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Feature piece – ADVANCED MEDICAL IMAGING AT VIFM

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Installation of a mortuary-based computed tomography (CT) scanner in 2005, heralded a new era in medicolegal death investigation at VIFM. Forensic pathologists have embraced CT as an integrated image analysis into their everyday work practice, whether it be part of the preliminary examination process, planning an autopsy dissection or better understanding of autopsy findings. The original concept of the CT scanner at VIFM was to introduce modern medical imaging into what has traditionally been an autopsy-based speciality of forensic pathology.

In 2004, the Victorian State Government funded the CT purchase and installation primarily to assist in identification of deceased persons especially in mass disaster. From the outset, however, it was apparent that CT provided a previously impossible ability to non-invasively view the internal anatomy and pathology of a deceased person. Using that information, it could be determined if there were findings that had contributed to death, or no abnormality such as trauma that could explain the person's death. This interrogation eventually became known as "triage" of the body which together with external examination, viewing of circumstances of death and medical history and rapid toxicological examination of blood, could be used to decide likely cause and manner of death, and whether further investigation such as autopsy was necessary to further that understanding.

The Victorian *Coroners Act 2008* formalised that process in what is known as the "preliminary examination" and in world first legislation specifically included "imaging of the body including the use of computed tomography (CT scan), magnetic resonance imaging (MRI scan), x-rays, ultrasound and photography" into that preliminary examination. All deceased persons, whether they be intact or body parts, reported and presented to the Coroner in Victoria have whole body CT scanning. Since April 2005 when the first decedent was scanned at VIFM, we have undertaken 108,000 scans. All images are stored and available for rapid retrieval from a dedicated PACS (Picture Archiving and Communication System). This is an invaluable database of forensic radiology for research, but also a permanent means of case review in a process known as "digital exhumation".

CT scanning is now a routine procedure at VIFM with all mortuary technicians taught and licensed to scan under the supervision of specialist medical imaging technologists. Scanning is undertaken at all hours of the day and night, and specialist CT guided techniques such as PMCT angiography, biopsy and orogastric tube placement have been introduced to enhance diagnostic ability. Forensic pathologists are all taught to view and interpret postmortem CT (PMCT) images and coroners are all aware of the capabilities of CT scanning in determination of death causation.

Interpretation of PMCT differs from clinical CT (in the living). The body changes after death; not least the process of decomposition causing appearances that are not familiar to radiologists. Anatomical alterations occur such as lividity, collapse of blood vessels without a blood pressure and clotting or sedimentation of blood. Pathology is often much more extreme than in clinical radiology given that the person has succumbed to that disease process or trauma. The emphasis of PMCT interpretation also differs with a change in balance of the cause/effect equation. In clinical practice the primary focus is on the effects of a disease process or trauma whereas the endpoint of PMCT is death thus the primary focus is the mechanism that has led to that death e.g. cerebral haemorrhage requires treatment by a clinician whereas a forensic pathologist requires an understanding of how it occurred by way of trauma or a natural event. There must also be an understanding of PMCT findings in a medicolegal context whereby those findings can have substantial and unforeseen consequences for the judicial system that may not be so relevant in the clinical world.

The forensic radiologist provides support and acts as a consultant to the forensic pathology group for more difficult cases or for cases that require presentation as expert evidence in a court setting including coronial inquests or criminal courts.

Under the auspices of the Royal College of Pathologists of Australasia (RCPA), a Faculty of Postmortem Imaging (FPMI) has been created with the assistance of VIFM pathologists and radiologists. This provides a pathway for more advanced training in PMCT and a forum for scientific endeavours in postmortem imaging. Several of our pathologists and radiologists are faculty members, contributing to ongoing education.

Research is one of the key objectives of the Act of Parliament (*Victorian Institute of Forensic Medicine Act 2024*) that establishes VIFM. PMCT contributes to this through pathological, anthropological, and odontological research as well as investigation into mechanisms of trauma and applications of imaging in artificial intelligence through partnerships with Monash University and other educational institutions.

The initial intent of identification of the deceased using PMCT at VIFM has been vindicated. It is now a standard tool for odontologists and anthropologists to assist in daily identification of deceased persons. The Black Saturday bushfires of 2009 exemplified the capacity of PMCT as a victim identifier in mass casualty disaster. In 2009, VIFM had the infrastructure, technical knowhow and 4 years' experience with identification using PMCT, and it proved to be invaluable in scanning and triaging the large number of body bags, examining the contents of those bags and flagging results to pathologists, odontologists and anthropologists, as well as a resource of review at the time of antemortem and postmortem reconciliation for final identification. It spawned the concept of "scan once, view many times" reducing the need for repeated manual handling of the body bags. Based on this unique experience and published results in an international peer-reviewed journal, PMCT has now become a gold standard for victim investigation in mass disaster and has been integrated into Interpol DVI protocols.

Magnetic Resonance Imaging (MRI) is a technique that utilises an immensely powerful magnet and FM radio waves to produce images that reflect the concentration and local environment of hydrogen atoms (predominately water molecules) in the body. It offers benefits beyond conventional PMCT in specific anatomical regions such as the brain, spinal cord, and heart. It is also valuable in assessing soft tissue injury. Organs and soft tissues of neonates and young children are particularly well demonstrated. Paradoxically these areas of the body are not well seen on PMCT thus postmortem MRI (PMMRI) is the ideal adjunct to PMCT.

With the support of the Victorian State Government the Institute was able to purchase and install the first MRI in our mortuary.

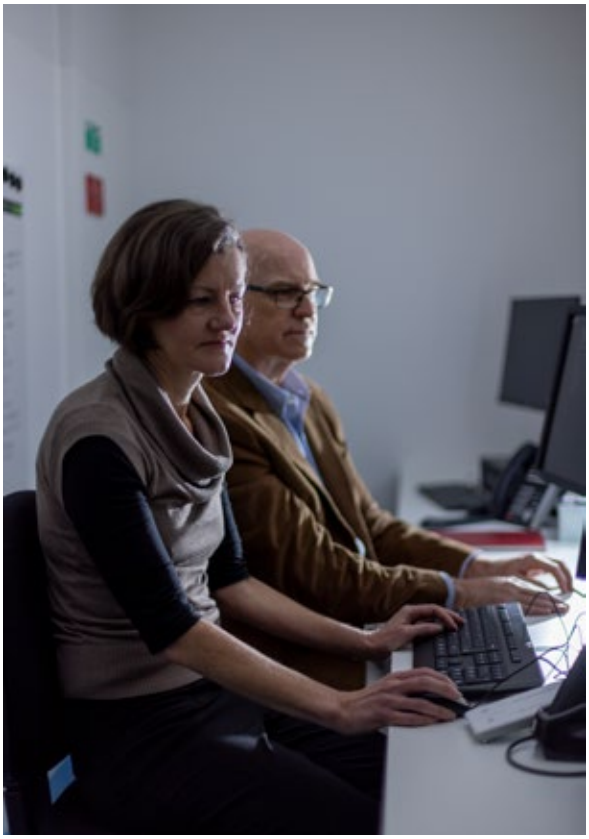
The powerful magnetic field from the MRI must be shielded from staff and equipment, and use of FM radio waves means that the scanner must be encased in a dedicated Faraday cage to remove interference from the outside environment. In addition, the scanner will be used for both deceased persons and living persons.

Interpretation of PM-MRI is also a specialised task. To understand the complexities of such work, Chris O'Donnell (VIFM Consultant Forensic radiologist) had the opportunity to visit Ontario Forensic Pathology Service (OFPS) in Toronto in 2019. The OFPS have an MRI installed in their mortuary for some years and following review of all their cases over a 4-week period. Chris O'Donnell was able interact with the technical staff in their mortuary to better understand the difficulties faced in scanning deceased persons. It is clear from that experience that PM-MRI is quite different to clinical MRI in living persons. Artefacts such as decompositional gas and rigor mortis must be considered, and image acquisition is hampered somewhat by the lower temperature of the bodies after they exit the storage fridge.

MRI scanning will commence after installation (July 2025) and will be useful in those areas of PMCT deficiency i.e. brain, spinal cord, heart, and soft tissues. Given the enormous potential impact of MRI on forensic pathology practice and the limited availability of such mortuary-based technology (on a world basis), research is a key component of our work at VIFM. Ultimately it is the use of such imaging that will improve our understanding of cause and manner of death using scientific evidence-based investigation. There are already applications to the VIFM Research Advisory Committee for projects on the heart, and better understanding of the parameters required to perform MRI in the deceased.

Installation of MRI enhances the reputation of VIFM as a world leader in postmortem imaging and innovation. Medicolegal death investigation at VIFM is no longer just about an autopsy but instead is a sophisticated medical model that uses the latest technology in medical imaging and other scientific services.

The forensic pathologist working together with the coroner now have access to multiple modalities to assist in determining cause and manner of death. This gives them the ability to adjust their investigation based on wishes of the family, requirements of the judicial system, and public health.



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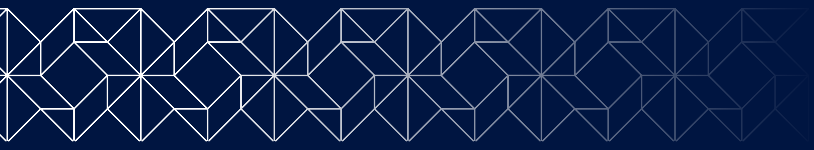

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