

## INTRODUCTION

Post mortem imaging (PMI) has a long-standing role in autopsy, with conventional radiography (CR) well-established in providing useful pathological information, for example with regard to detection of structural bone abnormalities, fractures and dysplasias [1]. There has been increasing use of PMI in recent years, particularly in forensic and paediatric pathological investigation, due to technological advances in cross-sectional imaging of computed tomography (CT) and magnetic resonance imaging (MRI), with CT allowing for excellent bone detail and MRI superior in providing information of soft tissues [2]. Furthermore, post-processing techniques and 3D scanning technology and animation which have been in use since the early emergence of post mortem imaging [3] continue to develop, allowing for continued evolution of post mortem analysis and accurate documentation, leading to qualitative improvements in pathological investigation [4]. The increased ability to accurately detect and localise pathology through imaging, either alone or in conjunction with minimally invasive autopsy, reduces the need for invasive traditional open autopsy [5] [6].

The growing use of imaging in post mortem assessment has led to the establishment of the International Society of Forensic Radiology and Imaging (ISFRI), a collaboration of worldwide specialists from pathological, radiological, legal and forensic backgrounds. One of the emerging goals from the first congress of ISFRI in 2012 was to 'build a foundation for establishing standards, educational guidelines and best practices in forensic radiology and imaging' [7] [8]. Despite the efforts of the ISFRI subcommittees to achieve this aim, we have anecdotal experience that radiology trainees in our region have limited knowledge and understanding of forensic and post-mortem imaging. As a result, there is a large trainee cohort who would potentially welcome the opportunity to gain experience and become more involved in PMI, perhaps with a view to sub-specialising in the future, but are naïve to the significance of forensic and post-mortem imaging in current and future practice.

The aims of this study were to assess our radiology trainees' understanding of PMI and of the current status of further opportunities to learn and train in this important emerging sub specialty of radiology.

## **METHODS**

### **Data collection**

An online questionnaire was produced using online tool SurveyMonkey® (<http://www.surveymonkey.com/>; SurveyMonkey.com, Palo Alto, CA). An invitation e-mail was sent in March 2015 to all 261 radiology trainees in our region (London, UK), which makes up 20% (261/1268) of the national cohort radiology trainees, to complete an online survey on post-mortem imaging. A reminder e-mail was sent out 3 weeks later, and the total time available to respond was 6 weeks (March - April 2015). The results were compiled into a spreadsheet for further analysis and descriptive graphical representation of the data is presented. The survey comprised four parts: demographics of respondent; personal experience and current knowledge of PMI; certification and reporting; engagement in learning opportunities.

### **Demographics**

Two questions were asked to establish level of training of the respondent and their current decision on subspecialty training.

1. Which year of training are you? (one answer permitted)

(1) ST1, (2) ST2, (3) ST3, (4) ST4, (5) ST5 and above.

2. Have you already decided on your sub speciality? (one answer permitted)

(1) Yes, (2) No, (3) Not sure.

### **Personal experience and current knowledge of PMI**

Nineteen questions were asked using a Likert scale to assess trainee confidence in their experience in and understanding of PMI

3. Regarding personal experience in PMI. The following questions required an answer (1) Strongly disagree, (2) Disagree, (3) Not sure, (4) Agree, (5) Strongly agree (one answer permitted per question)
  - a. I have a good understanding of the discipline
  - b. I have the opportunity to undertake experience in forensic and/or post mortem imaging in my current place of work or training programme
  - c. I would like the opportunity to undertake experience in forensic and/or post mortem imaging during my training
  - d. Post mortem imaging should be included within the Radiology trainee curriculum
  - e. I would consider sub-specialising in forensic and post mortem imaging
  - f. My current place of work has facilities in place/already performs forensic and post mortem imaging
  
4. Regarding the use of PMI. The following questions required an answer (1) Strongly disagree, (2) Disagree, (3) Not sure, (4) Agree, (5) Strongly agree (one answer permitted per question)
  - a. More should be done to promote forensic and post mortem imaging to the public
  - b. It will supercede and/or replace traditional autopsy in the future
  - c. It is an important adjunct to traditional forensic and post mortem autopsy
  - d. It has an important role to play in certain religious and/or cultural groups

5. How important are the following modalities in PMI? The following questions required an answer (1) Not at all important, (2) Not important, (3) Not sure, (4) Important, (5) Very important (one answer permitted per question)
- a. Plain Film
  - b. Ultrasound
  - c. Computed Tomography (CT)
  - d. CT Angiography
  - e. Magnetic Resonance Imaging (MRI)
6. Regarding professional roles in PMI. The following questions required an answer (1) Strongly disagree, (2) Disagree, (3) Not Sure, (4) Agree, (5) Strongly agree (one answer permitted per question)
- a. It is a clinical sub speciality
  - b. It is a radiological sub speciality
  - c. It is performed by pathologists
  - d. It is performed by radiologists

### **Certification and reporting**

Two multiple choice questions were asked regarding certification and reporting of PMI. Multiple answers were permitted.

7. Accreditation/certification of professionals in PMI should be (1) Radiologists, (2) Pathologists, (3) Radiographers, (4) Other (please specify)
8. Professionals who *report* on PMI should be (1) Radiologists, (2) Pathologists, (3) Radiographers, (4) Other (please specify)

## **Engagement in learning opportunities**

The final four questions related to trainee interest in PMI associated societies, journals and courses.

9. Would you like to learn more about forensic and post mortem imaging? The following questions required an answer (1) Yes, (2) No, (3) Not sure (one answer permitted per question).
  - a. I am aware of the International Society of Forensic Radiology and Imaging (ISFRI)
  - b. I am already a member/would be interested in becoming a member of ISFRI
  - c. I would be interested in subscribing to JOFRI
  - d. I would be interested in attending courses/lectures on PMI.

## **RESULTS**

A total of 43 individual responses to the survey were received out of a total of 261, representing a 16.5% response rate. Two responses were discarded as they were incomplete and unable to confirm the location of their training scheme, leaving a 16% (41/261) response rate.

### **Demographics**

The majority of respondents were advanced in their training, with 59% (24/41) at ST4 or ST5 level or above. Most respondents have already decided on their training subspecialty (27/41; 66%), which is to be expected given the higher percentage of more senior respondents.

### **Personal experience and current knowledge of PMI**

85% (35/41) of trainees either disagreed or strongly disagreed that they had a good understanding of PMI in current practice. Many trainees (23/41; 56%) also strongly disagreed that they have the opportunity to undertake PMI experience within their current place of work or training scheme. However, the majority of trainees responded positively to questions regarding learning opportunities, with 71% (29/41) either agreeing or strongly agreeing that they would like the opportunity to gain more PMI experience during training, and only 29% (12/41) not sure. No respondents disagreed (fig.1) 59% (24/41) agreed that PMI should be included in the training curriculum (fig.1).

Consideration of PMI as a subspecialty was divided amongst respondents, with most (17/41; 41%) remaining unsure. An even minority were confident they would (strongly agree 4/41; 10%) or wouldn't (strongly disagree 4/41; 10%) subspecialise in PMI (fig.1).

Figure 1. Responses (%) regarding personal experience in post-mortem imaging, ranging from strongly disagree to strongly agree (Appendix 1).

Regarding the use of PMI, the majority of trainees recognised that imaging is an important adjunct to traditional autopsy, with 85% (35/41) in agreement of its importance in post mortem assessment. 73% (30/41) agreed that PMI is of particular importance to certain religious or cultural groups (fig.2).

The role of PMI in replacing or superceding traditional autopsy split opinion, with approximately one third disagreeing (13/41; 32%), one third not sure (14/41; 34%), and just under one third in agreement (11/41; 27%) that imaging will play the major role in post mortem assessment rather than traditional autopsy in the future (fig.2).

Over half of trainees agreed (23/41; 56%) that more should be done to promote PMI to the wider public (fig.2).

Figure 2. Responses (%) regarding the use of post-mortem imaging, ranging from strongly disagree to strongly agree (Appendix 1).

90% of trainees felt that CT had an important (21/41; 51%) or very important (16/41; 39%) role to play in PMI (fig.3). Plain film was also considered important (18/41; 44%) or very important (13/41; 32%). The responses for whether MRI was important (17/41; 41%) or very important (12/41; 29%) gave similar values seen for plain film. Ultrasound was deemed to be not important (20/41; 49%), as was CT angiography (15/41; 37%) (fig.3).

Figure 3. Responses (%) regarding the importance of post-mortem imaging by modality, ranging from not at all important to very important (Appendix 1).

### **Certification and reporting**

Over half of trainees think that PMI is a radiological subspecialty (21/41; 51%) rather than a clinical subspecialty (12/41; 29%), and slightly more consider PMI to be undertaken by radiologists (23/41; 56%) than by pathologists (19/41; 46%) (fig.4).

Figure 4. Responses (%) regarding professional roles in post-mortem imaging, ranging from strongly disagree to strongly agree (Appendix 1).

Whilst many trainees agreed that certification and accreditation should be for radiologists (40/41; 98%), followed by pathologists (28/41; 68%) and radiographers (25/41; 61%), the vast majority felt that *reporting* PMI should be left to radiologists (39/41; 97%) rather than pathologists (11/41; 27%) or radiographers (5/41; 12%) (fig.5).

Figure 5. Opinions regarding which professionals should have certification/accreditation in post-mortem imaging, and which should report on post-mortem imaging (Appendix 1).

### **Engagement in learning opportunities**

The majority of trainees who responded had not heard of ISFRI (35/41; 85%). However there is a good proportion of trainees who are already members or would be interested in joining ISFRI (12/41; 29%) with 27% (11/41) remaining unsure (fig. 6). 39% (16/41) would also be

interested in subscribing to the Journal of Forensic Radiology and Imaging (JOFRI). 88% (36/41) of respondents would attend courses and lectures on PMI, with only 7% (3/41) not interested in further learning opportunities in PMI (fig.6).

Figure 6. Opinions regarding current awareness and further education in post-mortem imaging (Appendix 1).

## **DISCUSSION**

This study shows that whilst our radiology trainees recognise that imaging is an important part of the autopsy process, they do not have adequate exposure to post mortem imaging. Most respondents believed that they would like more experience, and thought that PMI should be included in the training curriculum, as they see radiology and radiologists having a significant role in PM imaging in the future. These are important factors for training schemes to consider, in order to provide the experienced radiology staff which would be needed for a national PM imaging service to complement existing autopsy practice.

The fundamental role of the radiologist in daily clinical practice is to accurately interpret imaging of varying modalities in order to pinpoint pathology. Thus radiologists already have many skills which can be useful to the understanding and accurate interpretation of imaging used in modern day autopsy. However imaging findings observed after death often differ significantly to those seen in normal clinical practice and there is a risk of misinterpretation if radiologists rely solely on clinical experience for PMI interpretation [9]. It is therefore essential that radiologists and pathologists combine their expertise in order to ensure precision of post mortem interpretation and reporting, and to establish successful integration of routine PMI in coronial and forensic autopsy [9]. In this study, many trainees appreciate that PMI is more likely to be used as an adjunct to traditional autopsy rather than a

replacement (fig. 2), implying their understanding of the integral role of the pathologist in PMI. However the majority also expressed that it is the role of the radiologist to report PMI scans rather than the pathologist (fig. 5), potentially in conflict with the ISFRI ideal of a multidisciplinary subspecialty combining expertise from both pathology and radiology [10]. We feel that subspecialist training and certification in PMI is paramount to the future development of this important emerging subspecialty, and cooperation between radiologists and pathologists is vital to ensure cohesive learning, establishment of educational guidelines and standardised practice in post mortem and forensic assessment [11], in order to achieve the aims set out by ISFRI [12].

One interesting statistic was the lack of respondents who felt that CT angiography had a strong part to play in modern PMI. As CT angiography now plays a significant role in the majority of PMI worldwide, with excellent diagnostic response rates [13, 14], this is further indirect evidence that UK trainees having a limited understanding of the current PMI techniques.

There are limitations in our study. As with all online questionnaires, we had a relatively low response rate of <20%. Our results may be skewed in favour of those who already had an interest in PM imaging. If this is the case, then extrapolated to the national radiology trainee cohort in general, then this provides a small minority of trainees who would be interested in PM imaging. We also did not attempt to survey pathologists, but acknowledge that their responses to the same questions (e.g. Fig 5) may have been polar opposite. Forensic pathologists with an interest in post mortem imaging would be an interesting group to study further.

Our survey has demonstrated that there is a distinct lack of understanding regarding PMI in the regional radiology trainee cohort, and currently very little opportunity to undertake any experience in PMI whilst in training. However with over 70% of trainees stating they would like the opportunity to learn more about PMI during training, and that nearly two thirds think that PMI should be included in the curriculum (fig.1), it is clear there is a desire for more

trainee experience in PMI. Increased trainee exposure to PMI through the use of dedicated lectures and courses is fundamental to fulfilling this demand is vital to accessing and training potential PMI sub-specialists of the future.

## **CONCLUSION**

Radiology trainees feel that they have insufficient exposure to or training in post mortem imaging to provide the reporting resources needed in the future. Incorporating PM imaging training into the training curriculum would be welcomed by radiology trainees, and may go some way to alleviating a future shortfall of radiologists specialising in post mortem imaging.

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## APPENDIX 1

### Figure legends

#### Personal experience and current knowledge of PMI

**Figure 1.** Responses (%) to questions regarding personal experience in PMI, on a 5 point Likert scale, included: 1 - Strongly disagree (black); 2 – Disagree (hatched grey); 3 – Not sure (white); 4 – Agree (dotted grey); 5 – Strongly agree (grey). Only one answer was permitted per question.

**Figure 2.** Responses (%) to questions regarding the use of PMI, on a 5 point Likert scale, included: 1 - Strongly disagree (black); 2 – Disagree (hatched grey); 3 – Not sure (white); 4 – Agree (dotted grey); 5 – Strongly agree (grey). Only one answer was permitted per question.

**Figure 3.** Responses (%) to questions regarding the importance of modalities in PMI, on a 5 point Likert scale, included: 1 – Not at all important (black); 2 – Not important (hatched grey); 3 – Not sure (white); 4 – Important (dotted grey); 5 – Very important (grey). Only one answer was permitted per question.

**Figure 4.** Responses (%) to questions regarding professional roles in PMI, on a 5 point Likert scale, included: 1 - Strongly disagree (black); 2 – Disagree (hatched grey); 3 – Not sure (white); 4 – Agree (dotted grey); 5 – Strongly agree (grey). Only one answer was permitted per question.

### **Certification and reporting**

**Figure 5.** Responses (%) to multiple choice question regarding accreditation (black) and reporting (white) in PMI, according to profession and including: Radiologists; Pathologists; Radiographers; Other. More than one answer was permitted.

### **Engagement in learning opportunities**

**Figure 6.** Responses (%) to questions regarding further experience in PMI included: Yes (white); No (black); Not sure (grey). Only one answer was permitted per question.