

# An image of sudden death: utility of routine post-mortem computed tomography scanning in medico-legal autopsy practice

Chris O'Donnell

## Abstract

Post-mortem computed tomography (CT) is an established technique at Victorian Institute of Forensic Medicine (VIFM) used to assist pathologists in determining cause and manner of death. It also plays an important role in identification of deceased individuals as exemplified by the 2009 "Black Saturday" Victorian bushfires in which the remains of 164 individuals were subjected to disaster victim identification procedures. CT scanning is now explicitly incorporated into the Victorian Coronial legislation (Coroners Act 2008), and is an important component of the preliminary examination process whereby a pathologist reviews the circumstances of a death, any pre-existing medical history, whole body CT images, the external appearances of the body and expedited (overnight) toxicological screen results, so that a recommendation to the Coroner may be formulated regarding the likely cause of death and necessity for autopsy. This process has seen a reduction in autopsies from a mean of 62% over the last 5 years to 47% of admissions in less than 12 months. VIFM pathologists perform the primary interpretation of CT images in consultation with a radiologist. A process of quality audit has been instituted in order to detect systematic errors in this interpretation, in addition to a structured education programme directed to correct those errors. New imaging techniques, notably whole body CT angiography and dual energy CT have the prospect of even more substantial forensic application.

**Keywords** angiography; cause of death; computed tomography; coroner; post-mortem

## Introduction

In mid 2005, a computed tomography (CT) scanner was installed into the mortuary of the Victorian Institute of Forensic Medicine (VIFM). Since that time all deceased persons admitted to the Institute have been CT scanned from head to toe, and images permanently stored on a picture archiving and communication system (PACS). Well over 15,000 cases have now been examined. CT images do not replace autopsy but assist pathologists in determining cause of death, manner of death, mechanism of injury and documentation of injury for presentation as evidence in court.<sup>1</sup> CT is also useful in identification of the deceased where

other techniques are not available or difficult to attain.<sup>2</sup> In a mass disaster scenario, CT is used as a triage tool.<sup>3</sup> In the 2009 "Black Saturday" Victorian bushfires, radiologists used CT imaging to separate human from non-human remains, determine the number of individuals within a body bag, assist odontologists and anthropologists in assigning gender and age, detect disease processes or medical procedures, and at the time of autopsy, localize metallic items within the body for retrieval by the pathologist. Routine CT scanning prior to autopsy or other bodily interventions produces images that are available at any time for retrospective review by pathologists or other interested parties, for example following the discovery of additional information by police in a process known as "digital exhumation".

Post-mortem CT interpretation is not the same as clinical CT. Images that would normally be considered unacceptable to the clinical radiologist are routine in post-mortem scanning. Notable contributory factors include a lack of oral or intravenous radiographic contrast, malpositioning of the body in the gantry, and metallic artefact due to foreign bodies located in or on the deceased person. Image analysis requires an understanding of the changes to visceral anatomy that routinely occur after death, features of the agonal process, artefacts of death including autolysis and putrefaction, as well as the consequences of resuscitation including external cardiac massage. Failure to recognize or understand these features can lead the reader of CT images into errors of analysis with the potential for inaccurate evidence or conflict with the pathologist's autopsy findings. Radiological findings of visceral pathology on post-mortem CT are similar but invariably more extreme than CT performed in the clinical environment given that individuals have succumbed to that pathological process.

The interpreter of post-mortem CT must have a thorough understanding of forensic autopsy<sup>a</sup> practice in particular the nature of injury and outcome of trauma, realizing that the mechanism or manner of death may be as important to the forensic pathologist as the consequences of inflicted injury on a particular organ. Ultimately the individual who produces a written radiological report must understand the relevant legislation, be prepared to provide verbal expert evidence to a court and endure the demands of a legal system that rightly tests the validity and interpretation of presented facts in a rigorous manner. Substantial background information including (but not restricted to) the circumstances surrounding the death should be available at the time of image analysis. Ideally CT imaging should be undertaken in a co-operative environment with pathologists and radiologists working together in a forensic institute or situation where the CT scanner is co-located with pathologists such as in a hospital department. It is not the province of an occasional user working in isolation.

This issue of CT image interpretation has recently been explored by Filograna.<sup>4</sup> She has discussed the three sources of

<sup>a</sup> Unlike England and Wales but similar to many areas of the world, all medico-legal deaths including so-called *routine* coroner's cases, are examined in a single Institute by forensic pathologists. Thus where the word *forensic* is used within the text it is taken to include all deaths, both routine and forensic i.e. it includes deaths that would be examined by histopathologists in England and Wales.

**Chris O'Donnell** MBBS FRANZCR MMed GradDipForMed is the Principal Consultant Radiologist at the Victorian Institute of Forensic Medicine and Department of Forensic Medicine, Monash University, Australia.

error in diagnostic imaging; notably perceptual (finding present but not recognized), cognitive (incorrect interpretation of a finding) and system factors (organizational issues in the institution) and related them to the conduct of post-mortem CT imaging. The relative novelty of post-mortem CT imaging means that all three factors are commonly encountered. Perceptual errors are inevitable when the observer is inexperienced with the imaging modality or there is a new application of that modality i.e. CT imaging of the deceased. Cognitive error is also likely if the paradigm of clinical CT interpretation is applied directly to the evaluation of the deceased and system error will flourish if the imaging is being performed and interpreted in an environment that is divorced from the forensic pathological context.

Post-mortem CT images should therefore be assessed by those with a background in forensic medicine and understanding of post-mortem pathology and cross-sectional imaging. This has spawned a new subspeciality termed “*necro-radiology*”.<sup>5</sup> At VIFM the sheer number of admissions and limited access to radiological expertise precludes the written interpretation of all CT scans by a radiologist (as routinely occurs in clinical practice). Pathologists have taken primary responsibility for the viewing of images with a radiologist providing consultation on a case by case basis. This pragmatic approach has been criticized yet forensic pathologists have many of the desirable attributes described above i.e. an in-depth understanding of traumatic effects on the body and experience in provision of expert evidence as well as court practices. Pathologists are well aware of the artefacts of death and the mistakes of interpretation that can occur in forensic practice, described so eloquently in the classic paper by Moritz.<sup>6</sup> Pathologists at the VIFM have been educated on the CT findings of such artefacts as well as the radiological correlates of pathological processes – their particular area of expertise. Unlike the radiologist who is often constrained by limited provision of background information, the pathologist has considerable data available at the time of CT reporting notably circumstances surrounding death provided by police, previous medical history, toxicology and ultimately the ability to perform external examination of the deceased person even if no autopsy is forthcoming. Any CT findings identified on the pre-autopsy CT scan can if necessary be viewed directly at the time of autopsy. This process of ‘validation’ has been invaluable and an ongoing educative exercise to pathologists.

Although initially reluctant, pathologists have embraced the new technology notwithstanding the potential for interpretive error due to lack of experience<sup>7</sup> or understanding of CT image acquisition. An ongoing teaching programme has been supplemented by a quality audit whereby 10% of all cases are retrospectively reviewed by the radiologist. Radiologist’s findings are matched with the pathologist’s written CT observations and any discrepancies graded as substantial (i.e. a CT finding that might reasonably be expected on radiological grounds alone to be the cause of death), minor (i.e. a CT finding that of its own might not reasonably be expected to be the cause of or responsible for the death, but might possibly be considered to be a contributory factor to the death) or incidental (i.e. a CT finding that is incidental to the cause of death but is of particular medical or pathological interest). Substantial and minor discrepancies are discussed with the pathologist and in appropriate cases, images

reviewed at a weekly departmental pathology meeting. This process allows for the identification of systematic error and redress by education.

The audit has secondary consequences. It reveals technical issues i.e. CT hardware failure or findings considered by the radiologist to be the result of error by technical staff. Any such finding is relayed to the mortuary management and corrections made. If systematic technical error is revealed then re-education of technologists is instituted. The process also acts as an ongoing learning process for the reviewing radiologist since CT results are directly correlated with the pathologist’s autopsy findings and interpretations.

In the 4 years following installation, CT was used very much as an adjunct to the routine procedures of forensic pathology at VIFM. For example if CT revealed an obvious cause of death e.g. ruptured atheromatous, abdominal aortic aneurysm, and the circumstances were not deemed suspicious, then a recommendation might be made to the coroner that autopsy was not required as a ‘natural’ disease process responsible for the death had been identified. If the cause of death was not obvious on circumstantial grounds but there was a significant history of medical co-morbidities, non-suspicious circumstances, and no specific CT findings (including no evidence of significant trauma) then autopsy might not be performed if an objection to such a procedure had been raised by the senior next of kin and the coroner was of the view that death was most probably the result of natural causes (otherwise not specified). Alternatively the circumstances of death might not have been suspicious yet CT revealed a concerning finding such as a subdural haematoma or unexplained healing rib fractures in a child prompting further investigations including a full autopsy. CT was routinely used by pathologists following autopsy to clarify an autopsy finding e.g. demonstration of a pelvic fracture to explain detected pelvic haematoma or provide an image for presentation to investigators e.g. multiple, rounded, depressed skull vault fractures due to injury inflicted with a hammer. On occasion pathologists might overlook the examination or documentation of a particular body region at the time of autopsy yet retrospectively be able to review CT images prior to completion of their report e.g. diameter of the aortic valve.

All previous applications of post-mortem CT have continued, however, recent changes to the Victorian Coroners Act<sup>8</sup> have reinforced the use of CT in everyday practice. The Act creates the concept of a preliminary examination entailing (a) visual including dental examination of the body (b) review of personal and health information, (c) taking of bodily fluids, (d) imaging of the body including X-rays, CT, MRI, US and/or photography, (e) taking of surface swabs and (f) fingerprinting of the body. A preliminary examination (or component part thereof) is performed on all deceased persons reported to the coroner and admitted to VIFM. The Act allows the coroner to determine that a reportable death requires no further investigation “if a medical investigator conducts a medical examination on the deceased person and provides a report to the coroner that includes an opinion that the death was due to natural causes”. At VIFM a so-called duty pathologist is the nominated medical investigator created in response to the Act. Using the facility of the preliminary examination, the duty pathologist forms a judgement on whether the death was natural and provides to the coroner a recommendation as to the necessity for an autopsy. The

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