicated orographic configuration of the Canton Ticino. All of these played a major role in the idea of the project, in its implementation and in the different strategies chosen to exploit “what was already there”. The Director of the Regional Hospital of Lugano the Cantonal Hospital Organization (Ente Ospedaliero Cantonale EOC) and the Radiology Department of Lugano coordinated the first steps of the project and contacted the Legal Medicine Team from Italy and the Justice and Police Departments giving birth to the initial project. Available facilities had to be fully and conveniently exploited in order to obtain Cantonal approval. New communication and archiving systems had to be in part implemented for efficient interdisciplinary Collaboration. We describe a suggested “starter-kit” that could be exported possibly in other similar realities both in Switzerland and in other Countries.

<http://dx.doi.org/10.1016/j.jofri.2013.03.018>

## Value of minimally invasive, whole body, post-mortem CT angiography in determining causes of spontaneous haemopericardium

Sarah Parsons, Chris O'Donnell

*Victorian Institute of Forensic Medicine and Monash University, 57-83 Kavanagh St, 3006 Southbank, Australia*

**Introduction:** Whole body post-mortem CT angiography (PMCTA) is routinely used to detect bleeding sites. This presentation examines the capacity of our technique to detect the site and cause of rupture in cases of haemopericardium(HPC).

**Methods:** 360 Autopsies where the cause of death was cardiac tamponade due to non-traumatic HPC were reviewed. Candidate cases for PMCTA were detected on the preliminary CT scan. Full autopsies were performed on all cases after angiography.

**Results:** Ventricular rupture leading to HPC was described in 161/360 (45%) cases. 118/161 (73%) from the left ventricle, 3 (<2%) from the right ventricle and in 40 (25%) no rupture point was described. Aortic dissection or aneurysm rupture was identified in the remaining (55%) cases. 25 PMCTA and autopsies were performed for HPC. Causes at autopsy included 13 (52%) aortic dissection, 10 (40%) left ventricular rupture, 1 (4%) aneurysm and 1 (4%) hemorrhagic pericarditis. The site of rupture (by way of contrast leak) was identified in 17 (68%). Of the 8 negative cases, 4 were dissection (all identified on PMCTA), 3 left ventricular rupture and 1 pericarditis. All 3 of the false –ve PMCTA for left ventricular rupture had poor ventricular contrast filling, 2 due to inadequate contrast volume and 1 due to inadvertent venous infusion.

**Discussion:** Our preliminary review of autopsy reports for HPC indicate that the vast majority of ventricular rupture is on the left thus single phase PMCTA using femoral arterial infusion may be all that is required. In 84% of cases, PMCTA has performed at VIFM was able to demonstrate the site and/or cause of HPC. All aortic dissections/aneurysms were detected. Failure to demonstrate left ventricular rupture was due to poor technique.

**Conclusion:** PMCTA is effective for demonstrating sites of rupture in non-traumatic HPC.

<http://dx.doi.org/10.1016/j.jofri.2013.03.019>

## The forensic reference phantom—A new tool for quality assurance of attenuation measurements in forensic radiology

Thomas Ruder<sup>a</sup>, Gary Hatch<sup>b</sup>, Lars Ebert<sup>a</sup>, Yannick Thali<sup>a</sup>, Sebastian Schindera<sup>c</sup>, Dominic Gascho<sup>a</sup>, Michael Thali<sup>a</sup>, Garyfalia Ampanozi<sup>a</sup>

<sup>a</sup> *Institute of Forensic Medicine, University of Zurich, Winterthurerstr. 190/52, 8057 Zurich, Switzerland*

<sup>b</sup> *Radiology-Pathology Center for Forensic Imaging, Departments of Radiology and Pathology, University of New Mexico, 1101 Camino de Salud NE, 87102 Albuquerque NM, USA*

<sup>c</sup> *Clinic for Radiology and Nuclear Medicine, University Hospital Basel, Spitalstrasse 21/Petersgraben 4, 4031 Basel, Switzerland*

**Introduction:** The purpose of this paper is to present the technical specifications of the Forensic Reference Phantom (FRP), to test its behavior relative to organic test materials, and discuss potential applications of the phantom in forensic radiology.

**Methods:** The FRP prototype is made of synthetic materials designed to simulate the computed tomography (CT) attenuation of water. It has six bore holes accommodate multiuse containers. These containers were filled with test materials and scanned at 80 kVp, 120 kVp, and 140 kVp. X-ray attenuation was measured by two readers. Intra- and inter-reader reliability was assessed using the intra-class correlation coefficient (ICC). Significance levels between mean CT numbers at 80 kVp, 120 kVp, and 140 kVp were assessed with the Friedman-test. T-test was used to assess significance levels FRP and water.

**Results:** Overall mean CT numbers were  $0.7 \pm 2.8$  HU for the FRP;  $-997.3 \pm 6.6$  HU for air;  $-130.3 \pm 21$  HU for oil;  $0.1 \pm 2.9$  HU for water;  $36.2 \pm 7.9$  HU for muscle tissue; and  $1805.4 \pm 438.5$  HU for cortical bone. Inter-reader and intra-reader reliability were excellent (ICC > 0.994 and ICC = 0.999 respectively). CT numbers were significantly different at different energy levels. There was no significant difference between the attenuation of the FRP and water at all energy levels.

**Conclusions:** The Forensic Reference Phantom is a new tool for quality assurance of attenuation measurements and research in forensic radiology. The mean X-ray attenuation of the FRP is equivalent to water. The phantom can be scanned on routine post-mortem CT to assess the composition of unidentified objects. In addition the FRP may be used to investigate new imaging algorithms and scan protocols in forensic radiology.

<http://dx.doi.org/10.1016/j.jofri.2013.03.020>

## Forensic imaging: 3D visualization of scattered CT-dense particles contained in the skin

Wolf Schweitzer, Michael Thali, Thomas Ruder

*Institute of Forensic Medicine of the University of Zurich, Winterthurerstrasse 190/52, 8057 Zurich, Switzerland*

**Purpose:** Particles of X-ray dense material like metal, glass or rocks may scatter across superficial skin layers in the course of blunt trauma such as explosions, falls, blows, or other impacts of later interest to police investigation. Yet, visualizing their distribution in a way that is illustrative enough to aid further investigation constitutes an open problem.

**Method:** We applied visualization techniques implemented in IDL (Exelis VIS, Boulder, CO, USA) to a number of clinical and post-mortem cases (1 instance of tiny rocks impaled into the skin, 1 instance of explosive device derived metal particles, 1 instance of glass fragments). From CT data, tracing and distance calculations are used to map volume data information to the body isosurface. We preserve location but magnify size appearance. Visualization was validated using various models (dummy data, animal skin).

**Results:** Particle visualization massively depends on partial volume effect. Resulting colored 3D surfaces of the CT-derived skin can provide accurate and relevant visualization of tiny particles sufficiently large or CT-opaque. In the instance of the explosion case, reconstructive conclusions could be made as to location and count of blows that significantly added to the investigation rather than merely supplementing it.

**Conclusion:** Visualization of such particle distribution can be a hard indication for acquiring a post-mortem CT scan as it adds anatomical particle distribution maps which an autopsy can never document in the same way.

<http://dx.doi.org/10.1016/j.jofri.2013.03.021>

## Feigning a craniotomy flap as an injury: An interesting case of fabrication

Luv Sharma

*Department of Forensic Medicine, University of Health Sciences, 124001 Rohtak, Haryana, India*

**Case report:** Fabricated injury is a major problem of forensic experts. Scant literature pertaining to the study of these entities is available and no specific and authentic criterion is laid down to label which injury should be declared as fabricated. Such injuries may be produced for many reasons including charging an enemy with assault or attempted murder or make simple injuries appear serious. Another rarer set of confusing injuries are termed as feigned/fictitious injuries. They basically involve pretense on the part of the patient to show injury. Fictitious injuries are also called as simulated injuries. I present an interesting case of such a simulated injury in which the patient tried to present an old surgical craniotomy flap as an entirely new injury in order to place a false charge against his relatives involved in a property dispute. The case was referred to our Institute from a peripheral hospital where the medico-legal report described two incised wounds on the scalp; the radiological investigations (NCCT head) being evasive. A new CT-scan was done at our center. The presence of a healed curvilinear surgical scar and more importantly evidence of craniotomy flap with burr holes in the CT-scans (both previous and new) were conclusive in detecting feigned injuries by the patient in connivance with the doctors at the periphery. Illustrative CT-scan films are provided to highlight the importance of forensic radiology in solving such unusual and deliberate situations.

<http://dx.doi.org/10.1016/j.jofri.2013.03.022>

## Court on the web: Courtroom simulation in distance learning

Jacque Vallis

*Teesside University, TS1 3BA Middlesbrough, UK*

**Abstract:** This year the postgraduate forensic radiography program at Teesside University has moved from blended to distance learning delivered entirely online. This was a result of practitioners being unable to be released from work to attend university. Furthermore, the distance learning mode of delivery has enabled international students to participate in the program. There were a number of aspects of the blended program that students highly valued, such as the use of external subject specialist lecturers, practical workshops, and courtroom simulation. One of the challenges in transferring this program to distance learning has been focused on how these practical based sessions that rely on resources located at the university can still be delivered when students will never attend. Radiographers engaged in forensic practice may be required to attend court to give evidence, something which the International Association of Forensic Radiographers (2012) states is on the increase, based on the number of requests for advice received from radiographers. The blended delivery took students into the mock courtroom during their block of attendance at the university to be cross-examined on their evidence and statement. Students reported that this process was highly important in enabling them to prepare for the real thing and in teaching them how to write a good statement. This university is the only Higher Education provider that offers such training; therefore, the team were keen to keep this in the program. This presentation will examine how this has been achieved with the courtroom simulation using software Adobe Connect webinar software, provided by Mizaru. In addition, the experiences of the staff and students involved will be discussed.

<http://dx.doi.org/10.1016/j.jofri.2013.03.023>

## A computational framework for CT-based craniofacial reconstruction

Dirk Vandermeulen<sup>a</sup>, Peter Claes<sup>a</sup>, Wim Develter<sup>b</sup>, Sven De Greef<sup>c</sup>, Walter Coudyzer<sup>d</sup>, Guy Willems<sup>c</sup>, Paul Suetens<sup>a</sup>

<sup>a</sup> *Medical Imaging Research Centre, Herestraat 49 Bus 7003, 3000 Leuven, Belgium*

<sup>b</sup> *Forensic Medicine, Kapucijnenvoer 33 Blok i—Bus 7001, 3000 Leuven, Belgium*

<sup>c</sup> *Orthodontics—Forensic Odontology, Kapucijnenvoer 7 Blok a Bus 7001, 3000 Leuven, Belgium*

<sup>d</sup> *Forensic Radiology, UZ Gasthuisberg Herestraat 49, 3000 Leuven, Belgium*

**Introduction:** Estimating the facial outlook from an unidentified skull is a challenging task in forensic investigations. This paper presents the implementation and testing of a fully automatic pipeline for computerized craniofacial reconstruction (CFR).

**Methods:** A database of age-, gender- and BMI-annotated full-head 3D cross-sectional CT reference scan images is used. The database is continuously being upgraded with new reference cases. Furthermore, the procedure can be easily extended to include data of different ethnicities when such data become available. Facial and skeletal surfaces are automatically extracted for every image in the database. Reconstruction of the face of an unidentified skull (scanned 'as is', not requiring a time-consuming soft tissue removal procedure) is started by warping all skull surfaces in the database to the target skull. The resulting transformations are then applied to the associated facial surfaces resulting in as many

warped facial surfaces as individuals in the database. A single consensus facial surface is generated by combining the individual reconstructions taking into account gender, BMI and age matching. By implementing this procedure on a cluster platform, reconstructions can be obtained in less than 10 min, irrespective of the number of reference images, which is considerably shorter than current manual reconstruction procedures.

**Results:** Validation was performed using a cross-validation leave-one-out scenario where each image in the database was reconstructed using all other images in the database as reference. The reconstructed and actual facial surfaces are then compared using statistics of intersurface distances. On a database of 72 reference individuals a maximal reconstruction error of 4 mm was obtained.

<http://dx.doi.org/10.1016/j.jofri.2013.03.024>

---

## Application of PMCT in cases of deaths potentially caused by tension pneumothorax

Krzysztof Woźniak<sup>a</sup>, Artur Moskała<sup>a</sup>, Tomasz Konopka<sup>a</sup>,  
Ewa Rzepecka-Woźniak<sup>a</sup>, Filip Bolechała<sup>a</sup>, Piotr Kluza<sup>a</sup>,  
Katarzyna Latacz<sup>b</sup>

<sup>a</sup>Jagiellonian University Medical College, Department of Forensic Medicine, Grzegorzewska 16, 31-531 Kraków, Poland

<sup>b</sup>Jędrzej Śniadecki Hospital, Młyńska 10, 33-300 Nowy Sącz, Poland

**Introduction:** The standard autopsy technique allows checking for the presence of air in pleural cavities, but it is very problematic to estimate the volume of gas. So it is hard to evaluate significance of the symptom, especially for considering as the cause of death.

**Methods:** Retrospectively, among routinely examined 269 cases with application of PMCT preceding conventional autopsy in 6-month' time (from August 2012)—cases with apparent PMCT signs of tension pneumothorax (a large sided pneumothorax with mediastinal shift to the side and flattening of the hemidiaphragm) were chosen and analyzed in relation to the actual cause of death.

**Results:** 73 (about 27% of the total) cases with presence of air in pleural cavity/ies were reported, out of them 11 with features of tension pneumothorax, in 5 very apparent. Cases of tension pneumothorax were not only limited to post-traumatic changes (it seems that most interesting was the case of a single stab wound with the damage of the left lung through the diaphragm, in which PMCTA disclosed lack of significant leakage from bigger blood vessels), one case was related to pneumonia.

**Conclusion:** PMCT in contrast to conventional autopsy gives evidence of pneumothorax easily and “repeatedly”, providing opportunities for identification of tension pneumothorax as the cause of death.

© 2013 Published by Elsevier Ltd.

<http://dx.doi.org/10.1016/j.jofri.2013.03.025>