Post Mortem CT in Trauma Patients: A Case Series

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Learning objectives

Five cases of recent post mortem imaging at the Royal Adelaide Hospital are presented, with imaging results compared to the formal autopsy reports.

Learning objectives include:

- To highlight the general benefits and limitations of post mortem CT, including benefits unique to our institution.
- To raise awareness of post mortem imaging as a developing subspecialty of radiology and to present current evidence justifying the role of imaging in the post mortem examination.

Background

Trauma is the leading cause of death in people under the age of 45 in Australia. [1] Patients who die within the emergency department following a traumatic event can pose a diagnostic conundrum for the treating clinicians. In particular, was there a treatable cause that could have prevented the death?

Formal autopsy is often not performed and if undertaken, reports usually take a significant amount of time to become available. Post-mortem computed tomography (PMCT) of trauma patients can provide valuable information in a short time frame regarding cause of death and may allow process improvement.

The Royal Adelaide Hospital (RAH) is the major trauma centre in South Australia. In collaboration with the Coroner's Court, the RAH is performing PMCT on trauma patients who die within the hospital before a diagnostic CT is performed. Strict inclusion, exclusion and patient confidentiality criteria are utilised.

A series of five PMCT cases are presented, focussing on relevant radiological findings and including a discussion on the benefits of rapid assessment with CT imaging.

Imaging findings OR Procedure details

Case Reports:

Case 1
Clinical:

- Motor vehicle crash (MVC).
- Patient suffered cardiac arrest and clam-shell thoracotomy was performed in the emergency department (ED). Pericardial blood was evacuated and spontaneous cardiac activity returned however the patient had a further arrest and resuscitation was not successful.

Detected on PMCT:

- Bilateral haemopneumothoraces and pulmonary contusions, along with mediastinal haematoma around the ascending aorta, aortic arch and SVC.
- Conclusion from the PMCT was that the death was due to traumatic aortic injury.

Detected on autopsy:

- Autopsy demonstrated avulsion of the right subclavian, right common carotid and left common carotid arteries, all of which originated directly from the aortic arch.
- Full thickness tears of the aortic arch wall.

Detected on one but not the other:

- Small subcapsular liver haematoma and small retroperitoneal haematoma was noted at autopsy but not clearly seen on PMCT.

See Figures 1 - 2

Case 2

Clinical:

- MVC. Patient suffered cardiac arrest and was unresponsive to cardiopulmonary resuscitation (CPR).

Detected on PMCT:

- Haemorrhagic cerebral contusions, intraventricular haemorrhage and extensive facial fractures.
- Bilateral pneumothoraces and extensive pulmonary contusions.
- Sternal fracture and multiple displaced bilateral rib fractures which resulted in a reduction of the anteroposterior diameter of the chest. The heart was compressed and rotated on its axis.
- Perisplenic haematoma suggestive of splenic laceration.
Detected on autopsy:

- Autopsy findings were concordant with PMCT for the chest findings, however no splenic or liver laceration was identified.

See Figures 3 - 4

**Case 3**

**Clinical:**

- MVC. Clamshell thoracotomy was performed. The heart was found to be empty and a large mediastinal haematoma was noted. Internal cardiac massage was performed, however there was no response to resuscitation efforts.

**Detected on PMCT:**

- PMCT revealed subarachnoid and subdural haemorrhage, multiple facial fractures, depressed skull fracture and features suggestive of raised intracranial pressure.
- Mediastinal haematoma adjacent to the aortic arch.
- Bilateral haemopneumothoraces (it is difficult to differentiate if this was a result of primary trauma or from thoracotomy).

**Detected on autopsy:**

- Circumferential laceration of the proximal descending thoracic aorta with adjacent mediastinal haematoma.

**Detected on one but not the other:**

- Fat pulmonary emboli and 1cm liver laceration were identified on autopsy but not seen on PMCT.
- Subdural haematoma identified on PMCT was not seen at autopsy.

See Figures 5 - 7

**Case 4**

**Clinical:**
• MVC. The patient was in cardiac arrest on arrival to the RAH. Emergency thoracotomy was performed and internal cardiac massage commenced. Thoracotomy demonstrated no haemopericardium or cardiac injury, however there was no return of cardiac output.

Detected on PMCT:
• Features of raised intracranial pressure, with tonsillar herniation and parenchymal, extra-axial and intraventricular blood.
• Systemic air embolism with gas seen within the left atrium, suprahepatic IVC and hepatic veins.
• Splenic laceration with haemoperitoneum and left renal laceration with retroperitoneal haemorrhage.
• Large open left shoulder girdle injury with avulsion of the neurovasculature.

Detected on autopsy:
• An external only post mortem examination was performed revealing multiple soft tissue abrasions and small lacerations.
• No formal autopsy was performed to allow correlation with PMCT.

See Figure 8

Case 5

Clinical:
• Fall from height, complicated by difficult retrieval.

Detected on PMCT:
• Extra-axial haematoma at the level of the base of skull. No parenchymal haemorrhage.
• Very large superficial soft tissue haematoma extending from the base of the neck to sacrum with a maximum diameter of 47cm and estimated volume of 4.9 litres was noted. Presumed hypovolemic arrest.
• Multiple bilateral rib, lumbar spine, sacral and pelvic fractures. Open left femoral shaft fracture and right acetabular fracture.

Detected on autopsy:
• As yet no autopsy results are available.

See Figure 9
Discussion:

PMCT imaging is a developing subspecialty of radiology and is increasingly performed in Australian centres. PMCT imaging has been conducted at the RAH since 2013; on cases that fit strict guidelines. This includes patients that die within the RAH ED during resuscitation who have not already undergone CT during this presentation. Imaging is to be performed within 2 hours of death and permission obtained from the Coroner. Non-contrast studies of the head, neck, chest, abdomen and pelvis are performed.

Formal autopsy remains the gold standard for post-mortem evaluation of injury and cause of death. [3] However the number of autopsies performed is decreasing, this is often due to the invasive nature of the procedure. [4] Autopsy is also technically challenging and time consuming. [5] PMCT has many advantages compared with traditional autopsy, these include:[5, 6, 7]

- It is minimally invasive, with higher acceptance by relatives or people with religious beliefs.
- The procedure is fast to perform.
- Analysis of the imaging can be performed quickly.
- The imaging is stored digitally, is accessible and allows for re-examination or second opinions. The imaging can also be used to improve understanding of complex pathology and anatomy in a legal setting.
- The body can be scanned from head to toe and allows for examination of regions such as the pelvis, which is traditionally difficult to assess at autopsy.
- There is no tampering or destruction of forensic evidence.
- No risk of infection or contamination.
- Increased ability to detect gas embolism, pneumopericardium, pneumomediastinum or small pneumothoraces, which are more difficult to appreciate at autopsy.
- PMCT can act as a guide to the pathologist performing an autopsy.

Non-contrast PMCT demonstrates a limited ability to detect a number of pathologies, such as superficial abrasions, lacerations, small contusions involving organs and subtle vascular structure damage. [5,8] This was true for a number of the above cases. The most common discordance between PMCT and autopsy reports related to multiple superficial abrasions/contusions and lacerations not reported on CT. These are unlikely to be the cause of death, however may be significant from a forensic point of view.

Major vascular injury was suspected in case 1 and 3 with indirect signs such as mediastinal haematoma noted. In these cases formal autopsy further delineated the details of the vascular pathology. PMCT angiography is valuable at detecting and localising vascular injury. [9] A detailed explanation of PMCT angiography is outside the
scope of this discussion, however involves cannulation of large calibre vessels, usually the femoral artery and vein with injection of a contrast media via a pump into firstly the arterial and then the venous system. This is currently not performed at our institution due to staffing, equipment and funding constraints. [10]

In this case series other findings not reported on CT, but detected at autopsy include liver laceration/haematoma, small retroperitoneal haemorrhage and fat emboli. PMCT however described more fractures than reported at autopsy. In case 3 a subdural haematoma was detected which was not seen at time of autopsy. Of the four cases which demonstrated gas within solid organs or vasculature, none of these findings were commented on during autopsy, however two autopsy reports did refer to this finding mentioned in the PMCT report. Despite variations between PMCT and autopsy reports there were no cases of which cause of death could be considered as altered when the PMCT results were considered following review of the formal autopsy and associated histology and blood tests.

A number of studies have been performed comparing PMCT with autopsy in trauma related deaths. CT has been found to be superior to autopsy in the detection of abnormal air accumulations, however autopsy was superior at detecting organ and vascular injuries. [11] One study assessed traumatic and non traumatic adult death with PMCT, MRI and formal autopsy. In this population they found a major discrepancy rate of 32% between the cause of death identified by radiologists on PMCT and at autopsy. [4] A literature review showed inconsistent evidence regarding PMCT as a reliable alternative to autopsy in the diagnosis of cause of death. However they recommend PMCT should be used as a partner to autopsy rather than a substitute, due to the previously described significant benefits. [5] It should be noted however that in certain selected cases at the RAH (not included in this case series), a formal post mortem was deemed unnecessary due to the results of the PMCT. [Conversation with Pathology Department, RAH August 2015]

Reporting radiologists also need to be aware of differences unique to post mortem imaging and thus a degree of forensic training has been suggested by some authors. [5] Gas formation for example, can often provide a diagnostic dilemma as distinction can be difficult between gas due to putrefaction or from antemortem perforation or embolism. [4] All cases at our institution were scanned within 2 hours of death and therefore putrefaction is felt to have little impact on the interpretation of the imaging.

On average formal autopsy reports take approximately 4-6 months to become available. A further benefit of performing PMCT imaging in our institution is the ability to feedback immediately to treating trauma teams. For example PMCT performed on case 5 demonstrated a large haematoma within the soft tissues of the back. This had gone unnoticed during the resuscitation. The PMCT allowed for rapid team feedback and
therefore has the potential to be used for team resource management and process improvement which can improve clinical outcomes in future cases.

Images for this section:

**Fig. 1:** Coronal PMCT image demonstrating large mediastinal haematoma (red arrow) and haematoma extending into the soft tissues of the neck. Hyperdense wall of the aorta (blue arrow) is often seen at PMCT. [2]
Fig. 2: Axial PMCT image demonstrating bilateral haemopneumothoraces and pulmonary contusions.

Fig. 3: PMCT imaging showing decreased AP diameter of chest with left sided displacement of the heart.
Fig. 4: PMCT image demonstrating possible splenic laceration with haematoma (arrow to right of screen) and suspected subcapsular liver haematoma (left of screen).
Fig. 5: Left sided subdural haematoma (blue arrow) is demonstrated, however this was not seen on formal autopsy.
Fig. 6: Left sided subdural haematoma (blue arrow) is demonstrated, however this was not seen on formal autopsy.
Fig. 7: Gas within the pulmonary artery (black arrow), there is also mediastinal haematoma and pneumomediastinum, rib fracture with haemothorax (blue arrow) and subcutaneous emphysema (orange arrow).
**Fig. 8:** PMCT image demonstrating splenic laceration (green arrow), open left shoulder girdle injury (red arrow) and likely systemic air embolus with gas in the hepatic veins (yellow arrow).
Fig. 9: PMCT image demonstrating extensive haematoma within the soft tissues of the back (red star).
Conclusion

PMCT is proving a valid method of evaluating extent of injury and cause of death in trauma cases. Within our institution correlation with autopsy and PMCT reports from the above cases has demonstrated only minor variation and cause of death based on PMCT analysis could be considered as unaltered upon review of the formal autopsy results. Despite the multiple benefits of PMCT, autopsy remains the gold standard and PMCT should be seen as complimentary to this. However, in certain selected cases in our institution formal post mortem has been deemed unnecessary due to results from the PMCT.

It should also be noted that there are significant differences between antemortem and post-mortem CT imaging and the reporting radiologist needs to be aware of common findings due to post mortem change in order to avoid error.

Within our institution PMCT also has the potential to provide valuable information to clinical teams within a short time frame regarding possible cause of death, which may allow for process improvement.

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