

19th IAFS WORLD MEETING
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ORAL SESSION

Session 14.2

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LIVEBIRTH OR STILLBIRTH? USE OF POST-MORTEM COMPUTED TOMOGRAPHY AS A ADDITIONAL TOOL

Author(s): Wingenfeld L¹; Koerner M²; Keil W¹

Institution(s):¹INSTITUTE OF FORENSIC MEDICINE, UNIVERSITY OF MUNICH; ²RADIOLOGY, UNIVERSITY HOSPITAL LMU MUNICH

Case Report: A 22 year old student spontaneously gave birth to her baby at home. According to the mother, the baby was stillborn and said that the baby was not breathing and crying. The mother has a strict arabic family background and the relationship with her german boyfriend was a trade secret. Prior to the autopsy examination, and within 10 hours after the birth of the baby, a full body CT scan were undertaken as a part of the post-mortem examination. The imaging revealed small ventilated areas in the lungs. Smallest air bubbles were seen in the esophagus and stomach but not in the small and large intestine. The autopsy examination showed after opening the thorax markedly atelectatic lungs. Instead of this finding the lung swim test was on both sides positive. The swim tests of stomach and the intestine was negative. The external and internal examination showed no congenital or natural disease, no signs of physical force. To note was only plenty adherence of meconium on the body surface of the baby. The histological investigation could not explain the death, especially an aspiration of meconium or amniotic fluid could not be demonstrated. In the summary in difficult cases with inconsistent autopsy findings the use of post-mortem computed tomography could be a useful additional tool for the differentiation whether the child was liveborn or stillborn.

Keywords: *Post Mortem* Computed Tomography; Liveborn; Stillborn

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POSTMORTEM VIRTUAL ESTIMATION OF FREE ABDOMINAL BLOOD VOLUME

Author(s): Ampanozi G¹; Flach PM²; Hatch GM¹; Ruder TD¹; Thali MJ¹; Ebert LC¹

Institution(s):¹INSTITUTE OF FORENSIC MEDICINE, UNIVERSITY OF ZURICH; ²INSTITUTE OF FORENSIC MEDICINE, DEPARTMENT OF RADIOLOGY, UNIVERSITY OF ZURICH

Introduction: There is an internationally growing interest on using imaging modalities in forensics. Within the framework of minimally invasive autopsy, a method for estimating free fluid volume is being introduced. The purpose of this retrospective study was to examine the reliability of virtually estimated intraabdominal blood volume by using segmentation techniques on postmortem computed tomography (PMCT) data.

Materials and Methods: Twenty-one cases with free abdominal blood were investigated by PMCT and autopsy. The blood volume in the abdominal cavity was estimated by manually segmenting the data using segmentation software (Amira, Visage Imaging, Germany) and the results were compared to autopsy data. Six of 21 cases had undergone additional post-mortem computed tomography angiography (PMCTA). The hypothesis to be tested was that there is no significant statistical difference between virtually-estimated and autopsy-measured blood volume.

Results: The volumes estimated virtually by segmentation of the abdominal blood did not differ significantly from those measured at autopsy ($p > 0.05$). Additionally, the presence of extravasated contrast medium in the abdominal cavity did not bias the results significantly.

Conclusions: Virtual estimation of abdominal blood volume is a reliable technique. The virtual blood volume estimation is a useful tool to deliver additional information in cases where autopsy is not performed or additional PMCTA potentially alters the fluid volume. Virtual estimation of free abdominal blood may even be beneficiary for management of traumatic injury in the living patient.

Keywords: Virtopsy; Blood Volume; Segmentation; *Post Mortem* CT

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POST-MORTEM IMAGING IN FORENSIC INVESTIGATIONS: PRACTICAL APPLICATION

Author(s): Gherardi M¹; Castelli M¹; Machado D²; Meloni T²

Institution(s):¹AUSL VALLE D'AOSTA SC MEDICINA LEGALE, VIA CHALIGNE, AOSTA, ITALY; ²AUSL VALLE D'AOSTA SC RADIOLOGIA DIAGNOSTICA E INTERVENTISTICA, VIA GINEVRA, AOSTA, ITALY

Abstract: Multislice computed tomography (MCT) and magnetic resonance imaging (MRI) examination of deceased individuals is largely increasing in the field of forensic pathology. While CT is the technique of choice for documentation and analysis of pathological features such as gross tissues injury, skeletal fractures, foreign bodies and abnormal gas collection (air embolism, decompositions effects ecc.), RM is superior to autopsy in detecting very small abnormalities of the central nervous system allowing a thin sections of the whole brain. On these basis radiological body processing is becoming a useful guide for forensic pathologist during autoptic dissection with a reliable impact on the accuracy of conventional autopsies for many purposes. Information obtained by post-mortem imaging can be useful for the body identification, to determine the cause and manner of death or to evaluate the vitality of injuries. However, there are several post-mortem changes and decomposition patterns that may affect the appearance of the body on radiological imaging which are unusual to clinical radiologists. Occasional experiences in post-mortem imaging have a high risk of findings misinterpreting if are solely based on clinical criteria. An integrated cooperation between radiological specialists and pathologist is crucial for a correct integration of data obtained by autoptical dissection and post-mortem imaging. We report the experience performed applying radiological technologies for forensic purposes in deceased persons in Valle d'Aosta (North Italy) in order to evaluate both the critical and the useful aspects of the practical application of noninvasive imaging techniques to the classical post-mortem investigations in humans.

Keywords: Forensic Pathology; Multislice Computed Tomography; Magnetic Resonance Imaging.

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THE INFLUENCE OF POST-MORTEM CT-ANGIOGRAPHY USING ANGIOFIL ON BIOCHEMICAL INVESTIGATIONS OF VITREOUS HUMOUR

Author(s): Palmiere C¹; Widmer C¹; Augsburger M¹; Mangin P¹; Grabherr S¹

Institution(s):¹CURML LAUSANNE

Abstract: Postmortem computed tomography angiography (PMCTA) is becoming increasingly essential within the broader discipline of forensic radiology and forensic pathology. According to the protocol developed by Grabherr and coworkers and published in 2010, the vascular system of the body can be filled with a contrast agent mixture composed by the oily liquid Angiofil[®], consisting of iodized linseed oil, and paraffin oil. This contrast agent mixture allows performing high-quality PMCTA and reduces the risk of misinterpretation in the radiological diagnosis thanks to a complete filling of the vascular system and to the performance of multiple phases of angiography. One of the aspects to define in PMCTA is, however, the influence of the contrast agent mixture on the results of toxicological and biochemical analysis and, consequently, the opportunity to collect samples for toxicology and postmortem chemistry before the injection of the contrast agent. The aim of this study was to compare the results obtained from postmortem chemistry analyses (30 PMCTA cases) performed on two vitreous humour samples, one obtained before the injection of the contrast agent and one obtained at the time of the autopsy, after the PMCTA. The time interval between the sample collections, before and after PMCT, was six hours. These results were compared to those obtained from postmortem chemistry analyses performed on two vitreous humour samples of 30 control cases that did not undergo PMCT. These samples were collected with an interval of at least six hours. Six markers were tested (sodium, chloride, glucose, lactate, creatinine and urea nitrogen). Our first results seem indicate that different values can be observed for each marker between the first and the second vitreous humour sample in both groups. These differences seem to be related to the time elapsed between the first and the second collection. The injection of the contrast agent seems not to influence postmortem chemistry analyses of vitreous humour, at least for the markers tested in this study.

Keywords: *Post mortem* Angiography; *Post Mortem* Chemistry

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FORENSIC EXPERTISE ON TRAUMATIC BRAIN INJURY ACCORDING TO CT AND MRI IMAGING

Author(s): Jakovski Z¹; Lazarevska M²; Stankov A¹; Cakar Z¹; Janeska B¹

Institution(s):¹INSTITUTE OF FORENSIC MEDICINE, CRIMINOLOGY AND MEDICAL ETHICS, SCHOOL OF MEDICINE, UNIVERSITY ST'S CYRIL; ²INSTITUTE OF RADIOLOGY, CLINICAL CENTER, SCHOOL OF MEDICINE, UNIVERSITY ST'S CYRIL AND METHODY

Case Report: The mechanisms of brain injuries, their timing, and their eventual consequences are often part of the expert opinion requested by the Court. We are presenting a case in which the Court requested an expert opinion of the injuries sustained by a driver involved in a traffic accident. The main question was whether the driver had first suffered a stroke which could have caused the accident. The medical documentation showed that the driver was brought to the hospital in a stuporous condition, with right hemiparesis. External examination revealed hamatomas and oedema on the left frontal region of the head and left eye. CT scans performed 3 hours after the accident show edema of left frontal and parietal lobes, and hypodense lesions of the left frontal and temporal cortices were also present, which is characteristic but not specific for contusion in CT images made 3 hours after the accident. Seven days after the accident, on follow-up CT images, hypodense lesions were better detected because the swelling of the brain had retracted. On MRI images performed 6 months after the accident, the same lesions are still present and look like encephalomalacia, gliosis and cortical reduction atrophy; which did not contribute to the forensic conclusions. According to the CT and MRI images we can not confirm or reject the possibility of stroke shortly before the accident. But the finding on CT images of hypodense lesions of the left frontal and temporal lobus which affected cortex of the brain, and comparing them with the injuries on the head in the left frontal region and left eye indicate to us that these changes of the brain are more likely to be contusions caused by the blow to the head, rather than by a stroke.

Keywords: Brain Injury; CT; MRI; Mechanism

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DIGITAL AUTOPSY AND EVENT RECONSTRUCTION IN INVESTIGATION OF FATAL FALL FROM HEIGHT IN MALAYSIA: ILLUSTRATION OF 2 CASES

Author(s): Abd Wahid S¹; Vanezis P²; Bagali P²; A. Chandran M²; Thali MJ²

Institution(s):¹FORENSIC UNIT, HOSPITAL UKM; ²ACADEMY OF FORENSIC MEDICAL SCIENCES (UK)

Abstract: Fatal fall from height is quite common in forensic practice. The causes of death in these cases are mostly due to head injury or multiple injuries due to the fall itself. However, determination of the manner of death is very challenging in some cases. We present 2 cases to illustrate the difficulties to decide homicidal, suicidal or accidental manner of deaths. The digital autopsy revealed pattern of bone dislocations and fractures which predict the mechanism of injury and impact. The reenactment/reconstruction predicts the mechanism of the fatal falls. We propose the use of digital autopsy and event reconstruction to assist in determination of the manner of death.

Keywords: Fall from Height; Manner of Death; Head Injury; Forensic Pathology; Fracture Skull

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PRESENCE (AND PERSISTENCE) OF CORONARY THROMBOSIS AFTER POST-MORTEM COMPUTED TOMOGRAPHY ANGIOGRAPHY

Author(s): Palmiere C¹; Doenz F²; Bize P²; Binaghi S²; Chevallier C²; Mangin P¹; Grabherr S¹

Institution(s):¹CURML LAUSANNE; ²SERVICE DE RADIODIAGNOSTIC ET DE RADIOLOGIE INTERVENTIONNELLE, CHUV, LAUSANNE

Abstract: Postmortem demonstration of coronary arteries occlusions in cases involving sudden unexpected death or in cases of suspected myocardial infarction is of fundamental importance in forensic pathology. However, postmortem examination of coronary arteries can be problematic. Serial horizontal sectioning can produce crush artifact in heavily calcified arteries, whereas longitudinal sectioning may dislodge thrombi and lead to misdiagnosis. Performance of postmortem angiography before autopsy provides a permanent record for documentation of coronary arteries distribution and patency. It also allows focusing the dissection technique. The first systematic method for the postmortem study of the coronary arteries was described by Schlesinger in 1938. Many techniques have been studied since then, involving the use of different contrast agents. Grabherr and co-workers published in 2010 a standardized protocol for whole body PMCTA (postmortem computed tomography angiography) using a contrast agent mixture composed by the oily liquid Angiofil®, consisting of iodized linseed oil, and paraffin oil, and Virtangio perfusion device, called the "multi-phase post-mortem CT-angiography". The aim of this study was to investigate whether a fresh coronary artery thrombosis could still be recognized after CT-angiography. We reported four cases in which PMCTA revealed the suspicion of coronary thrombosis that could be verified during the conventional autopsy. Images obtained from PMCTA and conventional autopsy (with horizontal sectioning of the coronary arteries), as well as histology, were compared for each case. Our first results seem indicate that the presence of a coronary occlusion at the postmortem angiography is confirmed by the presence (and the persistence) of a fresh coronary thrombosis detectable at the convention autopsy and histology. These observations seem to lead to the conclusion that postmortem angiography according to multi-phase PMCTA-protocol is useful to demonstrate the presence of coronary thrombosis. Coronary thrombi are not dislodged by the postmortem vascular perfusion and radiographic images correlate well with macroscopic and microscopic findings.

Keywords: *Post mortem* Angiography; Coronary Arteries; Coronary Thrombosis

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SUBARACHNOID HEMORRHAGE ON ADMISSION CT: VALUE OF MINIMALLY INVASIVE, POSTMORTEM CT ANGIOGRAPHY IN DETERMINING CAUSE OF DEATH

Author(s): Parsons S¹; Fernando T¹; Odonnell C¹

Institution(s):¹VICTORIAN INSTITUTE OF FORENSIC MEDICINE

Introduction: With few exceptions, all deceased persons admitted to the VIFM since 2005 have been CT scanned on admission. Whole body postmortem CT angiography (PMCTA) was introduced in 2010 as a further tool of initial investigation. This presentation will examine the capacity of our PMCTA technique to adequately opacify intracerebral vessels and its ability to demonstrate underlying cause in cases of non-traumatic subarachnoid hemorrhage (SAH) identified on the admission CT scan. The impact of angiography on the initial investigation of SAH and its use in determining cause of death will be discussed.

Methods: Candidate cases for PMCTA are assessed on the preliminary CT scan and coronial permission sought for the angiographic procedure. A modified Bern technique is employed using a Dodge embalming pump to deliver 1700mL of a 1:10 iodinated radiographic contrast and PEG 200 solution. Full autopsies are performed where possible. All PMCTA case files and images were reviewed. CT scans were assessed to determine the degree of intracranial arterial opacification using a scale of poor (minimal intracerebral contrast), moderate (major intracerebral vessels but no peripheral branches), and good (major intracerebral vessels including peripheral branches).

Results: 18 PMCTA were performed with full autopsy correlation in 14. Of the 12 non-SAH cases, 2 were assessed as poor opacification, 2 poor/moderate, 2 moderate, 1 moderate/good and 5 good. The 2 poor and 2 poor/moderate cases were carefully examined and found to be associated with massive contrast leak from disrupted vessels outside the skull. The 6 SAH cases were assessed as 1 moderate/good, 4 moderate, and 1 poor/moderate. PMCTA detected an aneurysm in 5/6 SAH cases. In one case PMCTA was negative yet a thrombosed aneurysm was detected at autopsy. Vessel opacification was classified as poor/moderate in that case. Contrast leaking from aneurysms into the subarachnoid space was observed in 4 of the 5 cases. In one case, a giant aneurysm was detected on PMCTA but no leak seen due to contrast pooling in the lumen.

Discussion: Adequate opacification of the circle of Willis can be achieved in the majority of cases using the PMCTA technique adopted at VIFM. Technical failure or injuries sustained by the deceased leading to contrast leakage outside the skull explains the cases of poor opacification. Non-traumatic SAH is commonly seen on admission CT at the VIFM. In the past, exact origin of hemorrhage and thus cause of death could not be determined without an autopsy to examine the intracerebral vessels. Even at autopsy an underlying cause is not always determined. PMCTA was able to detect 5 of the 6 aneurysms in our SAH cases and point of rupture in 4 of those 5. The introduction of PMCTA at VIFM has allowed the intracranial circulation to be examined using a minimally invasive procedure and the cause of bleeding detected in the majority of non-traumatic SAH cases. In situations where a family has requested that no autopsy be performed, as allowed by the Victorian Coroners Act 2009, PMCTA provides a means by which a cause of death may be determined.

Conclusions: Minimally invasive PMCTA adequately opacifies the intracranial circulation, and determines cause and mechanism of death in most cases of non-traumatic SAH, with a point of bleeding detected in the majority. In concert with routine postmortem CT imaging it

Keywords: *Post mortem* CT Angiography; Subarachnoid Hemorrhage; Autopsy

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VIRTOPSY AND COMPUTER EMULATION: IS THE CRANIOCEREBRAL INJURY AFFECTED BY ITS GEOMETRIC AND PHYSICAL CHARACTERISTICS?

Author(s): Liu N¹; Zhao H²; Li Z¹; Zheng J¹; Zou D¹; Chen Y¹

Institution(s):¹INSTITUTE OF FORENSIC SCIENCES, MINISTRY OF JUSTICE, CHINA; ²DEPARTMENT OF RADIOLOGY, RENJI HOSPITAL, SHANGHAI JIAOTONG UNIVERSITY

Introduction: Human's skull and brain have a irregular geometric configuration and complex physical characteristics. As produced different stress distributions, it might lead to a varied morphological change of craniocerebral injury when blunt force conducted on different cranio-position. This phenomenon can be observed in human cases of craniocerebral injury and measured by computer tomography (CT) and emulation.

Materials and Methods: 91 clinical and 12 autopsy cases of craniocerebral injury that suffered by blunt force were selected. The relationship between force position or direction and damage sequels, such as injury degree, fracture position and contre-coup cerebral constusion, were observed by epidemiological retrospective study. All the cases were scanned by multi-slice CT (MSCT) for virtual autopsy (virtopsy) analysis. The Digitalimaging and Communications in Medicine(DICOM) data of craniocerebral CT were then inputted into MIMICS computer software for reconstructing a digital model of three dimensional finite element. Aided by ANASYS computer software, the distribution of stress and strain on the digital skull under different blunt impact were recorded and analyzed. The result was compared with that from human cases.

Results: (1) Among press force from three directions, frontal, temporal and occipital, the most serious of stress and strain were observed when it impacted by occipital force. It implied occipital force more easily produced a serious craniocerebral injury because of the geometric characteristics of skull. (2) Disregard of force direction, the skull base withstood higher stress than other parts of skull because of its physical characteristics. That means there was a higher likelihood of fracture in skull base than that in other parts.

Conclusions: The geometric and physical characteristics of human skull may affect the distribution of stress and strain. It may then affect the serious degree and morphological changes of craniocerebral injury.

Keywords: Craniocerebral Injury; Blunt Force; Virtopsy; Computer Emulation; Finite Element

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POST-MORTEM MSCT EXAMINATION IN CASES, WHERE SUBSEQUENT CONVENTIONAL AUTOPSY HAS FAILED TO PROVIDE ADDITIONAL SUBSTANTIAL INFORMATION

Author(s): Wozniak K¹; Moskala A¹; Urbanik A²; Klys M¹

Institution(s):¹DEPARTMENT OF FORENSIC MEDICINE, JAGIELLONIAN UNIVERSITY MEDICAL COLLEGE, KRAKÓW, POLAND;
²RADIOLOGY, JAGIELLONIAN UNIVERSITY MEDICAL COLLEGE, KRAKÓW, POLAND

Introduction: In collaboration with the Department of Radiology, the Department of Forensic Medicine at the Jagiellonian University Medical College leads routine post-mortem MSCT examinations since March 2009. The number of examinations performed since that time until May 31st, 2011 is 147. In most cases, evaluations of PMCT yield rich sets of data complementary to the information obtained during conventional autopsy. Due to the fact that in certain cases, subsequent conventional post-mortem examination fails to provide additional substantial information, it is necessary to evaluate the usefulness of post-mortem MSCT examinations as a replacement of conventional autopsy.

Materials and Methods: In two cases of corpses of: (1) a victim of a traffic accident, driving a single-track vehicle, (2) a victim of fall from a height in the setting of high mountains - post-mortem MSCTs were performed prior to proceeding with conventional autopsies. Equipment used: Siemens Somatom Sensation 16 (slice thickness: 0.75 mm for the head and 1.5 mm). DICOM files were obtained from the CT examinations, and analyzed using the Osirix software.

Results: The cross-section (2D) images and three-dimensional (3D) pictures and animations visualize not only the injuries resulting in deaths, but also the particular mechanism of injury. Specifically, the victim's role in the motor vehicle accident can be deduced with great certainty from the images presented. Similarly, the probability that the victim of the fall sustained "defensive" injuries in an attempt to prevent the fall is very high.

Conclusions: It seems that the conventional forensic autopsy will remain the primary post-mortem examination for many years. However, it is possible that in some cases it will be replaced completely by post-mortem imaging studies. This will be possible only when the results of post-mortem imaging techniques will satisfy all the needs of legal proceedings.

Keywords: *Post mortem* MSCT; Cross-section Images; Three-dimensional Pictures; Mechanism of Injury

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VIRTOPSY - 10 YEARS EXPERIENCE IN SWITZERLAND

Author(s): Thali M¹; AVTZ¹

Institution(s):¹UNIVERSITY ZURICH

Abstract: Imaging has changed the world and greatly influenced modern medicine. In the 2009 report concerning "Medical Examiners and Coroners systems: current and future needs" of the "National Academy of Science" is written, that modern imaging technologies (Virtual autopsy, Virtopsy) has a great potential to detect forensic relevant findings. The advent of high resolution multi-detector row CT scanners and fast MRI scanners in the last decade has allowed the development of imaging techniques that have greatly enhanced the diagnostic potential of these two imaging modalities. While conventional radiographs have played a valuable role in forensic diagnosis and practice for over a century, recent investigations with both CT and MRI suggest that these imaging tools are capable of much greater contributions. A major innovation is the ability to display imaging findings in 2D and 3D planes that closely replicate the findings at conventional autopsy and make the interpretation of the studies more easily understood by non-radiologists. CT and MRI may be used to supplement traditional autopsy techniques, to provide a complete anatomic assessment prior to limited autopsy, or in certain circumstances to replace it, such as in blunt accidental trauma, or drowning deaths. These studies may also provide options in the setting of religious and cultural objections to conventional autopsy. While CT has the advantage of providing rapid whole body imaging of great anatomic detail in a short time, the superior contrast resolution of MR provides soft tissue characterization that is not achievable by CT. MRI is less widely available and more time consuming but may be applied to the postmortem evaluation of specific body parts to aid in the diagnosis of specific causes of death that may be characterized by subtle soft tissue changes. Both CT and MRI provide a permanent pictorial record of anatomic findings that may be retained and analyzed for medical and legal purposes post mortem and offer advantages in quality assurance that may be difficult to replicate with conventional autopsy. The forensic science and medical examiner communities have shown interest in the use of CT and MR autopsy imaging. However, while CT and MR imaging are widely available in the clinical care of the living, forensic facilities face problems of access to autopsy imaging due to financial, technical, transportation, interpretation, and related difficulties. For the past 15 years, our Forensic Institute in Switzerland been concerned with imaging problems in forensics. In 2009 the robot-supported automated system integration of 3D surface scanning and multislice CT with postmortem biopsies was successful as a "Virtobot" developed. After what is now 5 years, the over 100 postmortem angiographies show impressive results from the research activities. In the early part of 2010, our Total Imaging Total Matrix TIM-MRI system that has been in operation since 2009 could be extended with the so-called synthetic MRI software. The advantage of this TIM synthetic MRI system lies in the fact that in one examination step various MRI sequences (such as T1-T2-PD, etc.) could be performed from tip to toe without any change of the surface traces. In the daily forensic service applications it has become evident that through applying this approach a increase in quality and a improvement in the forensic diagnostics can be achieved and the examination results based on the imaging are often quicker and, thanks to a more visual 3D reconstruction, can be displayed in a way that lay persons can understand and comprehend. Momentarily, in terms of workflow and process, this Virtopsy-system integration is the only forensic examination track in a forensic institute that has brought together all the modalities and technologies in this form for daily use and research (www.virtopsy.com).

Keywords: Virtopsy; Forensic Imaging; 3D Reconstruction