



A limited overview of forensic radiography in six countries as presented at the ISFRI 2021 congress

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ABSTRACT

The International Association of Forensic Radiographers (IAFR) facilitated a session at the online congress of the International Society of Forensic Radiology and Imaging in May 2021. The session provided an overview of forensic imaging and the role of the forensic radiographer across a range of six countries. This review summarises the common themes and differences, as well as recommending a wider survey of forensic institutes and forensic radiographers and noting an opportunity for the IAFR to provide online education to meet the postgraduate education and training needs of radiographers internationally.

Introduction

Within the forensic field, there are different approaches to how forensic radiology and imaging are used and embedded in the local legal system. In some countries, forensic radiology is not used at all, whereas in other countries it is used to 'triage' prior to the autopsy to review the bony structures. In other jurisdictions the complete range of imaging techniques may be employed, such as post-mortem computed tomography angiography (PMCTA), CT-guided biopsies, ventilated PMCT (vPMCT), post-mortem magnetic resonance imaging (PMMRI) to supplement or in some cases to replace the traditional autopsy.

The imaging approach depends on a range of considerations including different legal systems, traditions, financial resources, applicant, case load, accessibility to scanners and advances in imaging technology. The manner in which radiology is used determines the qualifications that must be set for the person who will perform the imaging, e.g. operate the imaging equipment. Perhaps a standard CT protocol can be taught to a mortuary technician, but they should still be

supervised by an imaging specialist who has technical expertise and an understanding of the image quality requirements, i.e., a radiographer. In addition, there is the safety aspect of radiation legislation that must be adhered to. As soon as other modalities are added to CT, such as conventional X-ray in suspected physical abuse, performing CT-guided biopsies, PMMRI, PMCTA, vPMCT, reporting, writing expert witness reports, research, etc., more highly qualified personnel are required to facilitate this or take the imaging to a higher level.

In addition, the translation of clinical developments to the forensic sciences is an important part of staying up to date. The implementation of these new advanced imaging techniques, e.g. dual energy CT or certain MRI sequences, is only possible if there is sufficient specialist radiographic knowledge available within the forensic institutes.

By using a "clinical" imaging modality within the forensic context, a translation must be made between both worlds; one will also have to be aware of the terminology that is used in both worlds. For example, in the Netherlands, the role of Forensic Radiology Consultant has been created to bridge the gap between the forensic radiology unit and the police or

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the public prosecution service but they also determine which imaging modalities are used based on the case information provided by the police and the preliminary result of the PMCT.

The above example highlights the different interpretations of the role of the "forensic radiographer". In some countries, it remains 'only' to perform imaging; whereas in other countries, the role of forensic radiographer is incorporated into the forensic team and works closely with the forensic pathologist, mortuary technicians, radiologists, police officers and prosecutors. In Australia, forensic radiographers provide an initial interpretation of the post-mortem imaging to help guide pathologists in their investigation; whereas in the UK and Switzerland, radiographers insert catheters to perform PMCTA or endo-tracheal tubes to perform vPMCT.

By increasing international contacts through networking during conferences, attending webinars and being a member of professional associations such as the International Association of Forensic Radiographers (IAFR) and the International Society of Forensic Radiology (ISFRI), these differing interpretations, approaches and working methods are shared and discussed, ultimately maximising the potential contribution that the forensic radiographer can add to improve the quality of the investigative process.

In order to provide a better overview and understanding of the range of different interpretations of the role of the Forensic Radiographer, this article provides an overview of the advantages and disadvantages, the challenges and considers future "role" development for forensic radiographers internationally. The IAFR aims to support forensic radiographers develop forensic imaging within their country.

In the Appendices are the short abstracts of the ISFRI 2021 speakers within the IAFR session:

- A Australia by Anthony Buxton
- B Denmark by Christina Carøe Ejlskov
- C Finland by Fox Marttinen
- D Japan by Dr. Tomoya Kobayashi
- E UK by Dr. Claire Robinson and Amy-Lee Brookes
- F West-Switzerland (Lausanne/Geneva) by Alejandro Dominguez, Céline Schnegg and Dr. Silke Grabherr

Method

In addition to the abstracts from the IAFR session at the ISFRI 2021 congress, the IAFR asked each of the presenters to complete a short survey with additional questions in order to get a better impression of the role of the forensic radiographer across the six countries represented. The IAFR would like to emphasise that this was not an extensive survey to outline a complete international overview.

Results

Information from the abstracts submitted, as well as responses to the survey circulated to the six presenters has been summarised in the tables below.

Background

By limiting the survey to those who presented at the ISFRI 2021 congress in Krakow, it is not possible to obtain an accurate overview of the number of forensic institutes in countries involved nor whether this is in proportion to the population density or the land area. We know is that Switzerland has been a forerunner in the field of medical forensics and the development of in-house imaging techniques. Denmark and Finland, with 3 and 5 forensic institutes respectively, also offer a more structured approach. Table 1 suggests that population density does not appear to be a factor in the organisation of forensic imaging with smaller countries seeming to have a better structure but it could also be that there is less diversity within their legal system. Upon review of the

Table 1
Background of forensic radiography.

	Population	No. of forensic institutions	No. of forensic radiographers	Qualifications	PM-XR	NAI	Bone Age	Drug trafficking	PM-Fluoro	PMCT	PMCTA	V PMCT	PM MRI	PM Biopsies	Advising	Reporting
Australia	26m	States have CT whereas territories use hospital CT scanners	QLD = 1.5 NSW = 3.6 VIC = 1 SA = 1 WA = ? TAS = 0 ACT = ? 2	*					✓							✓ Radiographer Review/Impression (10% reported by radiologists)
Denmark	5.84m	3	1		✓	✓				✓						✓ (at Aarhus)
Finland	5.5m	5	1	Board certified	✓	✓		✓								
Japan	125.7m	PMCT performed in clinical dept in hospital											✓			✓ Radiographers provide opinion
UK	67m		Usually ad hoc so number unknown		✓	✓										
Switzerland																✓

location where forensic radiology is performed, it appears that the minority of the institutes undertake forensic radiology themselves. Imaging is often acquired in hospitals located nearby forensic institutes; a good example of this is Japan where most post-mortem imaging is performed in a large number of hospitals throughout the entire country (Table 1).

Remarkably enough, there are only a few specialised Forensic Radiographers active among the ISFRI 2021 presenters who have received some form of certification and/or additional training. It can be deduced from the articles that the work is often done by clinical radiographers or Mortuary Technicians who are under the “supervision” of a (forensic) radiographer, but a clear profile with an associated training pathway is missing.

With regard to the imaging techniques to be used, the ‘gold standard’ of PMCT is performed in all countries (not always routinely, but it is available), with an additional PMCTA in some countries (Table 1). PMMRI is also performed in the UK, Switzerland and Japan in particular. When physical child abuse is suspected, a conventional X-ray Skeletal Survey is performed in addition to the PMCT scan. It is striking that vPMCT is only performed in the UK and not in any other countries/institutes represented in the IAFR session at ISFRI 2021, whereas pre-autopsy PM biopsies are only performed in Switzerland. The advisory role of the radiographer currently appears to be limited to the UK, but this may be seen as a professional attitude and not as a specific task of the radiographer. Also, reporting of the forensic imaging by radiographers is not yet embedded in the countries surveyed and is often only considered to be advisory or a preliminary interpretation.

Roles and Responsibilities of the Forensic Radiographer

There appears to be a lack of structure to the role of the Forensic Radiographer internationally with the acquisition of CT imaging delegated to Mortuary Technicians in 50% of the countries represented (Table 2). In Australia and Denmark, the Forensic Radiographer supervises the CT scan acquisition and provides technical advice so they are responsible for the technical quality of the CT images produced. Radiographers have an undergraduate degree which may be supplemented by postgraduate education and training, specialising in modalities such as CT or MRI. No other profession has this level of technical knowledge underpinning their skills. It is this minimum education requirement that defines a radiographer as “a trained healthcare professional typically certified or licensed to produce medical imaging (such as X-rays or CT scans) for diagnosis or screening” [1]. The IAFR have clearly defined the Forensic Radiographer as being “any state registered radiographer/radiologic technologist who has undertaken a course of post-graduate education in forensics approved by the IAFR; or any state registered radiographer considered by their professional body/employer to have sufficient experience to carry out forensic examinations and with a good working knowledge of all applicable legislation and guidelines” [2]. As with any multidisciplinary team, each profession contributes their own unique knowledge and skillset to ensure that the best outcome is achieved for each individual case.

Table 2 shows that the roles and responsibilities of the forensic radiographer are most clearly outlined in Denmark. The common themes include attending and presenting at case meetings (Denmark and UK), optimising scan protocols (Australia and Denmark), being involved in research (Denmark, Japan and Switzerland), being responsible for radiation protection (Denmark and Switzerland), training of others (Australia, Denmark and Switzerland) and cannulation for PMCTA (UK and Switzerland). Interestingly, it is uncommon for radiographers to be responsible for QA (as undertaken by the Forensic Radiographer in Denmark), to liaise with external organisations (performed by the Forensic Radiographer in Denmark), to be a PACS Administrator (undertaken by the Forensic Radiographer in Denmark), insert endotracheal tubes for ventilated-PMCT (performed by the Forensic Radiographer in UK), to perform 3D surface scanning (undertaken by the Forensic Radiographer in Switzerland) or to provide an opinion on image

Table 2
Roles & responsibilities of the forensic radiographer.

	Perform CT scans	Supervise CT scans	Present/ attend case meetings	Provide technical advice	Responsible for QA	Optimise protocols	Liaison	Research	PACS admin	Radiation Protection	Training of others	Cannulate for PMCTA	Insert ET tube for VPMCT	3D SS	Image Interpretation
Australia	Mortuary Technician	✓		✓		✓					✓				✓
Denmark	Mortuary Technician	✓	✓	✓	✓		✓		✓		✓				✓
Finland	Clinical Radiographers / Mortuary Technician														
Japan	✓			✓		✓		✓		✓					✓
UK	✓		✓		✓								✓		
Switzerland	✓					✓				✓	✓	✓		✓	✓

interpretation (performed by the Forensic Radiographer in Australia and Denmark).

This overview suggests that the IAFR should consider defining the roles and responsibilities of a forensic radiographer which can then be adapted to meet local needs and requirements in each country.

Opportunities for the Forensic Radiographer

All abstracts from the ISFRI 2021 presenters indicated that further professional development for Forensic Radiographer is necessary (Table 3). In relation to this, it appears that further role expansion of technical tasks performed by a forensic radiographer on a deceased person is desired. This includes cannulation for the acquisition of PMCTA, the insertion of ventilation tubes for vPMCT or PMCT-guided biopsies. Other areas of interest were further involvement in research and development relating to imaging techniques such as 3D Surface Scanning, photogrammetry, PMMRI or fused PMCT. Suggestions also included sharing of knowledge and experience with other institutes or hospitals when establishing a forensic radiology service or supervising undergraduate students completing an internship in forensic imaging.

As shown in Table 3 the most popular area for further development is the reporting of forensic imaging; some Advanced Practitioner Radiographers are already providing some level of structured reporting in conjunction with, or the under supervision of, a radiologist. It would be beneficial if the IAFR could provide more direction in relation to this by publishing guidelines with responsibilities and tasks clearly defined. These ambitious opportunities relating to the imaging of a medical

Table 3
Opportunities for the forensic radiographer.

	Opportunities
Australia	<ul style="list-style-type: none"> Extend role of Forensic Radiographer outside NSW to include Image Interpretation Radiographer Image Interpretation could be performed centrally Research opportunities for Radiographer Image Interpretation Role extension to include IV contrast administration in regard to best use of radiographer time, cost and expertise.
Denmark	<p>As radiographers have a professional insight to the imaging equipment, they can make best use of:</p> <ul style="list-style-type: none"> radiation protection techniques expansion of external research collaborations positioning and parameter settings for more specialized procedures when e.g. examining different and rare specimens evaluating CT scans and performing advanced 3D visualization and segmentation.
Finland	Dedicated forensic radiographers to support the imaging performed in the forensic institutes.
Japan	<ul style="list-style-type: none"> JART also conducts a licensing test of “Board-Certified Radiological Technologist in Autopsy imaging” for radiographers wishing to expand their knowledge and technique for PMI. Institutional collaboration and the nationwide sharing of PMI information as they seek to standardise and improve scan techniques to help establish Cause of Death. Research -ring artefacts, “fused PMCT” and body temperature when performing PMMRI scans
UK	<ul style="list-style-type: none"> Advanced Practice opportunities for radiographers Unique role but diverse Extend role to include cannulation for PMCTA & ET tube insertion for VPMCT Other jurisdictions and hospitals are trying to develop their own services, creating more opportunities and role development for radiographers in the future.
Switzerland	<ul style="list-style-type: none"> Part-time forensic radiographers, as it allows the radiographer to keep an eye on the fast evolution in the field of radiology, to help transfer practice and to obtain a professional well-being, thanks to various complementary activities. Extend role to include cannulation for PMCTA Participate in research Involvement in PMMRI research Involvement in 3S SS & photogrammetry Supervise undergraduate students completing an internship in forensic imaging

forensic investigation must be approached in a structured way with a formal training pathway resulting in certification of a more advanced level Forensic Radiographer.

Challenges for the forensic radiographer

Each presenter was requested to reflect upon the challenges faced by Forensic Radiographers in their country (Table 4). Due to the different contexts in which each presenter works, this provided a range of considerations from a lack of experience because forensic imaging is often undertaken on an ad-hoc basis (UK), to a lack of national guidelines in Finland and a reluctance for forensic radiographers to develop their role to include image interpretation (Australia). A common theme related to a lack of postgraduate education and training in forensic radiography including post-mortem anatomy and pathology (Australia and Finland). Limitations relating to the provision of the PMCT service were highlighted by Denmark when imaging is provided by Mortuary Technicians, particularly in relation to image quality and artefacts.

This overview provides an opportunity for the IAFR to fill these gaps by providing online education which can be undertaken internationally and to collaborate with professional bodies to adapt the IAFR best practice guidelines to their country.

Discussion

Reviewing the abstracts from the ISFRI 2021 congress (which provide a limited overview from each country) and the additional information provided in the survey completed by the presenters, trends relating to how the forensic world is organised, how imaging is utilised and what the role of the Forensic Radiographer involves have been identified which could be further explored in the future. Some of the common themes are discussed below and these could be used by the IAFR to help define and develop the role of the Forensic Radiographer.

Forensic vs postmortem imaging

The first point that requires clarification in relation to the definitions used was identified from the comparison of abstracts and refers to the

Table 4
Challenges for the forensic radiographer.

	Challenges
Australia	<p>In relation to radiographer image interpretation:</p> <ul style="list-style-type: none"> No legal standing Services that do not have radiographers cannot adopt this strategy Radiographers may be more expensive than mortuary technicians to employ and are limited to imaging only Possibility Forensic Pathologists could become reliant on the impression and not review themselves Many radiographers do not want the “stress” of being required to provide this service Education is required for radiographers on both the anatomy and pathology in deceased persons
Denmark	<p>As PMCT imaging is performed by forensic technicians:</p> <ul style="list-style-type: none"> They do not have the same background education as a radiographer So the CT scan protocols are very standardized and kept very simple Accurate positioning Affects image quality, including artefacts
Finland	<ul style="list-style-type: none"> Lack of national guidelines, especially for post-mortem imaging and DVI Lack of post-graduate education and training in forensic radiography
Japan	<ul style="list-style-type: none"> Unification of examination technology Unification of examination fees Have at least one Board-Certified radiological technologist at each major facility
UK	The majority of radiographers undertaking forensic work in the UK do so at an ad-hoc level, undertaking cases infrequently.
Switzerland	?

terminology of ‘forensic’ and ‘post-mortem’ radiology or imaging. These terms are often used interchangeably which can be confusing for the reader.

Forensic radiology encompasses the acquisition, interpretation, and reporting of radiologic images for the purpose of medicolegal investigations. The subject may be alive or deceased.

Postmortem radiology encompasses the acquisition, interpretation, and reporting of radiologic images of the deceased.

Number of active forensic radiographers

Now considering the definition of “forensic radiographer”, with the exception of Finland, one or more forensic radiographers perform the imaging within the forensic institutes or hospitals in each of the other countries represented. In some countries, the imaging is performed by Mortuary Technicians under the supervision of a Forensic Radiographer.

Future studies should further explore the advantages and/or disadvantages of employing specialised Forensic Radiographers and the wide variety of services and value previously demonstrated that they bring to the role. An example of this is in relation to the safe operation of the X-ray tube to increase the lifetime of the CT scanner. Whilst radiation dose may not be a consideration in PMCT, technical knowledge is required to optimise the scan parameters to avoid damaging the X-ray tube by overloading it. This is a minimum professional capability of all Radiographers who are the experts in this area.

Education/training forensic radiographers

Currently there are no requirements for any training or postgraduate education with the exception of the UK. All presenters in the IAFR session at ISFRI 2021 stated that the national rules for the employment of clinical radiographers are applied. If radiographers undertake additional training in forensics, this is usually organised within the local forensic institute or hospital. From a forensic point of view, it is important to educate radiographers so they understand the background of the forensic investigation. Therefore, they can contribute their radiographic knowledge to the imaging process to ensure the best image quality and advise in relation to additional imaging that may be helpful to the investigation. For more advanced imaging techniques, the expertise of appropriately trained radiographers is required to undertake research, e.g. to adapt or modify PMMRI sequences.

This survey of six presenters offers an opportunity for the IAFR to liaise with the International Society of Radiographers and Radiological Technologists (ISRT) to provide introductory education modules for undergraduate radiography programmes and to collaborate in the provision of continuing professional development (CPD) opportunities for radiographers.

Location of the forensic imaging

The results of this limited survey confirmed that forensic imaging is undertaken within a forensic institute or in a local hospital within these six countries. It is acknowledged that in some countries, the choice is based on whether the subject is alive or deceased. All living victims with the following indications are usually imaged within a clinical setting: attempted strangulation, suspected physical abuse/non-accidental injury (NAI) or drug trafficking.

Imaging modalities

The primary modalities used are conventional X-ray and PMCT. In some countries, PMMRI is used on a small scale which is directly related to the availability of MRI scanners and the associated costs. For the most part, the existing forensic institutes have CT scanners but cannot afford an MRI scanner given the numbers of deceased for whom PMMRI would be beneficial. The balance between accessibility and cost is the most

likely reason why some countries choose to have the imaging performed in local hospitals. Hospitals often have more than one CT or MRI scanner which are usually more accessible out-of-hours.

Additional techniques

The number of forensic institutes performing PMCTA in addition to a native PMCT in order to provide improved visualisation of the vascular system in cases of stabbing, aortic ruptures or aneurysms or medical misadventure are increasing. This is the result of The Virtopsy® Project [4] and the Virtangio® technique [3] developed by Swiss teams. The increased use of this imaging technique is supported by attending a specially developed Virtangio® course in Lausanne.

In this limited survey, only 1 or 2 institutes perform vPMCT which provides better evaluation of the lungs and the associated postmortem changes. It is acknowledged that the use of this technique was suspended during the COVID-19 pandemic for occupation health and safety reasons to protect the forensic staff.

Position of forensic radiology within a forensic investigation

All six presenters confirmed that forensic imaging is used to triage cases, as well as to supplement the autopsy. This is dependent on how the use of radiology is considered. If it is only deemed to be a medical tool, then it can be defined as post-mortem imaging. If the added value is considered from a technical point of view within the forensic investigation, then imaging can also be used for traces, reconstructions, testing of testimony, etc. This provides added value for forensic professionals other than medical forensic investigators such as the pathologist. Other professional groups that may benefit from the provision of forensic imaging include forensic detectives (e.g. traces of gunshot residue), forensic odontologists (e.g. dental reconstructions), anthropologists, all with their own fields of expertise.

Conclusion

This limited narrative review has summarised some commonalities and highlighted some differences in the role of the Forensic Radiographer in six different countries, as presented at the ISFRI 2021 congress. Very few forensic countries perform PMMRI, PMCTA, vPMCT or CT-guided biopsies. In general, PMCT is acquired for a wide range of indications, including both natural and unnatural deaths.

It is recommended that a survey of forensic institutes and forensic radiographers should be conducted more widely to obtain a representative view of the role of the Forensic Radiographer internationally. It has also suggested that there is an opportunity for the IAFR to provide online education to meet the postgraduate education and training needs of radiographers internationally.

Declaration of Competing Interest

None of the authors have any conflicts of interest to declare. Some are volunteer members or committee members of IAFR.

Supplementary materials

Supplementary data associated with this article can be found, in the online version, at [10.1016/j.fri.2023.200540](https://doi.org/10.1016/j.fri.2023.200540).

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