

Post-mortem imaging in adults

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Abstract

Post-mortem computed tomography (PMCT), offers a non-destructive approach to the investigation of fatal injuries and the diagnosis of deaths from natural causes. Strengths of PMCT include the demonstration of fractures, internal haemorrhage, vascular disease and tumours. Imaging can be combined with minimally invasive techniques in the investigation of deaths secondary to sepsis, metabolic causes and drug toxicity. Unlike traditional invasive autopsy, PMCT creates an observer-independent permanent record of the findings that is amenable to audit, and may be used for courtroom or other demonstration. In the United Kingdom, PMCT is increasingly used as a first line technique in coronial investigation. The cause of death can be ascertained without open autopsy in the majority of cases. The use of PMCT in the UK is driven by religious and cultural objections to invasive autopsy, a shortage of autopsy pathologists and concerns regarding the quality of autopsies. Despite the backing of the Royal Colleges and the Chief Coroner, a number of logistical and financial challenges must be overcome in developing a national service.

Keywords angiography; autopsy; coroner; CT; digital; imaging; MRI; post-mortem; procurator fiscal

Introduction

Post-mortem imaging, particularly cross-sectional imaging such as post-mortem computed tomography (PMCT), is increasingly being used to supplement dissection in a number of autopsy settings. One area of frequent use is in the setting of traumatic death, where PMCT offers a non-destructive approach to identification and assessment of bony injuries, haemorrhages and the presence of foreign bodies including projectiles. Furthermore, unlike traditional dissection, PMCT creates an observer-independent permanent record of the findings that may then be used for demonstration to other interested parties, such as in the courtroom.

More recently, post-mortem imaging including PMCT has been used as the primary, and frequently sole, means of internal

examination at autopsy. A number of terms have been used in both lay and scientific literature to describe such autopsies, including “virtual autopsy”, “digital autopsy”, “interactive autopsy” and “imaging autopsy”. In addition to the advantages described for traumatic death, drivers of the increased use of PMCT include religious and cultural objections to invasive autopsy and the development of reliable techniques for the assessment of the cardiovascular system.

This review will focus on the use of post-mortem imaging in adult non-forensic medicolegal autopsies within the coronial system of England and Wales.

Terminology

A number of the terms used within autopsy practice can have different meanings and connotations depending on country and jurisdiction. For the purposes of this article, terms will be used as understood in the United Kingdom (UK). The term “medicolegal” is applied to any autopsy being undertaken to determine the cause of death as part of an investigation carried out on the instruction of a coroner (England & Wales) or procurator fiscal (Scotland), whether this is for the purposes of establishing the nature of a natural cause of death, or is in relation to unnatural deaths. The term “forensic” is applied specifically to autopsies in which the death is related to a criminal matter, in particular where an individual is likely to be charged with homicide or other offence. Thus, not all medicolegal autopsies are forensic in nature. Autopsies in the UK may also be undertaken for medical interest. Such autopsies fall outwith the legislation for investigation of death and instead are covered by the Human Tissue Authority.¹ These autopsies are usually referred to as hospital autopsies or hospital-consented autopsies.

UK system of death investigation

Within the UK, different systems of death investigation are used in the constituent nations. Across all British jurisdictions, autopsies are conducted by suitably qualified pathologists or other medical practitioners at the request of the relevant investigating body and are not undertaken by members of the investigating body itself.

In England and Wales, the Coronial system applies. The region has been divided into a number of coronial jurisdictions and within each area, one senior coroner and their assistant coroners conduct investigations into death. A single chief coroner collates and monitors the activity of the area coroners and provides the Lord Chancellor with an annual report. Coroners are legally rather than medically qualified (although some hold both qualifications) and according to the Coroners and Justice Act 2009,² a coroner must be notified of, and has a duty to investigate, any death if the body is within that coroner’s area and they have reason to suspect that the death was violent or unnatural (including deaths related to occupational disease), or that the deceased died while in custody or state detention (including deaths whilst under detention of mental health or deprivation of liberty purposes), or that the cause of death is unknown. The coroner may be asked to suspend their investigation by a prosecuting authority if the death is possibly connected to criminal proceedings or to a homicide investigation (i.e. the case becomes forensic in nature). As part of the investigation of death a coroner

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is tasked with determining the identity of the deceased, where the deceased died, when they died and how they came about their death. The coroner has legal responsibility for the body for the purposes of investigating death. He or she might instruct a post-mortem examination to take place and following receipt of the findings, the coroner can then decide if an inquest is necessary, or if the investigation of death has concluded. Importantly, the Coroners and Justice Act 2009 makes provision that the nature of the post-mortem examination may be by imaging alone.

In Northern Ireland, the coronial system is broadly similar to that used in England and Wales. In Scotland, the Procurator Fiscal system applies. A procurator fiscal is legally qualified and works with the Scottish Fatalities and Investigation Unit. They are employed by the Crown Office and Procurator Fiscal Service, which reports to the Lord Advocate. All deaths in which the cause is not known, or that cannot entirely be attributed to natural causes (including occupation-related, drug-related, accident-related, violent or suspicious deaths), or that occur in the setting of neglect or fault, or that occur in relation to healthcare (medical or dental), or that occur in legal custody, must be reported to the procurator fiscal. The procurator fiscal then has a duty to make enquiries and determine the level of investigation required. They may determine that no further investigation is appropriate, or they may request a police report or a post-mortem examination if deemed necessary. The procurator fiscal may also seek to establish criminality or, in the public interest and in the case of deaths that may have been avoidable, to hold a fatal accident inquiry.³

According to the most recent Coroners Statistics annual,⁴ a total of 236,406 deaths were reported to coroners in England and Wales in 2015, accounting for 45% of all registered deaths. A total of 89,206 post-mortems were undertaken, representing 38% of all cases reported to them and 17% of all registered deaths. Although the overall proportion of deaths reported to coroners has not changed significantly in the last decade, the proportion of deaths in which an autopsy is then ordered is in general decline, with an absolute decrease of 23% over the last two decades in the UK. It has been postulated that the reasons for this decline include cultural and religious objections,⁵ in addition to the declining availability of pathologists and financial considerations.

In response to concerns about the large number of autopsies being undertaken in the UK,⁶ issues raised concerning the standard and quality of coronial autopsies,⁷ religious objections⁵ and cultural objections following the organ-retention scandals of the 1990s,¹ demand for alternative less-invasive ways of investigating deaths has been steadily growing.

An international perspective

The English and Welsh statistics can be contrasted with those of Japan, where the autopsy rate is reported as 2%. Some of this may be attributed to the differences in death investigation and the availability of funding⁸ but in addition, autopsy imaging facilities are available in 55% of all prefectures, and 89% of large hospitals that contain emergency departments will provide post-mortem imaging using clinical scanners. Imaging services have expanded over the last 30 years and today these are unselected rather than demand led; imaging is used as a screening tool using

established protocols to determine if an autopsy will be required as part of death investigation. Approximately 20,000 PMCTs take place annually.⁹

In the state of Victoria, Australia, PMCT is performed in all cases that present for death investigation and a recent evaluation of 318 consecutive cases¹⁰ was undertaken to consider the routine use of imaging as a means of avoiding full invasive autopsy. The findings indicate that for selected cases, in particular deaths in older individuals, PMCT may be used to reduce the need for invasive autopsy.

Across Europe, interest and development of imaging techniques including PMCT is growing. This is due to a number of factors, including declining rates of invasive autopsy for cultural reasons and a growing recognition of the diagnostic benefits of imaging techniques. Germany, Denmark, Italy, the Netherlands, France and Switzerland in particular have been evaluating the use of imaging techniques in a number of settings.^{11–19}

Which modality is most suitable for adult deaths?

In the UK, the first operational coroner's post-mortem imaging service began in Manchester in 1997.²⁰ Magnetic resonance imaging (MRI) and interpretation were provided by radiologists on a demand-led basis to the Jewish and subsequently Muslim communities. Over the first four years of the service, a total of 53 imaging autopsies were undertaken and a confident cause of death was given in 87% of cases. However, the findings were not correlated with autopsy and a subsequent small comparative study²¹ demonstrated a number of potential difficulties with the use of magnetic resonance imaging, particularly if the body had undergone decomposition. In addition, it was not possible to identify severe coronary artery lesions or to differentiate post-mortem blood clot from thrombus, or pulmonary oedema from pneumonic exudates. Although MRI was very useful in demonstrating structural abnormalities, soft tissue detail and the location of tumours, the failure of MRI to demonstrate coronary artery lesions was again highlighted in a larger study.¹⁴

In 2006, the Department of Health in England commissioned studies into the use of post-mortem imaging in the adult and paediatric populations. The initial validation study of the use of cross-sectional imaging in adults took place in Manchester and Oxford over a 3 year period.²² In a series of 182 adult deaths reported to the coroner, both MRI and PMCT were undertaken followed by a full autopsy. Overall, there was a 30% major discrepancy rate between imaging and autopsy findings. However, in contrast to the findings of the paediatric study,²³ PMCT was significantly more accurate than MRI in identifying the cause of death. PMCT was superior in the identification of coronary artery disease and intracranial haemorrhage, both frequent causes of death in adults. PMCT was also superior to MRI in the distinction of pneumonic infiltrates and pulmonary oedema due to heart failure. MRI was, however, better able to detect early myocardial infarction. This finding has been borne out by more recent studies from Switzerland.^{24,25} Jackowski and colleagues investigated a series of 76 adult deaths with post-mortem MRI followed by autopsy. There was excellent correlation between MRI and autopsy in the diagnosis of acute, subacute and chronic myocardial infarcts. In addition, MRI detected abnormalities that were interpreted as very early infarcts, up to 1 h old. These

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