O.1.01

Accuracy and interrater agreement in identifying cause of death on postmortem CT: prospective study in a forensic setting

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Since the introduction of postmortem computed tomography (PMCT) to forensic death investigations, numerous scientific manuscripts have been published comparing PMCT to forensic autopsy, underlining the strengths and weaknesses of each. However, variables like experience and expertise of the investigators, scanning protocols, distinct for each study and incomparable between study populations (e.g. traumatic versus natural causes of death, pediatric versus adult populations), led to a great variability of results. These factors affect the reported accuracy of PMCT in defining cause of death, compared to full autopsy - which varies widely in the literature and ranges from 6% to 70%.
We conducted a prospective study over a 5 months period, including 101 adult decedents in our study population. Routine whole-body PMCT and forensic autopsy was performed in every case. One radiologist and one forensic pathologist independently completed a standardized check-list with 110 distinct, predefined PMCT findings in each case and defined the cause of death based on PMCT findings in an additional consensus reading. This approach was mirrored by the two forensic pathologists who also determined the cause of death after autopsy. Both teams independently noted their respective level of confidence regarding the cause of death in each case. To enable statistical evaluation of data, causes of death were pooled in distinct categories.. PMCT-based cause of death and autopsy-based cause of death was compared to the cause of death, as stated in the final forensic report, which also included results of histological, toxicological and/or further analysis.
Agreement between the final report and PMCT and autopsy was 82% (83/101 cases) and 89% (90/101 cases), respectively. There was full agreement between the final report and both PMCT and autopsy in 80/101 cases (79%). On PMCT, the highest sensitivity was achieved for cardiac causes of death (92%), and the highest specificity for central nervous system (CNS) and vascular causes of death (100%). At autopsy, highest sensitivity and specificity was also reached for vascular causes of death (100%). The lowest sensitivity for both PMCT and autopsy was found in the miscellaneous causes of death (50% and 78% respectively). Diagnostic specificity for both PMCT and autopsy was high throughout all categories; the lowest value was 83% and 95%, respectively, for cardiac causes of death. Overall, levels of confidence of the investigators reflected the level of agreement between PMCT and the cause of death as determined in the final report, whereas levels of confidence regarding the diagnosis of the cause of death after autopsy did not correlate with the accuracy of diagnosis.
Every PMCT rater (radiologist and forensic pathologist) assessed 110 findings in each case on the standardized check-list. They only did differ in 1.9% (211/11110) of all findings.
This study reveals that experienced PMCT raters are able to correctly identify the cause of death - including cardiac death - in 83% of all cases based on non-contrast PMCT with a high correlation between subjective levels of diagnostic confidence and diagnostic accuracy.

O.1.02

The 'pseudo-CT myelogram sign': an aid to the diagnosis of underlying brain stem and spinal cord trauma in the presence of major cranio-cervical region injury on post-mortem computed tomography

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Introduction: The 'Pseudo-CT Myelogram Sign' describes the visibility of the cervical spinal cord and brain stem due to the presence of high attenuation subarachnoid hemorrhage (SAH) in the upper cervical spine and posterior fossa regions on postmortem computed tomography (PMCT) after blunt cranio-cervical trauma. This finding simulates the appearance of a CT myelogram study where hyper-attenuating contrast material is injected into the subarachnoid space to outline the spinal cord and associated structures. This study documents our experience in the detection of associated underlying low attenuation spinal cord or brain stem injuries in the presence of the Pseudo-CT Myelogram sign on PMCT.
Materials and Methods: The Pseudo-CT Myelogram sign was identified on PMCT in 20 decedents (11 male, 9 female; age 3-83 years, mean age 35.3 years) following fatal blunt trauma over a 5 year period at a single forensic center. Osseous and ligamentous cranio-cervical region injuries and brain stem or spinal cord trauma detectable on PMCT were recorded. PMCT findings were interpreted with consensus readings by 2 board certified radiologists who had a combined total of 7 years of PMCT imaging experience. PMCT results were compared to conventional autopsy in all cases.
Results: PMCT detected transection of the brain stem or high cervical cord in 9 of 10 cases compared to autopsy (Sensitivity-90%). PMCT was 92.86% sensitive in detection of Atlanto-Occipital joint injuries (n=14), and 100% sensitive for Atlanto-Axial joint (n=8) injuries. PMCT detected more cervical spine and skull base fractures (n=22, and n=10 respectively) compared to autopsy (n=13, and n=5 respectively).
Conclusion: The Pseudo-CT Myelogram sign is a novel description of a diagnostic finding, that if present in fatal cranio-cervical region trauma, is very sensitive for underlying spinal cord and brain stem injuries not ordinarily visible on PMCT. Its presence may also predict major osseous and/or ligamentous injuries in this region when anatomic displacement is not evident on PMCT.

O.1.03

Differences between postmortem CT and autopsy findings in forensic investigation of cervical spine injuries

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Background: As cervical spinal injuries (CSIs) can lead to death even as an isolated injury, accurate postmortem evaluation for CSIs is important in forensic medicine. However, due to complicated anatomy, the cervical spine is sometimes difficult to be evaluated by conventional autopsy. Although the additional evaluation of postmortem computed tomography (PMCT) can address to this problem, there are few studies about effectiveness of PMCT for CSIs with mixed results and, no study has clarified differences between PMCT and autopsy findings in CSI cases.
Objective:
To clarify differences between PMCT and autopsy findings in postmortem detection of CSIs.
Materials and methods: Forensic pathologists' database at our department was searched from October 2009 through December 2012. In each case, pathologists' autopsy data and radiologists' reports were reviewed in terms of presence or absence of bone fractures and intervertebral injuries. The reviews were performed separately on 14 bones (anterior and posterior part of C1-C7 bones) as for bone fractures, and 14 intervertebral structures (anterior and posterior part of the occiput-atlas and C1/2-C6/7 intervertebral structures) per each case.
Results: The study included 42 CSI cases, which means inclusion of 588 bones and 588 intervertebral structures. In both bone fractures and intervertebral injuries, no substantial concordance between PMCT and autopsy findings was observed (McNemar's test: $p<0.001$ and $p<0.001$ respectively). As for bone fractures, CT-detected injuries were larger in number than autopsy-detected injuries (CT: 74, autopsy: 23). The proportion of autopsy-missed bone fractures to CT-detected fractures and CT-missed fractures to autopsy-detected fractures were 77% (57/74) and 26.1% (6/23), respectively. As for intervertebral injuries, CT-detected injuries were smaller in number than autopsy-detected injuries (CT: 40, autopsy: 80). The proportion of autopsy-missed injuries to CT-detected injuries and CT-missed to autopsy-detected injuries were 35% (14/40), and 67.5% (54/80) respectively.
Conclusions: As substantial numbers of CSIs were only detected by either PMCT or autopsy, accurate evaluation for CSIs requires both modalities.

O.1.04

Optimisation of post mortem coronary computed tomography angiography compared to histopathology using a novel alignment procedure

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Introduction: Cardiovascular disease is a significant cause of sickness and mortality in the western world. The disease is based on a hardening of the heart arteries that normally take decades to develop leaving possibilities to discover it and possibly prevent the disease. Hardening of arteries is caused by sediments on the inside of the arteries, called plaque. Plaque can be classified as stable or unstable. The unstable plaque is the most important to diagnose, as they are in risk of rupture and can therefore cause a critical blood clot in the heart, which is responsible for several cardiovascular deaths every year.
Diagnosing plaque can be done using CT scanning of the heart. This examination is a technical challenge, as the chest is constantly moving (due to breathing and heartbeat) and small details should be imaged clearly. A new CT technique using a different energy level of x-rays to image the patient could improve the possibility to diagnose cardiovascular disease. Whether this new technique in CT scanners can show certain components from plaque composition is not investigated yet. Another possible optimization technique is the iterative reconstruction software, given the possibilities to lower the radiation dose. Will this show positive results, it will be possible to differentiate if the plaque in the heart arteries is stable or not. Diagnosing unstable plaques would make it possible to treat and potentially prevent more patients from a cardiovascular death and therefore provide great possibilities for future patients.
Materials & methods: Twenty human hearts obtained from autopsies were used. A contrast agent that solidifies after cooling was injected into the coronary arteries. CT scanning was performed on the heart alone as well as with the heart in a chest phantom. We used eight different CT protocols and the newest CT technique to image every heart. All CT images were analyzed with quantitative coronary plaque analysis software. The CT images analyses results were compared with their corresponding histological sections. A comprehensive procedure for ensuring the correct alignment of the images was developed as both a physical measure tool and a software program.
Results: We have succeeded in developing a new method for post-mortem coronary CT angiography to simulate clinical CT with the use of a human phantom. Preliminary results are available and showed a tendency of statistical based iterative reconstruction to have an increasing effect on size of the calcified plaques using coronary CT angiography compared to the gold standard of histopathology.
The comprehensive analyses and alignment process is still ongoing. Hopefully we will be able to characterize coronary plaques and discuss if the new techniques allow for detection of rupture-prone plaques at a low dose level in the near future.

O.1.05

The reliability of neck approach for whole body postmortem angiography in the cause of sudden death: a validation study

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Introduction: Post mortem computed tomography angiogram (PMCTA) using 'groin approach' or femoral vessels is commonly practiced. However, PMCTA using the Carotid Artery (CA) and lnternal Jugular Vein (lJV) or 'neck approach' has only been done for selective angiogram and not for whole body angiogram.
We focused on the cause of sudden death (COSD) as it is the commonest cause of death in Malaysia and the world and the most difficult to diagnose using post mortem computed tomography (PMCT).
The goal of this study is to determine reliability and effectiveness of PMCTA in the diagnosis of COSD using a modified neck approach.
Materials and Methods: This prospective study involved 80 sudden death cases undergone PMCT followed by PMCTA and finally autopsy. lnfusion of contrast solution using an embalming machine and via catheters inserted into the CA and lJV. The pathological findings relevent to the COSD were documented and compared with autopsy. Advantages and disadvantages of this approach were also documented.
Results: This approach has shown that it could opacified the whole body as good as femoral approach with better opacification of the coronary arteries and pulmonary trunk as well as the lower limbs. Opacification of the coronary arteries is better with left sided cannulation of the neck compared to right side. We also noted that the amount of contrast solution, rate and pressure needed for Asian sample is lower compared to western population as published previously. Nearly 60 % of all positive findings visualized on both PMCT and PMCTA we confirmed with autopsy. PMCTA also demonstrates a higher sensitivity for identiffing skeletal and vascular lesions. We documented shrinking or 'embalming effect' of the lungs and kidneys as well as dissection of the aorta using this technique which have never been documented previouslywith 'groin approach'.
Conclusion: PMCTA with 'neck approach is equally good as PMCTA with 'groin approach'with better opacification of the coronary arteries and pulmonary trunk as well as the lower limbs. Overall, PMCTA and conventional autopsy provide comparable findings.
Keywords: PMCT, PMCTA, Autopsy, Sudden Death

O.1.06
Early experience with the use of gas for postmortem angiographic computed tomography in lower extremity wounds
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Background: Postmortem computed tomography (PMCT) may significantly facilitate the diagnostic process in traumatic vascular damage. However, visualizing blood vessels in CT scans requires contrast administration. Typically, positive contrast agents are used for vessel enhancement. The Department of Forensic Medicine of Medical University of Warsaw in cooperation with the Chair and Department of General, Vascular and Transplant Surgery Medical University of Warsaw, began study with the use of negative contrast in the form of gas to visualize blood vessels.
Purpose: The purpose of this report was to present three cases of deaths due to lower extremity wounds, where gases were used to visualize wound channels and vascular damage.
Material and methods: There were two cases of stab wounds (to the thigh and leg) and one leg laceration. In each case, a forensic pathologist conducted a non-contrast PMCT. The examined areas included the head, torso, and lower extremities. Subsequently, following inguinal dissection (on the side of the wounded extremity), an endovascular 5-F pigtail catheter (in two cases) or a Foley catheter (in one case) was inserted via the femoral artery. In one case a 60-mL syringe was used to administer a total of 900 mL of air via an endovascular catheter. In the remaining two cases approximately one liter of helium each was administered from a pressurized container used for inflating balloons connected via a pressure regulator directly either to an endovascular or Foley catheter. One more PMCT scan of the lower extremities was conducted. In the cases where helium was used, in addition to the femoral arteries, the femoral veins were cannulated in a similar way and the gas was administered intravenously. However, only half of the volume was administered into the veins due to an observed artifact in the form of transient subcutaneous pneumatocele of the leg. In each case, a subsequent conventional postmortem examination was performed.
Results: The location of vascular damage was successfully visualized in all presented cases. Moreover, the wound channel in stab wounds, which was invisible or poorly visible on non-contrast PMCT scans, was additionally visualized. Vascular damage appeared as vascular outline discontinuation at the level of band-like gaseous extravasation stretching from the surface of the skin - and corresponding to the wound channel. The presence of a clear wound channel helps distinguish true vascular damage from a segmental lack of the vessel visibility due to other causes, e.g. the presence of a thrombus. We also observed significant gas extravasation in the soft tissues adjacent to the damaged blood vessels crossed by stab-wound channels, which corresponded to hemorrhagic sites found on the postmortem. Unfortunately, in one case the gas seeped in between fascia and subcutaneously in the distal part of the limb unaffected by hemorrhages, which may have been due to catheter tip migration beyond the vascular lumen at a vascular injury site.
Conclusions: A gas can be used in postmortem diagnostics of lower extremity wounds as a negative contrast agent in PMCT. Further studies are needed an improvement in the technical aspect of gas administration.

O.1.07
Classification of different kinds of foreign bodies revealed during PMCT examination
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Introduction: Foreign bodies are common findings in forensic PMCT examination. Since PMCT is often used as screening method in most cases foreign objects are accidental findings, but in some cases the whole examination concentrates on finding the exact object (i.e. projectile). Our PMCT research has started in 2009, since then we have completed more than 2500 medico - legal examinations in which wide range of different kinds of foreign bodies had been revealed.
Objectives: Presentation and classification of different kinds of foreign bodies visualized with PMCT data evaluation.
Material and Methods: PMCT data acquired using 16 - layer CT (clinical Siemens Somatom Sensation and, since the year 2012, own Siemens Somatom Emotion). Evaluation using OsiriX (Pixmeo, Switzerland). Found foreign bodies were categorized due to their localization, material and circumstances of appearance.
Results: Foreign bodies can by characterized by three parameters (1) - object localization, (2) - its material characteristics, and (3) - circumstances of presence of the object. As for localization objects can be divided into following groups: external to the body, free inside body cavities, tracks and localized inside tissues. As for material we can distinguish metallic and non-metallic objects. As for circumstances: post-explosion and ballistic, pounded, due to medical intervention, self-inflicted, other. The authors present a review of 2D and 3D images referring to groups of foreign bodies with different parameters.
Conclusion: PMCT examination adds new quality to forensic investigation when foreign objects are considered. Due to screening aspect of PMCT examination it has an important role in DVI cases. Objects can be localized before autopsy which makes finding them easier, or even possible. In some cases, based on HU value, type of material can be immediately estimated. Localization and identification of foreign objects with PMCT should be considered as one of most important aspects of this technique.

O.1.08
Post-mortem diffusion MRI of the cervical spinal cord and nerves roots
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Aim: Diagnostic imaging investigation of the cervical spine post-mortem (PM) can be beneficial for the identification of death-related injuries in trauma cases, since dissection of the cervical spinal cord and nerves is difficult during autopsy. Diffusion tensor imaging (DTI) allows for the evaluation of microstructural properties of nervous structures and can be used for this purpose. Validation with histology is needed to assess the added value of DTI for investigating peripheral nervous tissue. The aim of this work is to examine the architectural configuration and the microstructural substrate of the cervical spinal cord and its nerve roots with PM DTI and histological dissection in non-fixated subjects.
Methods: Five non-fixated PM subjects with normal anatomy of the cervical spinal cord were included; 5 men (4-6 days after death) with a mean age of 51 years (range 25-90 years). Two DTI protocols were obtained with diffusion-weighted spin echo single-shot echo planar imaging (EPI) sequence, i.e., (1) an 'isotropic' protocol to investigate the nerves (C4-C8), and (2) a 'high in-plane resolution' protocol to investigate the spinal cord and ventral and dorsal nerve roots (C5-C7). As an anatomical reference, a multi-echo fast field echo (mFFE) was acquired. Tissue samples of the spinal cord and peripheral nerve roots at the level of C5-C7 were obtained during the autopsy on the following day. Processing of the diffusion MRI data was performed with *ExploreDTI*. DTI based fiber tractography (FT) was performed and estimates for the fractional anisotropy (FA), mean (MD), axial (AD), and radial (RD) diffusivity of the cervical nerves (C4-C8) were computed.
Results: With FT performed on DTI data obtained with the 'isotropic' protocol it was possible to reconstruct the 3D architecture of the spinal cord, and nerve roots in all 5 PM subjects. We were able to show the dorsal and ventral nerve roots in great detail using the 'high in-plane' resolution protocol and identified a low FA in the grey matter and a high FA in the white matter. Diffusion measures were approximately 5 times lower than in vivo results obtained in earlier studies. Histological examination identified normal anatomy of the spinal cord and peripheral nerve roots in all 5 cases.
Conclusion: This PM DTI and FT study shows that it is possible to identify the cervical spinal cord and its nerve roots using these techniques. Histological examination identified normal anatomy of the spinal cord and peripheral nerve roots, which was in accordance with the architectural configuration found with FT. We were able to quantify the diffusion properties of these nerves PM, and the dorsal and ventral nerve roots were shown in great detail. We expect that DTI may contribute to the forensic investigation of cervical trauma cases.

O.2.01

Postmortem CT as an alternative to conventional autopsy?
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Objective: Postmortem research is an important condition to deliver high quality care. Non- or minimally invasive techniques are being investigated because conventional autopsy (CA) rates have decreased worldwide to 0-10% nowadays. The aim of this study is to explore the diagnostic performance of postmortem CT (PMCT) in identifying the causes of death.
Material and methods: 73 Patients (41 men, 32 women, age range 1-91 years (mean 57)) underwent PMCT before CA. Clinical patients, but also first aid patients were included. From each patient, a thorax/abdomen, a cerebrum and a cervical spine scan were performed before CA. The images were reviewed by three radiologists (neuro-radiologist, cardiovascular radiologist and abdomen-radiologist), all inexperienced with postmortem diagnostics. CA's were performed by pathology residents, which were blinded for the imaging results and vice versa. Sensitivity, agreement and corresponding 95%-confidence intervals of PMCT and clinical causes of death were calculated, with CA as the reference standard.
Results: In 65 patients (89%) CA was able to identify a cause of death. Sensitivity of PMCT and clinically identified causes of death were 45% (95%-CI: 32-57%) and 40% (95%-CI: 28-53%). Agreement was respectively 47% (95%-CI: 35-59%) and 42% (95%-CI: 31-55%). PMCT failed to identify myocardial infarction as the cause of death. Due to resuscitation artifacts or normal postmortem changes respiratory causes of death were also hard to diagnose on imaging. Sensitivity of PMCT identified causes of death in the category bleeding was 6/9=67% (95%-CI: 30-93%). Despite a bleeding was diagnosed in the other 3 cases, an incorrect cause of death was given.
Conclusion: Overall the diagnostic performance of PMCT is insufficient to fully replace conventional autopsy. Nevertheless, its performance in identifying bleedings or air accumulations is high. We believe PMCT will be a valuable screening examination to point (minimally invasive) autopsy in the right direction.

O.2.02
Virtual animation of victim-specific 3D models obtained from CT scans for forensic crime scene reconstruction: living and dead subjects
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Virtual reconstructions of the probable peri-mortem postures of the victims in actual crime scenes are important for better understanding the sequence of events during a crime or an accident. Victim-specific 3D models reflecting the individual physiognomics can be created from CT scans, both for dead and living subjects. 3D models of bones, skin and internal organs can be easily generated using post-processing imaging software. These 3D models can be virtually animated and made to interact in the virtually reconstructed crime scene, obtained using photogrammetry techniques.
A case with two victims of gunshot injuries is presented. Victim #1 was a man with three perforating gunshot wounds, one in the thorax and two in the abdomen. This victim died due to the lesions. Whole-body CT scans were performed before the autopsy and 3D reconstruction of bones, skin and relevant internal organs were generated. Using 3ds Max software, a virtual animated body was built and probable peri-mortem posture visualized. Victim #2 was a man, who survived the shooting, with three perforating gunshot wounds, one in the left arm and two in the thorax. Only CT scans of the thorax, abdomen and the injured arm were provided by the hospital. Therefore, the full body model reflecting the anatomical proportions of the patient was made using the Poser software. A combination of 3D models obtained from Poser and from the CT scans was used for the animation process.
A virtual reconstruction of the chain of events was performed combining medical information, crime scene evidence and witness testimonies. In such way, it was possible to more precisely evaluate the probable peri-mortem postures of the two victims, reconciling bullets trajectories, internal lesions with crime scene evidence and witness testimonies. Importantly, a permanent data set of all the information was created, allowing reviews of the scene at any time if new evidence comes to light.

O.2.03
A view from the cutting edge - the application of microCT in the differentiation between serrated and non-serrated blades in the infliction of stab wounds in skin
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Background: Knife crime has consistently been one of the most common forms of assault and homicide in the UK. Between April 2014 and March 2015, there were 182 homicides involving sharp instruments, this accounts for 36% of all homicides recorded during this time. Currently, there is no evidence-based protocol for distinguishing between serrated and non-serrated blades in stab wounds. Recent research has shown that striation patterns are present in stab wounds in cartilage caused by serrated blades. This was predominantly done using micro-computed Tomography (microCT). However, the application of this has led to conflicting results when used in a forensic case. This study aims to provide a repeatable, standardised protocol for the use of microCT in the visualisation of striations in skin.

Methods: Porcine skin was stabbed with a coarsely serrated, a finely serrated, and a non-serrated kitchen knife using a drop-tower method. Wounds were excised and prepared for imaging with a Nikon Metrology XT 225 microCT scanner. Different preparation techniques were trialled. These included: presentation of the wound (open, partially open or closed), preservation of the wound (no preservation or formaldehyde for 3 days or 6 days) technique specific settings (current and exposure on microCT) and the use of contrast agents (iodine and osmium tetroxide). The images were reconstructed and analysed using CT Pro 3D and VGStudio Max software packages.
Results: On analysis, the microCT images from the wounds caused by a serrated blade produced a visible striation pattern, whereas the wounds caused by a non-serrated blade did not. With regards to preparation of the samples, opening the wound and preservation were identified as key techniques to generate the optimum images using micro-CT. Through the use of volume rendering software, we were also able to produce 'virtual casts' of the air within partially opened wounds. The casts from wounds caused by a serrated blade also showed striation patterns. This is a less destructive method than the use of dental impression materials that has been used in other research.
Conclusion: This study to assess the viability microCT in the identification of striation patterns causing by serrated blades in skin provides evidence for the establishment of a protocol for use in forensic cases. Further work would look into the repeatability of this method in human skin, alongside the use of different tissue types e.g. heart and liver, and a wider variety of knives.

O.3.01

Using PMCT as an advanced teaching tool for anatomical based courses that do not have access to cadavers

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The exposure to cadavers is generally considered to be essential to anatomy learning within healthcare around the world, but a shortage of donated specimens and dissection facilities usually restricts this resource to medical doctor, dentist and specialized anatomy training. Hence, a large proportion of anatomical based undergraduate courses, such as nursing and midwifery, do not have access to cadavers for teaching purposes. The taught anatomy components for these subjects are undertaken therefore entirely from oral lectures, instructional videos, plastic models and printed materials. While these are all considered rich and powerful mediums used for student learning there is now a possible innovative adjunct, post mortem computed tomography (PMCT) images and videos.
The aim of this research project is to compare traditional methods of teaching anatomy to nurses and midwives as described above with an innovative method of combining the current teaching material with supplementary PMCT images and videos within both pre and post registration curriculums. The objective is to determine whether having access to this additional learning aid will enhance the course curriculums by increasing the students' understanding and learning experience of the subject.
The PMCT images will be created using OsiriX. This image software is dedicated to DICOM images produced by medical imaging equipment such as CT scanners. OsiriX has been specifically designed for navigation and visualization of multimodality and multidimensional images, including 3D reconstructions, 3D multi planar reconstructions (MPR's) and virtual endoscopy. The PMCT images will be shown in lectures and will also be available online, for students to access remotely for revision purposes, via the Universities secure Blackboard facility (educational learning management system).
The PMCT images and videos used in this project are designed to fit into and complement the current nursing and midwifery course curriculums. They will include detailed images of external soft tissues, musculature, nervous, venous and arterial systems, and the internal organs. Fly through videos moving from the external to the internal organs will also be included, to demonstrate the anatomical relationship between these individual biological systems. More detailed fly through videos of the cardiovascular and respiratory system, using virtual endoscopy tools, will also be created to produce a virtual human body dissection.
The study sample will consist of pre and post registration nursing and midwifery students studying undergraduate courses who have been exposed to either anatomy teaching using traditional methods or the innovative method of combining the current teaching material with supplementary PMCT images and videos. Data will be collected following the teaching sessions from both groups using a questionnaire entailing quantitative and qualitative elements. The data collected will be analysed using statistics and thematic analysis.
It is believed that the adjunct of a PMCT course component should improve the teaching and learning of anatomy by offering nursing and midwifery students an innovative virtual tour of a human body. The results of this study will be presented for the first time at the ISFRI 2016 meeting along with a demonstration of the PMCT images and videos utilised for teaching purposes in this study.

O.3.02

Post mortem CT findings of the neck in hanging cases

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Introduction: Hanging is a leading method of suicide in Australia, Germany and Japan. Although fractures of the hyoid bone (HB) and thyroid cartilage (ThC) are well known findings in hanging, the reported incidence in hanging fatalities differs dramatically, ranging from 0% up to 83.3%. Postmortem computed tomography (CT) images of hanging cases were analyzed to investigate frequency of fractures on theHB and ThC.
Materials and Methods: We retrospectively reviewed CT images of the neck of 110 cases of hanging (90 male, Average 40.5 y.o.) which went through full autopsy at Victorian Institute of Forensic Medicine (VIFM). CT images were analyzed by three-dimensional volume rendering (3D-VR), maximum intensity projection (MIP) and multiple planer reconstruction (MPR).
We classified the hanging cases using sagittal and 3D VR images into 5 groups according to the level of the ligature mark in relation to neck structures, the HB and the ThC. Types 1-5, were used as classifications according to the level of the ligature marks above the HB (type1), overlying the HB (type 2), between the HB and ThC (type 3) which defines the thyrohyoid membrane, overlying the ThC (type 4), and below the ThC (type 5).
Results: Type 3 was the commonest (49.5%), followed by type 4 (31.8%). There was only one case of type 1. Among the cases 47.3% had fracture(s) on the HB and/or the ThC at autopsy while it was 64.5% on the images. Type 3 had the highest frequency of the fractures (79.6%) on the images.
Discussion: CT scans demonstrated more fractures compared with autopsy since the radiography is an excellent way of confirming a fracture of ThC and CT is superior to radiography since it is able to reconstruct axial images into 3D volumes using rendering techniques
There were 3 kinds of mechanisms of the fracture were observed.
1. The HB and/or ThC is sandwiched between the ligature and the cervical spine by compression of the neck by the ligature.
2.The superior horn of the ThC is fractured by touching the cervical spine when tilted by compression.
3.The superior horn of the ThC is fractured by touching the tip of the mastoid process when the ligature moved it

upward. There was only one case with this type of mechanism in type 5, which had also a crack on the mastoid process.
When investigating the neck by CT imaging or dissection to determine if there is a fracture, it is very important to see the positional relationship of the ligature, HB/ThC and the cervical spine including the transverse processes.

O.3.03
Computer-aided stab wound channel reconstruction based on local visual depiction of entrapped air
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Purpose: Post-mortem CT is nowadays routinely used in forensic medicine, since CT data contains important information about injuries and courses of events. Air-filled stab wound channels, which are the basis for reconstruction of stab directions, can easily be seen in individual CT slices due to good contrast of entrapped air. To actually reconstruct stab directions it is necessary to understand the shape of individual occurrences of entrapped air and their spatial configuration. This requires efficient visualization techniques depicting entrapped air inside surrounding tissue. Traditional direct volume rendering uses a global mapping of intensity values to colour and transparency. It is not possible to selectively visualize air in stab wounds while hiding other occurrences this way like air outside the body or in other organs.
This work presents a novel approach for interactive depiction and spatially constrained visualization of entrapped air in CT data allowing efficient computer-aided reconstruction of stab directions in stabbing cases and their illustration for in-court presentation.
Methods: Given raw 3D CT input volumes, our multi-volume rendering technique allows to split the CT volume into disjoint regions which are visualized using different transfer functions. Thus it is possible to restrict visualization to regions where air originates from stab wounds or injuries. Such spatial regions are interactively specified by placing geometric primitives like spheres or cubes, roughly outlining the desired region in cutting planes, throughout the data set. Regions can be further refined using cutting operations based on extruded polygons drawn on the screen until only entrapped air locations remain. Data set portions containing entrapped air are visualized using a transfer function emphasizing the Hounsfield Units of air, while remaining air regions are suppressed. Visualization may be further improved by inserting 3D surface models of probable incidence weapons or geometrical primitives (arrows) indicating likely stabbing directions.
Results: Several case studies of stabbing incidents were analysed. In all cases the resulting illustrations could successfully separate stab wound induced air from other occurrences, thereby greatly improving the forensic expert's view on the data. The possibility to put 3D models of incidence weapons into geometrical alignment with the CT data enabled further forensic investigations, like plausibility checking of the use of a particular weapon and reconstruction of the course and sequence of events.
Discussion: Our proposed tools allowed forensic reconstructions of stab wound channels and their illustration in cases with present entrapped air. Stab directions could be visualized in a way that is easy to understand for laymen, which is a necessity for in-court case presentation. We found that our tools can also be helpful for gunshot wound visualization and other spatially constrained forensically relevant findings, which cannot be visually depicted using traditional techniques, e.g. air in the brain after the heart was stabbed. Despite its potential to give hints regarding a victim's posture at the time of infliction, we further noticed in one case a discrepancy of stab directions indicated by air entrapped in soft tissue and findings in bony structures, due to soft tissue deformation and closing of wounds.

O.3.04
Post mortem computed tomography (PMCT) discloses reduced lung density in drowning fatalities compared to controls
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Objectives: In this study we calculated the lung density of drowning fatalities with a control group for comparison, expecting to find an increased lung density in the drowning cases.
Materials and Methods: 40 drowning fatalities and an age- and gender matched control group of 75 non--drowned deceased individuals who had undergone PMCT and a standard autopsy. The lung density (gram/cm^3) was calculated from PMCT lung volume measurements and autopsy lung weights. Total lung radio opacity was measured in Hounsfield Units by PMCT. The t-test was used for comparisons of means.
Results and Conclusion: Both the lung densities and the total lung radio opacity were significantly lower and the lung volumes significantly higher in drowning fatalities ($P<0,05$). There was no significant difference in lung weights between cases and controls. This suggests that lungs from drowning fatalities contain an increased amount of air. The amount of aspired water is probably relatively small, but sufficient to wash out the surfactant, causing decreased lung compliance, formation of atelectasis and peripheral air--trapping. This corresponds to the autopsy finding of emphysema aquosum, which is usually described as hyper expanded, pale lungs. This study contributes to the understanding of the pathophysiology of drowning and demonstrates that PMCT can provide information in forensic cases of drowning victims, which is hard to obtain by autopsy, such as lung volume and radio opacity. It is to our knowledge the first time this information has been used for calculation of lung tissue density.

O.3.05
Imaging of resuscitation and emergency resuscitation devices - lessons learned from post mortem computed tomography

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Introduction: Whole body post-mortem computed tomography (PMCT) is a rapidly evolving technique that has been recently introduced in many countries to investigate cause of death and has been shown to provide valuable clinical insights that may positively affect clinical practice. Cardio-pulmonary resuscitation (CPR) involves the administration of chest compressions and artificial ventilation as well as the placement and use of various medical devices including airway or enteric tubes, vascular catheters, thoracostomy drains, intraosseous vascular access needles and defibrillators. CPR procedures are performed frequently by both pre-hospital emergency technicians and hospital medical service providers and are associated with risk of potential complications, including skeletal and visceral organ injuries.
Materials and Methods: In this study we reviewed the range of CPR-related complications noted at whole body PMCT in over 300 studies at our forensic institution. 3D imaging techniques were utilized in all cases. Clinical records of the CPR event were available in all cases. Autopsy correlation was available in over 90% of cases. Specialized autopsy techniques for detection of pneumothorax or pneumo-pericardium were not routinely utilized.
Findings: Observed complications included air embolism, pneumo-pericardium and pneumothorax, rib fractures, lung contusions and injuries to upper abdominal organs. These complications were often associated with mal-positioning of intraosseous and other vascular access needles, needle thoracostomy, and chest drains. Multiple acute symmetric anterior rib fractures were frequently encountered in elderly patients after CPR. Similar fracture patterns associated with lung contusions were noted occasionally in infants. Attempted thoracostomy decompression of pneumothorax or hemothorax using traditional thoracostomy needles (typically 5cm length or less) was noted often as unsuccessful due to inadequate needle length in the thick anterior chest walls of very muscular or obese adults. Air embolism in the right heart chambers and pulmonary arteries was observed on PMCT following intraosseous vascular infusion in very young children, possibly due to a vacuum phenomenon induced by chest compressions during resuscitative efforts; alternatively it may have been related to inadvertent air contamination due to the use of compression devices to facilitate rapid IV fluid infusion through the intraosseous device.
Conclusions: This study presents new information on complications from CPR and the use of associated emergency resuscitation devices. Such complications may be accurately depicted on PMCT but are not detectable, or routinely sought at autopsy in the absence of a suggestive history. Consequently these complications are very likely underreported, given that the great majority of autopsies worldwide are performed currently without correlative PMCT imaging. Recognition of the limitations of autopsy for detection of complications of CPR should promote the increased use of PMCT and dedicated autopsy techniques for death investigation in this frequently encountered setting. PMCT imaging of these complications may provide important feedback on CPR outcome to emergency medical service providers and such information may contribute to the future improvement of resuscitation techniques and devices.

O.3.06
Morphometric analysis of saw marks on human bones through micro-CT
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Introduction: The analysis of saw mark characteristics on bones can provide useful information about the type of saw used to produce the injury/mark. This study aims at testing micro-computed tomography (micro-CT) analysis of false start saw marks produced on human bones by different types of saws in order to correlate the metrical characteristics of the saw with those of the mark.
Material and Methods: This study was performed on 40 human defleshed metacarpal, metatarsal and phalanx bones, collected from individuals who donated their body to the University of Padua for research purposes. The saw marks examined in this study were generated using 5 new saws, including: 3 saws with alternating set and different teeth per inch (TPI; 5, 8 and 10, respectively) and 2 saws with wavy set and different TPI (18 and 24, respectively). All marks were inflicted manually by the same operator, holding the saw perpendicularly to the long axis of the bone, applying a single unidirectional stroke with an excursion of 15 cm in length, in order to simulate a false start. Each bone sample was scanned by a Skyscan 1172 HR micro-CT (Skyscan, Aartselaar, Belgium) with the following parameters: 14 µm isotropic voxel size, 51 Kv, 194 uA, exposition time 6050 ms, rotation step 0.7, frame averaging 2, 1280 x 1024 pixel Field of View. Reconstructions were performed by N-Recon Software (Skyscan, Aartslaar Belgium), subsequently, the bitmap files were converted in DICOM using the DICOM Converter® Software. Osirix (Open Source Software, Version 7.0.1) was used to perform all the measurements and elaborate the multiplanar (MPR) and 3D volumetric reconstructions. For each bone sample, on the MPR images, the following features were assessed: number of isolated marks on each bone, shape of the mark on the sagittal plane (rectangular or triangular), maximal depth and height measured on the sagittal plane and presence of metal residues.
Results: All saw marks were detected by micro-CT. Marks produced by saws with 5, 8 and 10 TPI showed two incisions with different shapes and dimensions, which were in some cases in continuity one with the other. Saw marks produced by saws with 18 and 24 TPI showed a single mark with rectangular shape and different dimensions. Metallic residues were observed in several cases.
Conclusions: The preliminary results of the study suggest that micro-CT could be a useful tool for the analysis of saw marks produced on human bones. The possibility to assess the morphometric features of each lesion indicates that this technique might provide accurate and precise information about the characteristics of the type of saw used.

However, further studies including a wider number of samples and using a higher variety of cutting weapons need to be performed to fully assess the potentiality of the presented radiological technique.

O.3.07

A simple solution - Integrating 3D surface imaging into automated PMCT-scanning procedures

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Purpose: Post-mortem computed tomography (PMCT) is used regularly to investigate bodies after the event of an unusual death. However, it cannot provide forensically relevant information regarding pattern injuries with distinct discoloration of the body's surface (e.g. color of hematomas). Although, various techniques for 3D surface imaging have been introduced to forensics, most techniques are cost-intensive, time consuming and can only be applied before or after the CT scan has been carried out. Here we introduce a 3D surface scanning system that can potentially be integrated into automated CT-scanning procedures, which is fast in acquisition time, low in acquisition costs and is easy to use.
Methods and Materials: The system is based on a movable frame carrying 7 digital single-lens reflex cameras. A remote control is attached to each camera that allows to release all shutters simultaneously. In combination with an automated CT-scanning protocol 2D images are taken during predefined breaks of the CT table movement. With the help of photogrammetry the three-dimensional information of the whole body can be calculated on basis of the acquired 2D images.
Results: Based on our preliminary results colored 3D models of the whole body were obtained in about 13 minutes. Data acquisition took 3 minutes for each side of the body while the subsequent data processing for supine or prone position took 10 minutes in order to compute a textured 3D model with a low resolution polygonal mesh.
Conclusion: The combination of 3D surface imaging and automated CT-scanning reduces the acquisition time for whole body documentations in medico-legal investigations. Fast acquisition time in combination with low financial costs offer the possibility to use 3D surface imaging more frequently in forensic investigations worldwide. Moreover, the combination of CT and 3D surface imaging is not limited to post-mortem investigations but can also be applied in a clinical setting. Finally, due to a moveable set-up the scanning system can be stored easily and can be applied to living and deceased person.

O.3.08

The possibility of using a virtual bone collection for forensic anthropology investigation

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Background: Forensic anthropological casework has experienced a reduction in reliability due to the lack of existing modern skeletal collections. Methods derived from skeletal collections are used in the development of biological profiles (estimated sex, age at time of death, ancestry and ante-mortem stature), which add valuable information to the search for a possible identity of an unknown deceased individual. The abovementioned methods are developed based on certain morphological and metric skeletal traits. These traits are known to be population specific. If the methods derived from one population group are applied to that of another population group, the methods may yield less reliable results. The consequence of this is that the deceased individual may remain unidentified. A possible solution to this problem is the compilation of a virtual skeletal database based on readily available and contemporary patient computed tomography (CT) data.
Objective: The aim of this study is to determine whether bone segmentations of patient derived CT scans are sufficiently precise for developing a 3D virtual skeletal database, given the variation in CT-scanners, scanning protocols applied in the clinical setting, and the segmentation process itself. In order to achieve this, the variation between two CT scanners, two standard patient scanning protocols and various mAs levels are investigated.
Materials and Methods: For this study, one cadaver trunk was scanned multiple times (N=5), using standard patient scan protocols, on both a Siemens Sensation 64 (Siemens, Erlangen, Germany) (Trauma Pelvis Protocol: 120kV, 200mAs, slice thickness 1mm, increment 1mm) and a Phillips Brilliance 64 (Philips Healthcare, Best, The Netherlands) (Pelvis protocol: 120kV, 150mAs, slice thickness 0.9mm, increment 0.45mm).
In order to account for all possible variations during clinical scanning, the two standard patient protocols were also performed whereby the mAs was halved. Segmentations, created using the program Articulus , of the pelvic bones out of the CT scans yielded standard deviation (SD)-colour maps, which are created by using one of the bone segmentations as a reference. The nearest-neighbor distance of each polygon point to the remaining (N-1) pelvis polygons was determined, yielding the variation (SD) of these distances for each point of the reference pelvis. Color mapping was used to map a color to each SD value, which visualizes regions of high and low variation. SD maps were created to visualize and compare precision data between scanner types, scan protocols and mAs values. F-test were finally used to create difference maps, which identify regions where the SD maps are significantly different.
Results and Discussion: The results of this study, which visualize by means of SD- and difference maps, whether scanner types, scan protocols, mAs values and the segmentation process significantly affect the modelling of virtual pelvic bones, will be presented at the conference.

O.3.09

Part-to-part comparison of computed tomographic (CT) three-dimensional (3D) reconstructions for forensic identification

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Objective: The frequency of advanced medical imaging as a diagnostic tool continues to grow exponentially. In the US alone as many as 80 million CT scans are conducted per year. As with dental records and radiographs, ante-mortem image to post-mortem image comparisons may be a useful tool in the identification of unknown, whole or partial, remains. However many current identification methods can be subjective in nature by using scaled rankings and 'eyeballing' methods to identify unique features or shapes. Part-to-part comparison analysis is a common tool used in engineering and industrial design that allows for the comparison and testing of product geometries. Utilizing this methodology, CT-derived 3D anatomical reconstructions of osseous materials can be compared quantitatively for the purpose of identifying unknown individuals.
Materials and Methods: A series of abdominal CT scans were acquired with a 0.625 mm to 1.25 mm slice thickness. The osseous material was isolated using the same threshold of 226-3071 Hounsfield units for all scans. The 12th thoracic (T12) and the 3rd Lumbar (L3) vertebrae were reconstructed in 3D. Hand segmentation was used to separate the T12 and L3 from their immediate superior and inferior vertebrae. Twenty-two bones from eleven individuals were reconstructed. One T12 and one L3 were selected at random to serve as the 'unknown individual.' The resultant 3D models were numerically coded and two practitioners were blinded for the analysis. They were given the models and tasked with identifying the individual using a part-to-part comparison analysis. A 95% match with a threshold of ±1 mm was considered an accurate identification. The software packages *Mimics* 18.0 was used for the initial 3D reconstruction, while the part-to part-comparison was conducted within *3-Matic* 10.0.
Results: The part-to-part comparison showed a 100% accuracy rating when identifying the unknown individual for both the T12 and L3 vertebrae. The average percent match for the T12 vertebrae comparison test pool sample was 36% ± 8%, with the highest match being 51% and the lowest being 27%. The average percent match for comparison test pool sample of the L3 vertebrae was 46% ± 10%, with the highest match being 62% and the lowest match being 33%.
Conclusion: Overall the part-to-part comparison analysis for both observers in identifying the vertebrae from the sample test pool was successful. To lower the percent match for the actual individual from 100% to 99%, the threshold of acceptance was lowered to ±0.0002 mm, indicating an accurate and reproducible method. While additional study of other anatomical geometries needs to be done, forensic practitioners can consider part-to-part comparison analysis as a potential identification tool.

O.3.10
Post-mortem X-ray Computed Tomography (CT) identification using ante-mortem CT scan of the sphenoid sinus
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Purpose: Forensic identification can be performed using radiographic techniques, if ante mortem images are available. The aim of this study was to evaluate forensic individual identification thanks to a visual comparison using CT-scan sphenoid sinus anatomical configuration, comparing post mortem scanner to ante mortem exams that included the sphenoid sinus
Method and Materials: This retrospective study was conducted in a university hospital. The supervisor of the study constituted 2 groups of analysis of 43 cases: an ante mortem group (33+10) and a post mortem group (33+10). Ante and post mortem CT scan were performed on 33 patients including sphenoid sinus. Ten head CT-scan were randomly selected in various neurological context and added to the ante mortem group. Ten other head CT-scan were randomly selected from our post mortem PACS system and added to the post mortem group. In order to avoid any bias, anonymity of the patients was preserved and no head structure but sphenoid sinuses were kept. An anatomical based classification system using the sphenoid sinuses anatomical variations was created according to anatomical and surgical literature. Through this classification, two readers had to identify a maximum of matched studies by subjective visual comparison, and detail remaining unmatched studies (readers were blinded from the exact numbers of matching studies).
Results: The first reader had a sensitivity of 100% [CI: 89.4%-100%] and a specificity of 100% [CI: 99.8%-100%]. Sensitivity and specificity were respectively 96.9% [CI: 83.8 % - 99.9%] and 99.9% [CI: 99.6% - 100%] for the second reader. Positive and negative values were 100% respectively [confidence interval: 89.4% - 100%] and [CI: 99.8% - 100%] for the first reader. Positive and negative values were respectively 93.9% [CI: 79.8%-99.3%] and 99.9% [CI: 99.7% - 100%] for the second reader. Inter observer variability was estimated by Cohen's kappa and an excellent agreement was found for the matched pairs (0.95) and for the unmatched pairs (0.81).
Conclusion: We reported an excellent validity and reliability of subjective visual comparison of ante- and post mortem CT-data using an anatomical based classification of the sphenoid sinus. When ante mortem dental pattern, fingerprints or DNA sample are not available, the visual comparison of anatomical concordance of the sphenoid sinuses allows to do personal identification. This robust and fast method is all the more interesting if the identity of the victim is presumed.

O.3.11
Forensic identification: validation of radiologic identification with dental CT
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The objective of this study was to test the accuracy and inter-reader variability of comparative radiologic identification based on dental post mortem computed tomography (PMCT) and ante mortem (AM) dental radiographs.
Five raters with varying degrees of expertise and experience independently compared 115 dental PMCT images to 114 AM bite-wing radiographs to identify matching pairs (n=98), unmatched PMCT images (n=17), and unmatched AM radiographs (n=16). Levels of confidence and number of concordant features of matched pairs were documented. Accuracy of matches/exclusions, interrater correlation coefficient (ICC) and correlation between correct matches/exclusions and both levels of confidence and number of concordant features were calculated for all raters. Mean accuracy was 92% for matches and 80% for exclusions. ICC regarding levels of confidence and concordant numbers of radiologic features was 0.623 and 0.907 respectively. Levels of subjective confidence were correlated with numbers of concordant features of matched pairs but accuracy of matches/exclusions was neither correlated to levels of confidence nor to numbers of concordant features.
This study shows that visual comparison of PMCT images with AM dental radiographs is a reliable method for identification. Accuracy of identification using PMCT/AM dental radiographs was as high as in comparable studies using postmortem (PM) dental radiographs/AM dental radiographs. Raters with practical experience in forensic identification and experience with the imaging modality (in this case: dental PMCT) achieve higher accuracy than inexperienced raters. Match accuracy did not correlate with subjective confidence or number of concordant points. It is advised to work in teams rather than individually when dealing with real cases in forensic identification, to minimize subjective interpretation and avoid confirmation bias.

O.4.01

Density of white matter as a marker for the post-mortem interval using CT: a longitudinal study and potential in forensic cases

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Purpose: The aim of this study is to examine whether the duration of the post-mortem interval (PMI) is correlated with the density of grey matter (GM) or white matter (WM) of the brain in a longitudinal study. These results will be compared with correlations obtained in a cross-sectional study using forensic data, and subsequently the possibilities of predicting PMI based on the density of GM or WM will be discussed.
Material and methods: Five donated human bodies (age: 78.4±8.6 years) were scanned between 4 and 48 hours after death, with one-hour intervals. Eighty-two human bodies from forensic cases (age: 47.1±19.3 years) were scanned once after death, as part of a police investigation. PMI in forensic cases was classified using 7 classes based on police records. Density of GM and WM in Hounsfield Units (HU) was determined at the level of the basal ganglia. Statistical tests include a linear mixed model, reliability analysis using the intraclass correlation coefficient (ICC), linear regression, and one-way ANOVA.
Results: For the longitudinal study, a significant positive linear relationship of PMI with WM was found ($p<.01$), with an estimated fixed effect of .0450, CI [.0204, .0696]. There is no significant linear relationship of PMI with GM. A random slope for each donated body best fit the linear mixed model for the density of GM, and a random intercept best fit the model for both the density of GM and WM. In the forensic bodies, a significant difference in the density of GM ($p<.005$) and WM ($p<.005$) is observed between PMI class means. The density of GM and WM increases up to a PMI of 48 hours, after which a plateau is observed. The increase in the density of WM between a PMI of 0 to 48 hours is greater in forensic (8.14HU) than clinical cases (2.21HU). During this same PMI window, the density of GM increases 8.59HU in forensic cases, and decreases -.08HU in clinical cases. Inter- and intra-observer reliability was greater for the density of GM (ICC=.471, ICC=.946) compared to WM (ICC=.150, ICC=.747).
Conclusion: These results show that in a controlled longitudinal study, the density of WM has most potential to be used as a marker for PMI. They show a positive relationship with evidence for equal slopes in all bodies and inter-individual variation in the intercept. This positive correlation between PMI and the density of WM is also observed in forensic cases, despite the cross-sectional study set-up and the uncontrolled environmental conditions. This persistence under a range of conditions suggests the presence of an underlying mechanism that explains the increase in WM density in relation to PMI. The higher spread and slope of data in forensic cases might be attributed to different environmental conditions and variation between subjects as observed in the clinical cases. Because of these unknown variables in forensic cases, the longitudinal data alone is insufficient to design a prediction model for PMI. This would require greater understanding of the conditions in each forensic death.

O.4.02

Thoracic and abdominal injuries after manual or AutoPulse™ resuscitation on PMCT

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Introduction: In the industrialized countries OHCA is the leading cause of death. Annually 275,000 out-of-hospital cardiac arrests (OHCAs) are treated in Europe. In recent years the use of automated device-assisted cardiopulmonary resuscitation (CPR) has been greatly increased. Manual and device assisted CPR have been associated with different kind of post-resuscitation injuries, probably due to the different amount and direction of force that is used. The aim of this study was to compare the resuscitation injuries between manual CPR and mechanical CPR using AutoPulse™ by post-mortem computer tomography (PMCT), focusing on thoracic and abdominal injuries.
Materials and methods: We performed a retrospective review in the PMCT of patients whose death was confirmed in our hospital between July 2012 and December 2015. Patients <18 years and traumatic deaths were excluded. Patients were divided into three groups: no CPR versus manual CPR versus AutoPulse™ CPR.
The resuscitation injuries we identified by PMCT were as follows: rib fracture anterior or posterior, sternal and spine fractures, pneumothorax, pleural haemorrhages (HU>25), pleural fluids in mm (HU<25), haemoperitoneum (HU>25), retroperitoneal haemorrhages (HU>25), lacerations of the pancreas, spleen, liver and kidney (defined by either parenchymal laceration or surrounding fluid (HU>25), abdominal free air and induration of the epigastric fat. The total duration of the CPR was noted.
Data were analysed using IBM SPSS Statistics for statistical analysis. We performed univariate analyses using the $?^2$ test for categorical variables and the Mann-Whitney U test for continuous variables.
Results: [preliminary results. Definite results will be presented at ISFRI 2016] The AutoPulse™ CPR bodies had more fractures of ribs and more haemoperitoneum, however non-significant.
We included 109 PMCTs with 55 no CPR; 26 manual CPR; 28 AutoPulse™ CPR. Total duration of CPR was longer in the AutoPulse™ group than in the manual CPR only group. Thoracic and abdominal injuries tend to be more frequent in the AutoPulse™ group. No CPR vs manual only CPR vs AutoPulse™ group: anterior rib fractures 0 vs 4 vs 10,5 (median); posterior rib fractures 0 vs 0 vs 0 (median); sternal fractures 0% vs 40% vs 12,5%; spine fractures 0% vs 40% vs 12,5%; pneumothorax 0% vs 0% vs 25%; pleural haemorrhages 33% vs 80% vs 62,5%; pleural fluids 20,4 vs 13,8 vs 11,3 mm (median); haemoperitoneum 16,7% vs 0% vs 12,5%; retroperitoneal haemorrhages 0% in all groups; pancreas laceration 0% vs 0% vs 12,5%; spleen laceration 0% vs 0% vs 12,5%; liver laceration 16,7% vs 0% vs 12,5%; kidney laceration 0% vs 0% vs 12,5%; abdominal free air 16,7% vs 0% vs 0%.
Discussion: AutoPulse™ resulted in more rib fractures and abdominal haemorrhage however results were not

significant to the manual only group. Manual CPR resulted mainly in anterior rib fractures.
This study has its downsides in the post-mortem design without intravenous contrast material. Therefore, we start a prospective study on the survivors of CPR, including intravenous contrast material.

O.4.03

The role of forensic imaging compared to classic autopsy in fatal gunshot incidents: a review of the literature

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Introduction: The aim of this review is to evaluate the available literature with regard to the correlation between autopsy findings and imaging techniques like CT and MRI in the forensic investigation of gunshot victims. This provides context to reviewing validity of CT and MRI imaging as a standard forensic process to be performed before an autopsy as a means satisfying the legal requirement of forensic evidence: provision of baseline reproducible evidence that can readily be subjected to peer review and second opinion.
Materials & Methods: A systematic search was performed in MEDLINE to identify studies comparing autopsy and imaging techniques after fatal gunshot incidents. Autopsy and imaging techniques were compared for forensically relevant aspects: entrance wounds, exit wounds, trajectory of the bullet through the body, detection of metal fragments and identification of relevant injuries. The autopsy was the reference standard in all studies.
Results: A total of 7 studies were included in this review. In each study a minimum of one and a maximum of five parameters could be compared with the imaging techniques and the autopsy. In 17 out of 22 times there was a 100% agreement between autopsy and imaging. In the other 5 times the correlation ranged between 53.7% and 87.2%.
Conclusion: This review shows that radiological imaging techniques such as CT and MRI are very accurate compared to autopsy in assessing the main forensic aspects in gunshot victims.

O.4.04

Normal and abnormal post-mortem fetal ultrasound: a pictorial review

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Aim:
1. Provide short reminder of the basics of foetopathology and its use cases
2. Identify these specific perinatal situations where postmortem imaging should be the preferred approach
3. Describe the normal findings of post mortem perinatal ultrasound
4. Illustrate a few cases of pathological findings and highlight the add value of perinatal ultrasound in the related cases
5. Explain why foetopathology and perinatal ultrasound should both be used as complementary approaches to handle these pathological cases

Content organisation:
1. Reasons for the need of alternative techniques to autopsy in the case of perinatal death
2. Indications for postmortem investigations further to intra uterine fetal death and termination of pregnancy
3. Organ-by-organ analysis of normal postmortem ultrasounf findings
4. Illustrative series of pathological findings with autopsy correlations
5. Optimized handling of perinatal death cases

Summary: There are two reasons for the growing use of postmortem imaging in the case of perinatal death on a worlwide basis: the shortage of foetopathologists and the increase in autopsy refusals. This sets a rationale for alternative methods to maintain the quality of post mortem reports. Imaging should play a major role, but ultrasound is the least investigated modality in use today.
The three most common etiologies of fetal death are malformation, infections and vascuar conditions (mostly placental). Perinatal utrasound is recommended for a quicker and more thorough diagnosis of the pathological case. Through a pictorial review of 75 cases we included since January 2014, we present normal postmortem ultrasound aspects of fetal anatomy and illustrate the interest of this new application in a series of cases pathological conditions.

O.4.05

Imaging correlates of feticide on perinatal postmortem magnetic resonance imaging

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Postmortem magnetic resonance (PMMR) imaging is becoming more widely used following perinatal deaths, particularly following termination of pregnancy to confirm antenatally suspected congenital abnormalities.
Fetal demise (or feticide) is often performed using intracardiac potassium chloride, intra-amniotic or intrathoracic injection of digoxin, or umbilical venous or intracardiac injection of 1% lignocaine. Each of these can cause characteristic artefacts on conventional PMMR, which may be misleading to those who are unfamiliar with these appearances.

This educational abstract will provides a literature review on the current approved approaches to feticide, and then depending upon the approach used, we illustrate the typical findings on perinatal PMMR following feticide. This includes intracardiac gas, pleural and pericardial gas, pleural and pericardial signal abnormalities, and umbilical cord signal abnormalities or cord haematoma.
By presenting a pictorial review of these abnormalities, we hope to draw practitioners attention to the artefacts caused by iatrogenic fetal demise, so that these do not get mistaken for pathological lesions in future.

O.4.06

Evaluation of MRI sequences and liquids potentially suitable for post-mortem vascular perfusion

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Purpose: This work investigated the appearance of liquids potentially suitable for post-mortem vascular perfusion and examination in MRI. Perfused vasculature and post-mortem tissue were simulated using a porcine phantom with tubular structures representing artificial vessels. Using a number of MRI sequences, the goal was to evaluate contrast between various liquids and surrounding tissue (muscle/fat), while ensuring an adequate depiction of anatomy and contrast between tissues (e.g. muscle/fat).
Methods and Materials: To simulate filled vasculature in a cadaver, 12 tubes with three different diameters (2, 3, 4 mm) were filled with four liquids (silicon oil, mineral oil, paraffin oil and a mixture of paraffin oil and 6% Angiofil®). These liquids were selected following previous characterisation of their physical and MRI-related properties across a forensically relevant temperature range. Filled tubes were horizontally inserted into a porcine belly tissue phantom and MR images (STIR, 2D FLASH, SPACE & TSE) were acquired at 3T with a 15-channel Rx/Tx knee coil. Approximate mean temperature of the phantom was 13°C, with no significant increase over the scan time (< 1 hour). Using existing knowledge of the temperature-dependent relaxation times of porcine tissue and the selected liquids, a temperature-dependent range of TI for the STIR sequences was selected (TI=100-220ms). In addition to a subjective visual evaluation of the images, CNR efficiency (CNR_{eff}), image signal intensity profiles and 2 metrics evaluating perceptual blur/image sharpness were used to objectively assess images.
Results: Nulling of the adiabatic fat signal was achieved using the STIR sequence with an inversion time of 160ms. At this point, investigated liquids delivered good contrast with both porcine fat (nullified) and muscle. Visual assessment, followed by a comparison of signal intensity profiles and CNR_{eff} values for the set of STIR sequences confirmed that the best effective contrast between fat-perfusate, muscle-perfusate and fat-muscle was achieved with this inversion time (TI=160ms). Here, the best (negative) contrast with fat was delivered by silicon oil, while the three other liquids produced high contrast with muscle. The STIR sequence (TI=160ms) was used for comparison with the 2D FLASH, SPACE and TSE sequences. Visual evaluation and signal intensity profiles revealed that SPACE images, while rich in detail did not deliver sufficient contrast between fat and muscle. Liquid-fat-muscle contrast was acceptable using 2D FLASH and maximised in TSE images. STIR sequences also offered excellent contrast, however these images were in general noisier.
Additionally, two metrics were used to assess the blur/sharpness of the images. Of all the investigated sequences, the 2D FLASH resulted in the sharpest images according to both metrics. The STIR and SPACE sequences followed closely, with the TSE performing least satisfactorily.
Discussion: For the STIR images, the experimental investigation of a range of inversion times enabled the selection of imaging parameters maximising contrast between tissue (fat, muscle) and liquids suitable for vascular perfusion. Visual assessment of the images was supported by evaluation of signal intensity profiles, CNR_{eff} and blur/sharpness. These confirmed the potential of FLASH and STIR sequences for application in the examination of post-mortem perfused vasculature using MRI.

O.4.07

Predicting the time point of fracture occurrence in adolescent rats: a qMRI-approach

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Aim: The determination of the time frame of a fracture healing process can be of high importance in cases of maltreatment or insurance litigations, and also of crucial importance in alleged cases of child abuse. The aim of this study is to determine the age of an induced fracture in adolescent rats via the application of quantitative magnetic resonance imaging (qMRI). This qMRI approach has already been proven useful for fracture age prediction in adults, and its applicability to still developing individuals shall be examined herein.
Methods: 35 MR scans of 7 Sprague-Dawley rats (male, 4 weeks old, scanned 3-7 times at days 1, 3, 7, 14, 28, 42 and 82 after fracture occurrence), were acquired on a 3T MRI scanner (TimTrio, Siemens AG, Erlangen, Germany). Prior to scanning a fracture was induced surgically, followed by conservative treatment. For the determination of quantitative MR characteristics two sequences were applied (PD-weighted 3D Flash and a T1-weighted 3D FLASH). Both sequences were used in order to calculate the longitudinal relaxation time T1 of the tissue. Changes in T1 relaxation time were investigated using a customized GUI in Matlab (R2014a, ©MathWorks Inc.) and evaluated by comparing the difference between a reference area of intact bone and the fractured area.
Results: The evaluation of the fracture gap over time showed an initial peak of T1 values in early bone healing,

which constantly decreased over time, suggesting that a quantitative assessment of fractures might be applicable. However, similar results were observed in the surrounding intact bone. This effect may be caused by bone marrow transitions and other growth factors during development. Therefore, to assess significant differences in T1 between intact and injured bone, relative values (bone minus fracture) over time were calculated, showing clear detectable changes of T1 after fracture occurrence.
Conclusion: QMRI of the initial phases of fracture healing is promising to provide information of the fracture's age by not only considering the fracture itself, but also the developmental stages of the surrounding bones. Further studies will be necessary to develop and validate a model for determination of a fracture's age in adolescents.

O.4.08
The effect of tissue preservation (refrigeration, freezing/thawing, or fixation) on tissue properties and post-mortem imaging
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Introduction: Preservation of ex vivo tissue by refrigeration, freezing, or fixation is useful in the laboratory setting, and these same techniques are used in the context of forensic death investigation. While preferable to decomposition, preservation nonetheless induces physical changes, which may alter imaging properties. The effect of tissue preservation on post-mortem brain imaging has been well-studied. This study is aimed at characterizing the effects of preservation on other tissue types. The specific goals include 1) determining how preservation affects the weight and CT density of ex vivo body tissues, and 2) determining how the MR relaxation times T1 and T2 change following preservation.
Methods: Eight tissues (aorta, cardiac muscle, fat, kidney, liver, lung, spleen, and skeletal muscle) were obtained from 3 porcine subjects. Six samples (2-5 g) of each fresh tissue were weighed. For each subject/tissue, 3 samples were fixed (10% neutral buffered formalin) and 3 frozen (-20^{o}C freezer) in sealed plastic cups for >2 weeks. After removal from formalin or thawing, each tissue sample was blotted with a paper towel and weighed again. For one subject, CT and MR were performed on fresh, thawed, and fixed tissues contained in covered 6-well plates. PMCT was performed at 90 and 120 kVp, with density standards (acrylic, polypropylene, and Teflon rods) included in the image. PMMR was performed at 1.5 T over a range of tissue temperatures as follows: 1) for fresh tissue, 35^{o}C to 4^{o}C, overnight in refrigerator, 4^{o}C to 35^{o}C the following day, 2) for frozen/thawed and fixed tissues, 4^{o}C to 35^{o}C.
Results and Discussion: After freeze/thaw, all tissue samples lost 5-10% of their original weight, due to water loss. Formalin fixation has two effects: cross-linking by formaldehyde (increases weight) and dehydration by alcohol (decreases weight). We find that the net effect is different for different tissue types, with some losing and some gaining weight (-3% to +22%). Nonetheless, for most tissues, neither freeze/thaw nor fixation caused a significant change in CT density (HU), with the exception of lung (both methods reduced HU) and fat (both methods increased HU). Interestingly, the weight changes are not correlated with the density (HU) changes, suggesting that the tissue also changes volume. Refrigeration, followed by re-warming to room temperature, results in little change in PMMR T1 or T2 values, except for fat and kidney medulla (T1 increases by 40%). Freezing/thawing generally results in somewhat greater (up to 45%) changes in T1, with the exception of fat (130% increase). Formalin fixation generally results in modest changes in T1 (<20%), with the exception of spleen (50% reduction). Freezing/thawing generally results in modest (<20%) changes in T2, again with the exception of spleen (60% increase). Formalin fixation results in modest changes in T2 (<15%) with the exception of fat (40% increase). Overall, relaxation time changes may be either positive or negative, with no apparent correlation with changes in weight or CT density. Therefore, it appears that a simple 'rule of thumb' regarding the effect of tissue preservation on MR imaging parameters cannot be stated.