Minimally Invasive Coroner’s Autopsy – The Present and (Near) Future

Prof Ian Roberts
Oxford
Declaration of interests

Ian Roberts has a fixed term contract with iGene London Ltd to provide training and clinical governance for post mortem imaging services.
The Coroner’s Autopsy

The Coroner’s autopsy service as we know it must change

Why?
The Coroner’s Autopsy

1. There is a high autopsy rate in England & Wales (20% of all deaths in 2012), >90% performed for Coroners

There will soon be too few pathologists to maintain a service.

75% of trainee pathologists no longer take the FRCPath autopsy examination

Autopsy backlogs - referrals from other Coroner’s jurisdictions “We can’t get a local pathologist to do this case in the next week”
The Coroner’s Autopsy

1. There is a high autopsy rate in England & Wales (20% of all deaths in 2012), >90% performed for Coroners

2. Traditional autopsy is unpopular with the public (90% of families would prefer a non-invasive alternative)
   
   Pathologists as doctors have a responsibility to minimise additional distress to the bereaved that may result from the performing of an autopsy.
   
   Pathologists have a responsibility to the Coroner to provide an accurate cause of death.
The Coroner’s Autopsy

1. There is a high autopsy rate in England & Wales (20% of all deaths in 2012), >90% performed for Coroners

2. Traditional autopsy is unpopular with the public (90% of families would prefer a non-invasive alternative)

3. A large number of Coroners’ autopsies are performed to a poor standard

NCEPOD report 2006

- one in four autopsy reports was judged as poor or unacceptable;
- in one third of mortuaries, the pathologist failed to inspect the body before the anatomical pathology technologist commenced opening it and removed the organs;
- in one in seven cases the brain was not examined;
- in one in sixteen cases, it was deemed that histology should have been taken in order to determine the cause of death;
- in nearly one in five cases, the cause of death as stated appeared questionable;
The alternative – post mortem imaging

A considerable evidence base now exists for the use of PM imaging

Personal experience - >600 cases investigated with PMCT ± MRI over 16 years
Why provide a digital autopsy service?

The first Coronal PM imaging service in the UK –
Sudden unexplained deaths in the community
MRI rather than full autopsy, following request by the family
Funded privately (~£900, by family or religious organisation)
In 90% the radiologist provides a cause of death, accepted by the coroner without autopsy

Bisset RAL et al. BMJ 2002; 324: 1423-24

The early PM MRI service had poor clinical governance and was not evidence-based. Diagnostic errors using PM MRI are frequent.


Over the last 20 years, research has led to development of new techniques and considerably improved the accuracy of PM imaging.

Roberts & Traill. Histopathology 2014;64:211-217
Which mode of imaging?

In general, CT is superior to MRI in detecting causes of death found in an adult coronial autopsy service.


<table>
<thead>
<tr>
<th></th>
<th>CT</th>
<th>MRI</th>
<th>Consensus CT and MRI</th>
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<tbody>
<tr>
<td>Major discrepancy rate with autopsy cause of death, all cases (%)</td>
<td>32% (26–40)</td>
<td>43% (36–50)</td>
<td>30% (24–37)</td>
</tr>
<tr>
<td>Proportion of cases with definite radiological cause of death, no autopsy needed (%)</td>
<td>34% (28–41)</td>
<td>42% (35–49)</td>
<td>48% (41–56)</td>
</tr>
<tr>
<td>Major discrepancy rate with autopsy when radiologist confidence is definite (%)</td>
<td>16% (9–27)</td>
<td>21% (13–32)</td>
<td>16% (10–25)</td>
</tr>
<tr>
<td>Major discrepancy rate with autopsy when radiologist confidence is not definite (%)</td>
<td>41% (33–50)</td>
<td>59% (49–67)</td>
<td>44% (34–54)</td>
</tr>
</tbody>
</table>

Data are % (95% CI) or number (%, 95% CI). Percentages are rounded to nearest whole number.

Table 3: Major discrepancy rate between autopsy and radiology cause of death
What are the strengths of PMCT?

Tumours and other mass lesions (eg. internal haemorrhage)
Fractures & pneumothorax
Intracranial pathology
What are the strengths of PMCT?

- Tumours and other mass lesions (e.g., internal haemorrhage)
- Fractures & pneumothorax
- Intracranial pathology
What are the strengths of PMCT?

Tumours and other mass lesions (eg. internal haemorrhage)
Fractures & pneumothorax
Intracranial pathology
What are the weaknesses of PMCT?

Detecting arterial occlusion and differentiating PM clot from thrombus.

<table>
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<tr>
<th>Diagnosis</th>
<th>Missed on imaging</th>
<th>Overattributed on imaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary heart disease</td>
<td>12/86 (14%)</td>
<td>15/95 (16%)</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>10/10 (100%)</td>
<td>1/1 (100%)</td>
</tr>
<tr>
<td>Bronchopneumonia</td>
<td>9/28 (32%)</td>
<td>4/28 (14%)</td>
</tr>
<tr>
<td>Intestinal infarction</td>
<td>4/6 (67%)</td>
<td>1/3 (33%)</td>
</tr>
</tbody>
</table>

Data are n/N (%). Denominators for the left-hand column are total diagnoses of these disorders in the autopsy causes of death. Denominators in the right-hand column are the total diagnoses of these disorders in the consensus radiology causes of death.

Table 5: Most common sources of major discrepancy between autopsy and consensus radiology cause of death
What are the weaknesses of PMCT?

Vascular calcification is demonstrated on CT, but not the vessel lumen.

CT

MR
Intravascular contrast - gas

Detecting arterial occlusion and differentiating PM clot from thrombus.

PM decomposition
Intravascular contrast – whole body perfusion angiography
Intravascular contrast – whole body perfusion angiography

Demonstration of precise source of haemorrhage in traumatic and operative deaths

Angiography performed by cannulation of right femoral artery and vein, and infusion of 1.7L of contrast using embalming pump.
Intravascular contrast – targeted coronary angiography
Coronary angiography is more sensitive than dissection at detecting coronary stenosis

Coronary angiography quantified 0-4 at coronary angiography and autopsy

100 coronary arteries in 25 autopsies

Agreement between angiography and dissection 57%

Angiography detected greater stenosis than dissection 38%

Dissection detected greater stenosis than angiography 5%
Detection of early myocardial infarcts

Filling of intramyocardial vessels with contrast demonstrates segmental filling defects secondary to coronary occlusion, highlighting recent infarcts.
Targeted pulmonary angiography
Distinction of PM clot from pulmonary emboli

Obstructive – dilated pulmonary artery, RV and RA pre-contrast injection

Wedge-shaped subpleural pulmonary infarcts

Obstructive – poor filling of pulmonary arteries (“failed” CTPA)

Does not mould to pulmonary arteries – “lumpy” outline/filling defect
Distinction of PM clot from pulmonary emboli

Scoring system for the diagnosis of pulmonary embolism

**Positive features** – each scored 1 if present

**Pre contrast**
- RA dilatation
- RV dilatation
- Impacted clot R & L PA bifurcation
- Coiled appearance/different attenuation at PA bifurcation
- Pulmonary infarct

**Post contrast**
- Impacted clot R & L PA bifurcation
- Coiled appearance/different attenuation at PA bifurcation

**Negative features** – each scored -1 if present

**Pre contrast**
- Small collapsed pulmonary trunk

**Post contrast**
- Horizontal anterior border in main PAs
- Opacification beyond main PAs

Pulmonary angiography followed by full autopsy

10/46 cases with pulmonary emboli diagnosed at autopsy

Pulmonary angiography scored blind of PM findings.

<table>
<thead>
<tr>
<th>With cut off of 3:</th>
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<tr>
<td>sensitivity</td>
<td>88%</td>
</tr>
<tr>
<td>specificity</td>
<td>92%</td>
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<tr>
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<tr>
<td>sensitivity</td>
<td>50%</td>
</tr>
<tr>
<td>specificity</td>
<td>100%</td>
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Impact of coronary angiography on minimally invasive autopsy service

120 autopsies, first 60 without angiography, 60 with angiography

Other minimally invasive investigations performed as indicated – aspiration of fluids for toxicology and biochemistry, biopsy of tumours identified at imaging.

No autopsy required:
38% without angiography
70% with angiography

Roberts & Traill. Histopathology 2014;64:211-217
Protocol for the use of PM imaging in the Coroner’s autopsy

**Oxford protocol:**

Pathologist selects cases appropriate for minimally invasive autopsy

- Full body CT + external examination → issue report & cause of death
  - no definitive cause of death
  - CT coronary angiography → issue report & cause of death
    - no definitive cause of death

Conventional autopsy, limited according to imaging findings

Other minimally invasive investigations performed as indicated – aspiration of fluids for toxicology and biochemistry, biopsy of tumours identified at imaging.
The Pathologist’s Toolbox

- Circumstances of death
- External examination
- Clinical history
- Instruments for dissection
- Microscope
- Laboratory tests
The Pathologist’s Toolbox

Circumstances of death

External examination

Clinical history

PM imaging

Instruments for dissection

Microscope

Laboratory tests
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Microscope
The Pathologist’s Toolbox

Circumstances of death

External examination

Clinical history

PM imaging

Instruments for dissection
Decision making in a digital autopsy service
Is an invasive procedure required?

25% of sudden adult deaths will require some type of invasive procedure

It is required when -
CT + angiography have not demonstrated a firm cause of death
There is an unanswered imaging finding
There is something in the history that is not explained by the imaging findings

A stepwise approach – any invasive procedure should be minimised to answer outstanding questions
The invasive procedure should be targeted and guided by the imaging findings

Development of new approaches to dissection – the “keyhole” autopsy
Minimally invasive dissection of pulmonary arteries

**Indications:**

Medical history or circumstances of death suggest the possibility of PE

CT findings suspicious – dilated pulmonary artery/right heart/pulmonary infarct
Minimally invasive dissection of pulmonary arteries

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CT findings suspicious – dilated pulmonary artery/right heart/pulmonary infarct
Digital autopsy services – the present

Development of post mortem imaging services in the UK has the support of the:
Chief Coroner
Department of Health
Ministry of Justice
Royal College of Pathologists
Royal College of Radiologists

The challenges:
Development of infrastructure
Financing a new service
Training of pathologists, radiologists, technical staff
Governance – quality assurance, national standards
Digital autopsy services – the present

THE USE OF POST-MORTEM IMAGING (ADULTS)

Introduction

1. The purpose of this Guidance is to provide a sound working procedure with minimum requirements where post-mortem imaging is used. The need for Guidance arises out of the fact that coroners have been using imaging in some parts of England and Wales albeit on a limited basis. This Guidance is not intended to be judgmental about the process of post-mortem imaging, merely to provide minimum standards where it is used.

2. In some parts of the country CT scanners (and sometimes MRI scanners) are used by coroners for the purposes of ascertaining the cause of death of an adult. Other countries use them too, for example Japan and the State of Victoria in Australia.

3. CT (computed tomography) imaging is considered by many to be of greater assistance than MRI (magnetic resonance imaging) in ascertaining a cause of death, but there are differing views. The former is also much cheaper.

4. The number of post-mortem examinations (autopsies) in England and Wales is very high compared with other countries with a coroner system. The Luce Review in 2003 found that the autopsy rate was between two and three times the rates of other comparable countries (pp 19, 164). Any sensible reduction in the number of autopsies would be welcomed (as the Lord Chancellor has indicated), particularly by bereaved families.

5. The use of images from CT scanning is one possible way of reducing the number of autopsies. Certain faith groups are particularly keen to avoid an autopsy, and many others would be pleased to avoid one.
How to provide a post mortem imaging service?

1. Using NHS staff and existing NHS CT facilities (out of normal working hours):

**Pros:** No capital costs of building new CT units

**Cons:** Coroner’s autopsy services in parts of the country are provided by public mortuaries not attached to NHS hospitals, and run by local authorities, not the NHS.

Many NHS CT units are not available for PM work due to large emergency on call workload

Staff availability and willingness to work unsocial hours

Staff costs – on call payments for radiographers and APTs – costs of running a service are high – NHS subsidising Coroner’s service.

Logistics of transporting bodies from mortuary to CT unit – radiology departments are in busy patient areas, in different buildings or different hospitals.
Oxford PM imaging service

3 pathologists, 2 radiologists

Imaging performed in Oxford using NHS scanner

“One stop” service:

Funeral director brings patient to Oxford for 6.15am/5.45pm.

CT ± targeted angiography at 6.30am/6pm

Limited autopsy if required immediately after CT

Body released and funeral director leaves in 0.5-1.5 hrs
Oxford PM imaging service

Minimally invasive autopsy service, mainly for faith communities in London and South East England.
Protocol agreed and MIA performed for 14 HM Coroners
1-5 cases/week
Oxford PM Imaging Service
Audit of first 100 cases

14 Coroner’s jurisdictions
Oxford PM Imaging Service
Audit of first 100 cases

Procedures required - 78% CT +/- coronary angiography only
Oxford PM Imaging Service
Audit of first 100 cases

Workload is increasing with time
How to provide a post mortem imaging service?

2. Using dedicated post mortem CT facilities:

Pros: Imaging can be performed at any time of the day – no need for out-of-hours work, same day report enables same day release of body
High throughput is possible (2,000 cases per annum per unit)
Cost/case falls as numbers increase
No transport issues for mortuary based units
HTA issues – CT guided needle biopsies

Cons: Capital costs of building new CT units.
Introduction of dedicated PM imaging facilities
Digital autopsy – the (near) future
A national network of PM imaging units

Current status of service development:

Three units in place: Sheffield
Bradford
Sandwell (W Midlands)

By the end of 2015: 12 units, covering London, Bristol, Midlands, North West, North East

By 2018: 20 units providing a national network of PM imaging facilities

Local pathologists lead the examination and decision making process
Radiology reported remotely
iGene minimally invasive autopsy protocol

**Deaths in the community referred to Coroner:**

Following referral for digital autopsy iGene staff select cases appropriate for PMCT

Full body CT ± coronary angiography (performed by radiographer)

↓

issues report ± cause of death to pathologist

External examination by pathologist

↓

Issues report to Coroner, or invasive procedure, limited according to imaging findings

Other minimally invasive investigations performed as indicated – aspiration of fluids for toxicology and biochemistry, biopsy of tumours identified at imaging.
The autopsy – the (near) future