Virtual Autopsy: Abdominal Postmortem MDCT

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• All images are from Naval Medical Center San Diego (NMCSD).
Background

Postmortem multidetector computed tomography (MDCT) can aid forensic investigation, including determination of the ultimate cause of death.

Specific findings and patterns can be seen in abdominal trauma, including military associated injuries.

Pre-invasive imaging of the patient is preserved for future reference, which may even serve as a non-invasive autopsy substitute in certain cases.
Educational Goals

• Examine institutional imaging indications and techniques
• Provide imaging findings in abdominal trauma, including military trauma/accidents
• Correlate postmortem imaging with clinical history and findings, including unknown causes of death
• Discuss CT findings/changes in relationship to decomposition

The target audience includes abdominal radiologists interpreting postmortem MDCTs, institutions performing forensic clinical autopsies, forensic radiology programs, and trauma centers.
Historical Perspective

• 1973: CT scanner introduced for clinical imaging, initially for brain and later whole body scans
• 1977: first described forensic CT: case of gunshot wound to the head
• 1990s & 2000s: clinical trials and publications comparing virtual and clinical autopsies
• 2013: International Society of Forensic Radiology and Imaging (ISFRI) founded
NMCSD Postmortem MDCT
Indications

• NMCSD primary indication for imaging:
  – Assist in determining cause of death if unknown
  – Identification, location, and projectile path (if applicable) of foreign bodies
  – Identification of fractures for the medical examiner
  – Active duty with unknown cause of death and/or aerospace crashes/accidents
NMCSD Postmortem MDCT Technique

- Remains are kept in a body bag, with dedicated imaging of the head and cervical spine, followed by whole body imaging from the neck caudally to include the extremities.

- Additional imaging, including 3D reconstructions, or changes to the normal protocol can be made depending on the pathological/clinical question.
NMCSD Postmortem MDCT Protocol

- Siemens Somatom Definition Flash 128 slice detector
- Axial acquisition
- 0.6 mm
- 295mA, 140 kVp
- 1 sec rotation, pitch 0.9
- Reconstructed into 3mm axial, coronal and sagittal images using both soft tissue and bone algorithms
- 3D images can be obtained from 0.6 mm reconstructed images at the workstation
Traumatic Abdominal & Pelvic Findings

Postmortem MDCT findings in blunt and penetrating trauma include:

- Vascular injury
- Solid organ laceration
- Hemoperitoneum
- Fractures

- Diaphragmatic rupture
- Pneumoperitoneum
- Bowel injury
- Spinal cord transection
36-year-old male who ejected from a crashing F-18. Note the extensive pelvic fractures (orange) and marked subcutaneous emphysema (blue), as well as a left-sided diaphragmatic rupture with bowel contents in the thorax (green).
23-year-old-male ejected from a Humvee as it rolled down an embankment. Intraabdominal findings included hyperdense fluid tracking along the margin of the right kidney, representing subcapsular hematoma (blue), as well as high density fluid along the right paracolic gutter, favored to signify hemorrhage (green).
36-year-old male who suffered a fatal motorcycle crash. Hyperdense material in the pelvis proved to be hemorrhage (green). Subcapsular hemorrhage also outlined the liver (blue).
29-year-old Marine involved in a motor vehicle crash. In addition to multiple neurologic, thoracic, and vascular findings, the deceased suffered significant pelvic trauma. Comminuted right acetabular fracture (green) and diastasis of the pubic symphysis are present (blue). No large pelvic hematoma was present, however.
Two separate patients suffering extensive trauma, including vascular injuries. The left demonstrates significant stranding in the central mesentery (green) concerning for vascular injury with a large amount of hyperdense fluid in the pelvis (orange), likely blood. The patient on the right had multi-level Chance fractures and transection of the spinal cord (blue), along with likely transection of the aorta (red).
Unknown Cause of Death

CT autopsy may be obtained to assist with determination of a cause of death in those involved in accidents (including aerospace) and/or forensic/medical investigations.

Specific abdominal organ damage and associated injuries can provide clues to a cause of death:

- Vital organ injury (e.g. trauma)
- Hematomas, lacerations, and fracture (e.g. abuse/murder)
- Vascular disease, injury, or severe atherosclerosis (e.g. unexpected cardiac arrest)
- Pneumoperitoneum (e.g. perforated diverticulitis or ulcer)
Unknown Cause of Death

Forensic autopsy of a 6-month-old male reportedly found dead under care of a babysitter. Lobulated region of hypoattenuation in the right posterior hepatic lobe raised the possibility of contusion, though cause of death remained unknown, even after physical autopsy.
41-year-old male brought in by ambulance with CPR in progress. Unknown cause of death, when he collapsed at the gym. Examination demonstrated extensive calcific atherosclerotic disease, much greater than expected for age, including the coronary arteries, aorta, and iliac arteries.
60-year-old female found dead at home with moderate to large amount of pneumoperitoneum (orange). Multiple colonic diverticula are present (green), as well as fluid surrounding a thickened gastric wall (blue). Perforated colonic diverticulitis and perforated gastric ulcer were both suggested, with the later determined as the ultimate cause of death.
This 60 year-old female without significant past medical history was found dead in her home. In the absence of CPR efforts, the multiple rib fractures (orange) and hemoperitoneum (blue) point toward blunt force trauma, and foul play was suspected.
Decomposition

• Classification schemes include “early, moderate, and advanced”
  – Early: cerebral autolysis, intravascular gas, intestinal distension and intramural gas
  – Moderate: cerebral settling, cavity fluid, cavity gas, small amounts of subcutaneous and visceral gas
  – Advanced: cerebral liquefaction, diffuse subcutaneous and visceral gas, insect/animal predation, etc.

• Reporting the degree of decomposition is helpful, especially when suspected injuries or causes of death may be confounded by postmortem state
Decomposition

Note the small amount of intravascular gas within the portal venous system (orange) and mild intestinal distension (blue), which can be normal post-mortem findings in early decomposition.
Decomposition

There is a moderate amount of free fluid within the pelvis (orange) and small amount of pneumoperitoneum (blue), which can be normal post-mortem findings seen in moderate decompensation, as in this patient found dead at home.
“John Doe” body that washed ashore. Note the diffuse subcutaneous and visceral organ gas (orange), organ collapse, and cerebral liquefaction (blue) indicative of advanced decomposition.
Decomposition in an Unknown Cause of Death

20 year-old male who drowned for unknown reasons.

Multiple left-sided rib fractures (blue) and large left pneumothorax (orange) may be the reason for the patient’s drowning.

Once again, note the severe subcutaneous and visceral gas indicative of advanced decomposition.
Utility and Future Considerations

Benefits of CT Autopsy:

- Assist in determination of ultimate cause of death
- Focused physical autopsy
- Long-term record of pre-physical autopsy state
- At times may preclude physical autopsy

31-year-old active duty male who died in Mexico. CT was obtained post-Mexican autopsy, and demonstrates changes from examination, including ventral abdominal incision (orange), large pneumopertioneum (blue), and lower rib fractures (green). This is in stark comparison to the pristine, preserved pre-physical autopsy CTs, which can be referenced if future questions arise.
Utility and Future Considerations

3D reconstructions and other modalities/techniques may be of benefit, as in this case of a 3 day-old female with severe skeletal dysplasia. Additional techniques undergoing investigation include magnetic resonance imaging and angiographic studies with artificial circulation.
Conclusion

Postmortem multidetector computed tomography (MDCT) can aid forensic investigation, including determination of the ultimate cause of death, especially when correlated with history and findings on physical autopsy.

Specific postmortem findings can be seen in abdominal trauma, including military associated injuries.

Postmortem findings can help to define the degree of decomposition.

Pre-invasive imaging of the patient is preserved for future reference, which may even serve as a non-invasive autopsy substitute in certain cases.
References

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