Positional Statement

Use of Radiography & Fluoroscopy in Disaster Victim Identification

Positional statement of the members of the Disaster Victim Identification working group of the *International Society of Forensic Radiology and Imaging*;

Mark D Viner*[1], Abdullah Alminyah[2], Mario Apostol[2], Alison Brough[2], Wim Develter[2], Chris O'Donnell[2], Denise Elliott[2], Sarah Heinze[2], Paul Hofman[2], Guillaume Gorincour[2], Mansharan Kaur Chainchel Singh[2], Morio Iino[2], Yohsuke Makino[2], Artur Moskała[2], Bruno Morgan[2], Guy N. Rutty*[3], Jacquie Vallis[2], Chiara Villa[2] , Krzysztof Woźniak[2]

1. Principle author
2. Members of the working group at time of production of this statement. All contributed equally to the agreement of this statement.
3. Group moderator and Chair International Society of Forensic Radiology and Imaging.

Corresponding author. Tel: +44 7956 340325; *E-mail address*: m.viner@cranfield.ac.uk (M.D.Viner)

Keywords: forensic, radiography, fluoroscopy, disaster victim identification, cause of death

Medical Imaging has an established role in the forensic investigation of death and has been used extensively in the investigation of mass fatalities. Imaging is applicable to human, animal and environmental material. [1-8]

The exact requirements for medical imaging in a mass fatality incident will depend on the nature of the incident. However, experience from previous large-scale incidents involving aircraft, terrorist attacks and acts of genocide has emphasised the need for imaging facilities to be available on-site in the Major Incident Mortuary. [9-12]

In such incidents we recommend that the main purpose for imaging will be:

1. Disaster Victim Identification (DVI)
2. Identifying the cause of, and contributory factors to death
3. Identifying potential hazardous materials within the body
4. Gathering evidence for criminal justice procedures

We propose the following processes and workflow in order to achieve integration with the DVI mortuary processes.

In providing these recommendations the authors recognise that the "professional titles" of staff involved in a DVI process may differ, depending on the country where the investigation occurs. Therefore, where a particular "professional title" is used in this document it does not preclude another member of staff performing this task, as long as they are trained or supervised to the standard expected of the staff grade stated for the specific task discussed.

Body Handling:

The safe handling of bodies or other material is beyond the scope of this document. However the imaging equipment and staff must work within the appropriate body handling protocols for a

particular event. When the body is delivered to the imaging area it must be placed on the radiography / scan table, ideally in an anatomic supine 'head-up' position.

Radiography

It is recommended that forensically-trained radiographers or appropriately trained cadaver imaging technicians undertake the radiography examinations required for DVI purposes. In jurisdictions where this is not currently possible, it is recommended that examinations take place under the supervision of the forensic pathologist. For brevity, the rest of this positional paper will refer to the forensically trained staff performing imaging as "radiographers".

Workflow

We propose that a workflow based on the principal of primary, secondary and tertiary survey should be undertaken as outlined below. A primary survey should be undertaken in all cases. Whether there is a requirement to undertake a secondary or tertiary survey will be dependent upon the incident, DVI question to be addressed and radiological methods employed.

The Primary Survey:

It is advised that this should be undertaken in all cases for the initial examination of all bodies and body parts at the mortuary. It should occur prior to examination by any other member of the DVI team, with the exception of the Hazardous Materials Identification Team in a Chemical, Biological, Radiological or Nuclear (CBRN) incident.

Bodies are taken directly from the body store to the primary survey area. Imaging for the primary survey should be performed without breaking the seal of the body bag. The entire body bag should be scanned in every case, as evidence may have become detached from the palpable body or body parts. A primary survey may be undertaken using Fluoroscopy, Digital X-Ray or multi-detector computed tomography (MDCT) scanning.

The primary examination will yield some or all of the following information about the contents of the body bag:

- Whole cadaver or Body Part, with description of anatomical parts seen.
- Indication as to whether body parts of more than one individual are present (if possible)
- Indication of whether any non-human body parts are present
- Location and nature (if possible) of any hazardous material, e.g. unexploded ordnance, metallic sharps, glass etc.
- Location of any projectile fragments with possible associated bony injury
- Location of personal effects (particularly useful in cases of cremated bodies, where these artefacts mat be difficult to locate visually)
- Presence of any unique identifying features that may require further radiographic investigation following autopsy and/or odontology

MDCT

The use of MDCT imaging is covered by a separate positional statement (8). It should be noted that in certain circumstances computed tomography scanning has significant advantages. In such cases, the use of MDCT for the primary survey may negate further imaging (including radiography for identification and dental imaging (the later as determined by the forensic odontologist)).

Fluoroscopy

Ideally, the examination should be undertaken by two radiographers together with the forensic pathologist recording the information. Alternatively two radiographers may undertake the examination, making a written record of the appearances for the forensic pathologist to refer to when undertaking the “strip & search” and external examination of the body.

The examination should be conducted without breaking the seal of the body bag. The bag should be placed on the fluoroscopy couch in the supine position if possible. A large field-of-view C-Arm fluoroscopy unit is preferred. The entire body bag should be screened from one end to the other, making several sweeps and adjusting the position of the cross arm to ensure that all areas are covered.

A written record of appearances should be made and the position of specific items noted diagrammatically as detailed below. Digital “spot” images should be made of specific artefacts and anatomical features as required. Images must be correctly recorded with the case number, date, time and radiographers’ initials.

The written record, together with any images produced should be handed over to the appropriate DVI officer, and a written record of this transfer should be made.

Radiography (Direct Digital X-Ray (DR), Indirect Digital X-Ray (CR) or film)

Two radiographers should undertake the examination. DR is the method of choice and in all cases, a radiography table with a film or “Bucky” tray should ideally be used. The examination should be conducted without breaking the seal of the body bag. The bag should be placed on the radiography table in the supine position if possible.

Large size (35cm x 43cm) DR sensors, CR plates or film cassettes should be used and placed cross-wise in the film tray. Radiographs of the entire body bag from one end to the other should be made ensuring that all areas are covered. The left and right sides of the bag must be indicated on the images unless the position of the body in the bag is known with certainty; in such a case the correct anatomical markers should be used.

A written record of the images, together with all images produced should be handed over to an appropriate DVI officer and a written record of this transfer should be made.

Following primary survey; the body bag will be transferred either back to a secure storage area or directly to the DVI area for examination. It should be noted that in some cases it will be necessary to return the cadaver or clothing/effects to the primary survey team if artefacts identified at the primary survey cannot be found

The Secondary Survey:

Direct digital radiographic examination may prove useful for identification by demonstrating the presence of unique dental and skeletal features, which have been previously documented in ante - mortem records. Standard practice in many previous mass fatality incidents has been for complete skeletal survey (antero-posterior (AP) and Lateral radiography) of all bodies and body parts. However, the use of MDCT, high definition digital fluoroscopy or radiography for the primary survey should provide sufficient information in the majority of cases and the additional time taken for a full AP and Lateral radiography secondary survey does not justify its application as a routine.

A full dental radiography survey is however recommended in all cases.

Skeletal Radiography
Where a routine secondary survey is indicated, the body should be returned to radiography following a "strip and search" and placed upon the table in the supine position. Two radiographers should perform the required examinations. DR, CR or film cassettes of appropriate sizes should be used in order to obtain standard views of the required areas in both the AP and lateral projections. It will be necessary to adapt standard radiographic technique and utilise a variety of positioning aids to achieve the correct views. Anatomical side markers should appear in the primary beam, and images should be correctly recorded with the case number, date, time and radiographers' initials.

Dental Radiography
The precise requirements for dental radiography will be determined by the working practices of the forensic odontologists. It is recommended that for the purposes of planning, that a full dental radiography survey should be undertaken by radiographers, forensic odontologists or appropriately trained dental nurses as part of the procedure.

A full dental survey will consist of a full mouth intra-oral (peri-apical) film series (14 films) and bitewing radiographs. Direct Digital (CCD), Indirect Digital (Phosphor plate) or film may be used. Paralleling technique should be used where possible.

A modified survey may consist simply of oblique lateral mandible views and bitewing radiographs. Further periapical radiographs can then be undertaken as required by the forensic odontologist.

The body should be placed on a suitable trolley and radiographs undertaken in a separate designated odontology area.

Images should be correctly recorded with the case number, date, time and radiographers' initials. If films are used they should be mounted in film mounts or laminated in the correct orientation.

Tertiary Examinations:
It is suggested that direct digital skeletal radiographs should be performed as a tertiary examination, and be reserved for:

- Any unique skeletal features seen on fluoroscopy or identified at autopsy by the forensic pathologist, anthropologist or odontologist

- For those cases which are proving difficult to identify via other means, and for which is considered that radiography may be useful

Two radiographers should perform the required examinations. DR, CR or film cassettes of appropriate sizes should be used in order to obtain standard views of the required areas in both the AP and lateral projections. It will be necessary to adapt standard radiographic technique and utilise a variety of positioning aids to achieve the correct views. Anatomical side markers should appear in the primary beam, and images should be correctly recorded with the case number, date, time and radiographers' initials.

Radiography Area
Space Requirements
At any incident, sufficient space is required for the equipment used for the primary survey examination (either MDCT, fluoroscopy or digital x-ray), and possibly for dental x-ray examinations and in some circumstances digital x-ray facilities.

The number of radiography stations will depend upon the numbers of DVI tables in use. However, assuming that experienced radiographers are used, the fluoroscopic survey on each body should take about 5-10 minutes, and therefore 1 fluoroscopy unit will be sufficient for the majority of incidents.

Dental surveys will probably take between 30 minutes to an hour when using film, depending upon the number of radiographs required. This period could be considerably shortened using digital equipment.

The requirement for skeletal radiographs will be highly dependent upon the nature of the incident, the degree of damage to soft tissues/cremation, degree of fragmentation etc. A full skeletal survey could take up to 1-2 hours when using film, and again, this period could be considerably shortened using digital equipment.

Workflow & Location

It is recommended that:

i. Fluoroscopy & Plain/Dental film x-ray areas are separated.

ii. Fluoroscopy area is located close to the body store as the first stage of the process. Note that bodies may need to be returned to fluoroscopy from DVI if artefacts/projectiles cannot be found

iii. Plain/Dental x-ray areas are located close to Odontology/Anthropology/Pathology & co-located with darkroom facilities if required. Note: Darkroom access is NOT required for fluoroscopy

A schematic workflow is shown in figure 1.

Health and Safety

Protection of staff working in areas where radiation exposure is possible is a mandatory legal requirement in most countries. Radiological protection rules are complex, and are dependent upon a number of factors, including the energy and intensity of radiation, distance from the source, nature of any protective barriers, the occupancy of adjacent spaces, frequency of use etc.

Irrespective of the imaging modalities to be employed, it is strongly recommended that the advice of a qualified radiation physicist is sought in relation to the final layout. In Europe they should be appointed as the “Radiation Protection Advisor” and a set of “Radiation Protection Local Rules” are required, based upon a risk assessment of the area. These will need to be read and signed by ***all*** staff working in the mortuary. Upon deployment, a radiation supervisor (usually a senior radiographer) will undertake a radiation risk assessment. This is then signed off by the Radiation Protection Advisor.

In most circumstances where radiography is employed in a non-permanent situation, (e.g. hospital wards, operating theatres, hospital mortuaries) lead protective barriers are not employed, but radiation protection measures are used, such as establishing a “controlled area” around the unit, restricting access to “essential staff” only, and the deployment of lead rubber aprons for personnel.

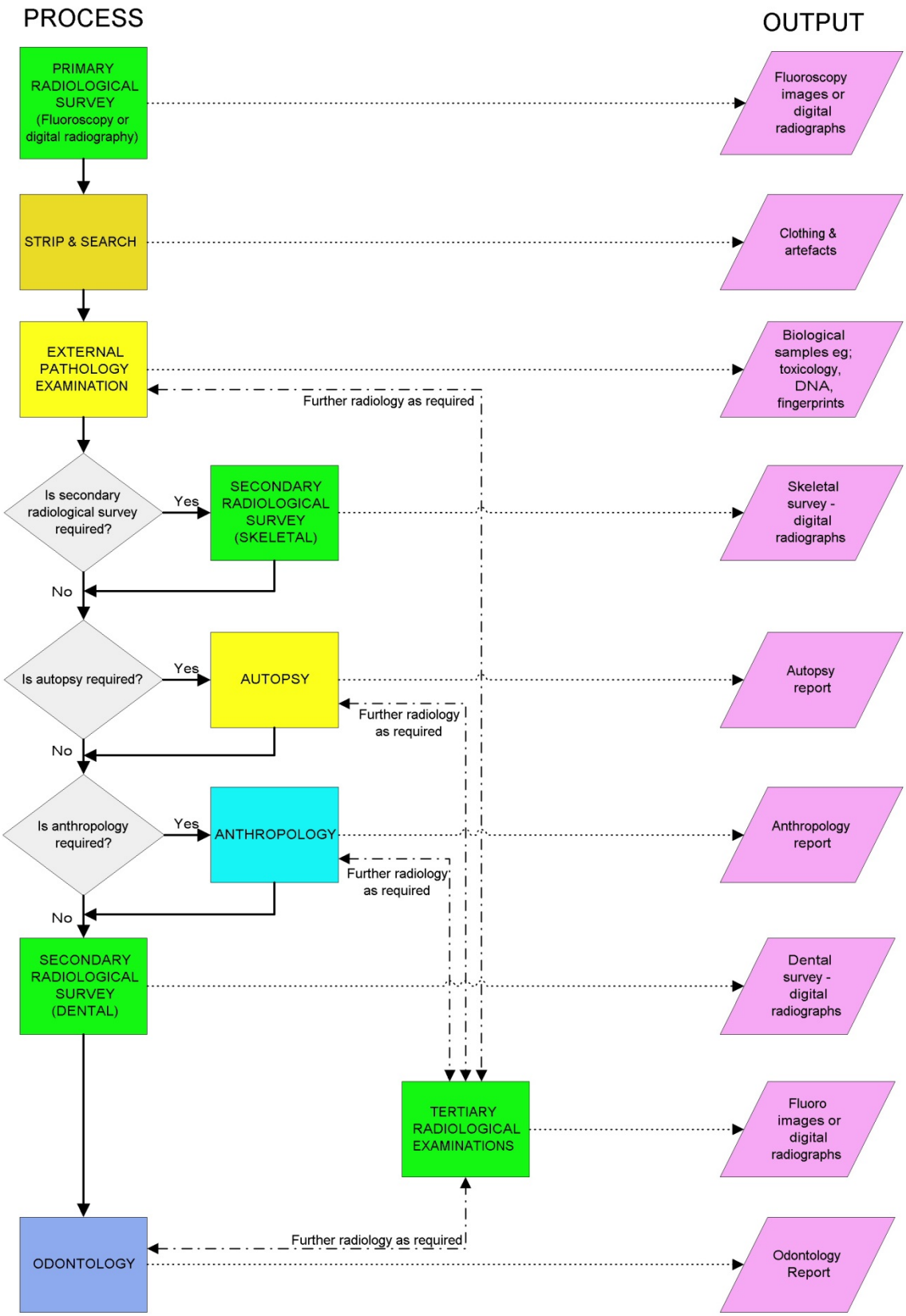

Fig 1 Schematic drawing showing how radiology should be integrated with the workflow of the DVI process in the emergency mortuary. From Viner M.D., "The Use of Radiology in Mass Fatality Events" in *Commingled Human Remains; Methods in Recovery, Analysis, and Identification.* 2014, Adams B.J., Byrd J, Academic Press, Oxford

A fluoroscopy area in particular is likely to be in the centre of the operational area, which may make it difficult to establish an exclusion zone around the controlled area. The use of lead screens for this area in particular may therefore be advisable.

With reference to the Plain/Film and Odontology radiography areas, if they are located in a position away from the main activity, it may be possible to make use of "distance from adjacent work areas" as an adequate radiation protection measure.

If processing chemistry is used on-site, this will need to be covered under appropriate risk assessments and appropriate safety equipment provided. Arrangements will need to be made for the safe disposal of waste chemical products in order to comply with Environmental Protection Legislation.

Image Data Handling:

Images can be produced in digital and/or film format. Hard copy prints of selected images showing specific points (after image analysis) may be useful.

Provision must be made for the secure storage of images which complies with the incident criminal justice standard. This may require an "authenticated" master copy being produced and handed to the authorities at the time of imaging.

Data transfer can be made to anywhere in the world for image analysis. Depending on image data size and internet bandwidth this may take a varying amount of time. Consideration must also be given as to how these images will be made accessible for viewing by pathologist, odontologist, radiologists etc. throughout the DVI process.

Image Interpretation:

All imaging undertaken should be reported. This can be done either locally or remotely and should be undertaken by an appropriately trained professional. In some cases this may involve images being sent to different specialists including forensic pathologists, radiologists, odontologists and anthropologists although the option to use an on-site radiologist DVI reporting team should be considered.

Ante-mortem radiological images (for example but not limited to radiographs, fluoroscopy, computed tomography or dental radiology) should be sought as part of the medical ante-mortem data gathering process as they can be used as a part of the comparative, identification process.

Acknowledgments

The principles of this positional statement are supported by the International Association of Forensic Radiographers (IAFR).

References

1. Singleton, A. C., The roentgenological identification of victims of the "Noronic" disaster*, Am. J. Roentgenol*., 66, 375, 1951
2. Lichtenstein, J. E., Madewell, J. E., McMeekin, R. R., Feigin, D. S., and Wolcott, J. H., The role of radiology in aviation accident investigation, *Aviat. Space Environ. Med*., 51, 1004, 1980.
3. Lichtenstein J. E., Fitzpatrick, J. J., and Madewell, J. E., Role of Radiology in fatality investigations, *Am. J. Roentgenol*., 150, 751, 1988.
4. Rutty, G.N., Robinson, C., Jeffrey, A. Morgan, B. Mobile computed tomography for mass fatality investigations*, Forensic Science, Medicine, and Pathology* 3 (2), pp. 138-145, 2007
5. O'Donnell, C., Iino M., Mansharan, K., Leditscke, J., and Woodford, N. (2011). Contribution of

postmortem multidetector CT scanning for identification of the deceased in a mass disaster: experience gained from the 2009 Victorian Bushfires. *Forensic Sci Int* **205**(1-3): 15-28.

6. Viner M.D, Lichtenstein J.E., Radiology in Mass Casualty Situations *in Brogdon's Forensic Radiology*, 2nd Edition, Chapter 13 p177-198, CRC Press, Boca Raton, 2011
7. Viner, M.D., The Use of Radiology in Mass Fatality Events, *in* Adams, B.J., Byrd, J.E, *Commingled Human Remains; Methods in Recovery, Analysis and Identification* Academic Press, Oxford, p 87-122, 2014
8. Morgan, B., Alminyah, A., Cala, A., O'Donnell, C., Elliott, D., Gorincour, G., et al. (2014). Use of post-mortem computed tomography in Disaster Victim Identification. Positional statement of the members of the Disaster Victim Identification working group of the International Society of Forensic Radiology and Imaging; May 2014. Journal of forensic Radiology and Imaging 2(3): 114-6.
9. Nye, P. J., Tytle, T. L., Jarman, R. N., and Eaton, B. G., The role of radiology in the Oklahoma City bombing, *Radiology*, 200, 541, 1996.
10. Harcke, H.T., Bifano, J. A., Koeller, K.K., Forensic Radiology, Response to the Pentagon Attack on September 11 2001. *Radiology* 223(1): 7-8., 2002
11. Viner, M.D., Rock, C., Hunt, N., Martin, A.W., MacKinnon, G, Forensic Radiography, Response to the London Suicide Bombings on 7th July 2005, *Proceedings of The American Academy of Forensic Sciences 58th Scientific Meeting*, Seattle WA, , p176 (2006)
12. Anderson A., Cox., M., Flavel A., Hanson, I., Hedley, M., Laver, J., Perman, P., Viner, M, Wright, R., "Protocols for the Investigation of Mass Graves" *in The Scientific Investigation of Mass Graves: Towards Protocols and Standard Operating Procedures*, Cambridge University Press, New York, NY, 2008