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Uncovering the causes of unnecessary repeated medical imaging examinations, or part of, in two hospital departments

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Abstract A study was undertaken to identify the causes of unnecessary repeated medical imaging examinations. The repeat analysis study investigated repeated medical imaging examinations at two medium sized hospitals in Sydney, Australia. The analytical part of the study was conducted jointly by a radiologist and a radiographer.
Overall there were 9.3% and 7.2% of total films repeated respectively at the two hospital sites. Unnecessary repeats were found to have been caused by numerous factors including: poor technical judgement, the adoption of unconventional techniques, non availability of radiologist for advice, patient movement or motion, equipment mishandling, disorganised practice and poor supervision of students. At both of the sites, senior radiographers were associated with 70.2% and 84.5% respectively of dark and light film errors, and 59.7% and 85.5% respectively of the repeated cases had students' involvement. On the other hand, junior radiographers were involved with 70.3% and 86.1 % respectively of positioning errors.
It was recommended that major changes be introduced to radiographer practice including, quality control, radiological techniques, training, supervision and continuing professional development. It was also recommended that the radiologist takes a more active role in future guidance and training of radiographers.

Key words: image analysis, equipment use, education, repeat analysis, exposure selection, positioning and techniques

Introduction

Repeating imaging examinations impacts significantly on imaging services by adding additional cost due to wastage of resources and reduced radiographer time.[1,2] Repeating examinations also affect patients by exposing them to additional radiation and causing them discomfort.

Evaluation through periodic repeat analysis studies has been an essential component of quality assessment in the provision of radiology services to control and minimise repeated examinations from more than four decades.[3] The tool has been used to identify the cause of errors in medical imaging examinations and assist in identifying areas of improvement in the continuing development and practice of the radiographer.[4] The analytical study is also a valuable tool for health services as a quality indicator, and a tool to monitor and measure efficiency.

An appropriate quality assurance program will assist the development and maintenance of an efficient radiology service. Several factors may contribute to errors resulting in repeat medical imaging examinations being taken. These factors include the knowledge and training of the radiographer (such as positioning errors, and dark and light films), the patient (preparation and motion), the organisation of the practice, and equipment failure.[5]

The role, knowledge and ongoing performance of the radiographer is critical to ensuring that all procedures are undertaken within the quality criteria and standards required.[6] With the introduction and application of clinical governance to all clinical areas, the onus is now on healthcare professionals including radiographers to evaluate performance, develop departmental audits and ensure effective and safe practice while minimising the associated risk. In addition, the recent move for future role expansion of radiographers in radiographic image interpretation, the administration of intravenous injections[7] and in nuclear medicine[8] therefore demands that radiographers need to ensure that their professional and legal obligations are met in daily quality assurance activities and clinical practice.

Patients having medical imaging examinations are exposed to harmful radiation that has detrimental biological effects[9]. Non-stochastic effects are also a concern, and according to Singh *et al*.[10] cancer could be triggered at a very low radiation dose. It is the responsibility of the radiographers who are using radiation for medical purposes to ensure that their patients are not receiving any unnecessary doses of radiation and that the benefits of the repeated examinations outweigh the harmful effects.

The aim of this study was to identify any common factors across imaging departments that contributed to repeating examinations, to determine the likely causes of repeated examinations, and to make recommendations for improvement. The study used the reject analysis study protocol as described by Gray *et al.,*[11] focusing on repeated films at two hospital medical imaging departments.

Methods and patients

Setting and patient groups

A repeat analysis study was conducted at two medium size hospitals, each approximately 200-beds and located in two

Table 1 Number of repeat and accepted films

Hospital	No. reject films	No. repeat films	% repeat	No. examinations	No. accepted films	Total films
Site 1	327	256	9.3	1503	2762	3089
Site 2	361	233	7.2	1535	3249	3610

different area health services within the Sydney metropolitan area in Australia. The first hospital, designated Site 1 in the study, is located in the south western region of Sydney. The second hospital, designated Site 2, is located in the western region of Sydney. The study included all inpatients and outpatients referred to each hospital over a four-week period for general radiological examination using a conventional film system.

Ultrasound examinations and all films taken by radiologists during special procedures such as barium studies and venograms were excluded from the study.

Repeat analysis method

In accordance with the method of Gray *et al.*,[12] reject films in the present study were defined as all scrap films including green films, black films, clean-up films, and patient films. Repeat films were limited to those radiographs that were not accepted and required an additional exposure to the patient.

All reject films were, in the first instance, collected in a box dedicated to reject films. Two independent senior radiographers monitored reject film collection at each hospital as part of the regular reject analysis study.

At the end of the collection period, all request forms for that month were forwarded to the chief radiographer's office. A copy of the electronic statistical data was also produced. Special electronic templates were produced to identify the examinations and the radiographer performing the examination. The chief radiographer took responsibility for the gathering of the data, sorting films and preliminary film analysis. A second and final round of film analysis was then performed conjointly with the reporting radiologist and the chief radiographer.

At first instance, films were sorted into four categories: Dark, Light, Positioning Error, and Miscellaneous. On completion of the reject film collection, the radiologist and the chief radiographer analysed the films and the results were tabulated on a worksheet. Structured face-to-face interviews were then held with each of the radiographers to establish the causes of the repeat films. Radiographers were specifically asked to comment on their films and identify the reason behind the error.

Identification of radiographers

Each radiographer involved in the study used markers bearing their initials on the film which identified the radiographer who had performed the examination and repeated the view. The identification of the radiographer was then confirmed using further information obtained from the radiographer's initials on the request form, the electronic data record and from the staff roster. Radiographers were classified in the study as 'senior' or 'junior', depending on their employment classification.

The senior radiographer category included the chief radiographer and level 3 medical radiation scientists. Junior radiographers included level 1 and level 2 medical radiation scientists.

At the end of data compilation, radiographers were interviewed to discuss their cases and to understand the reason behind the repetition of some examinations. In order to determine the causes of repeated examinations, investigators spent time observing radiographers performing the examination and discussed the technique with staff at clinical meetings. Observations, justifications and causes of such repeats were analysed and are listed in Table 9.

Error classification

This category is to sort films according to the error; e.g. dark, light, positioning, good film, motion error, equipment mishandling, clear and black films.

- Dark and light films were sorted into three different levels according to the severity of the error as follows:

  L1 slightly light D1 slightly dark
  L2 light D2 dark
  L3 too light D3 too dark

  Level 1 were cases that were slightly light or dark. Errors at this level might be cases where the patient was properly measured and an exposure chart consulted, but the image was too light or dark either due to pathology or patient structure. Level 2 cases were cases when the wrong measurement or poor judgement of the patient size had been applied. Level 3 cases were those where-where exposure selection had been inappropriate; as an example, selecting .2 instead of .02. All three level errors might also have had different causes than the examples given above.
- Positioning errors were classified as P1, P2 and P3 according to the level of adjustment required in positioning. For example P3 is the level where the positioning is severely rotated or off centre. Positioning errors includes:
  (1) wrong positioning;
  (2) cut-off or over-coned;
  (3) off centre;
  (4) marker obstructing site in question and;
  (5) anatomy in question not shown.
- Good films are images that would have been accepted by radiologists and should have not been rejected.
- Other errors have been classified as M for miscellaneous. This category includes:
  (1) patient preparation (jewellery or other metallic substances not removed)
  (2) double exposed
  (3) patient motion
  (4) equipment fault (processor)

Results

Films and examinations

As shown in Table 1, over 1500 examinations were undertaken at each site, with 3089 films used at Site 1 and 3610 films used at Site 2. At Site 1 there were 327 rejected films, of which 256 of were repeats. At Site 2 there were 361 rejected films, of which 233 of were repeats. Overall this resulted in a repeat rate of 9.3% at Site 1 and 7.2% at Site 2.

Table 2 lists the various examinations at each site. Table 3 lists details of the rejected films at each site.

Exposure error dark and light films

As shown in Table 4, approximately 47% of the repeated films at both sites were dark and light films. The alarming result was that senior radiographers were responsible for more than 70% of the repeats in this category at each of the sites (Table 5). The majority of dark and light repeats were of level 2 and level 3 error types, which needed more than a minor adjustment in exposure setting (Table 4).

Table 2 Examinations undertaken with the repeated films

Examination	Site 1	Site 2
Chest	81	85
Extremities	47	46
Abdomen	24	17
Head	29	24
Pelvic girdle	18	11
Shoulder girdle	11	16
Spine	27	23
Odontoid	13	6
Thorax	6	5
Total	256	233

Table 3 The rejected films

Hospital	No. green films	No. black films	No. blank clear films
Site 1	6	23	42
Site 2	38	26	64

Table 4 Types and degree of errors in films

Error Site 1	Level 1	Level 2	Level 3	Total
Dark	16	32	16	64
Light	21	23	13	57
Positioning	20	36	52	108
Good	16	0	0	16
Miscellaneous	11	0	0	11
Error site 2	**level 1**	**level 2**	**level 3**	**total**
Dark	16	28	27	71
Light	13	12	14	39
Positioning	14	28	22	64
Good	22	21	10	53
Miscellaneous	6	0	0	6

Good films

As shown in Table 5, the reject rate of good films at Site 1 was less than 7%, with the majority of those related to junior radiographers. However at Site 2 the reject rate was over 22% of the total repeats, with senior radiographers being involved in more than 62% of those cases.

Positioning

As shown in Table 4, positioning errors constituted a large proportion of the total errors in the study. Site 1 had 42% of the total repeats and Site 2 had less than 28%. Table 7 lists the various positioning errors through spinal examination. The junior radiographers contributed to the largest proportion of positioning errors with 86% and 70% of errors at Sites 1 and 2 respectively.

Miscellaneous errors.

As shown in Table 5 the percentage of error in this category was 4.3% at Site 1 and 2.6% at Site 2, of the total repeat rate.

Students

As shown in Table 8, student supervision still resulted in a large proportion of repeated films carrying students' markers. The majority of repeated films were attributed to supervision provided by senior radiographers, with 59.7% and 85.5% of films repeated by students being attributed to senior supervision at Sites 1 and 2 respectively.

Green, black and clear films

As per Gray *et al.* 13 green, black and clear films were considered as rejects and not as repeats.

Green films were fresh films disposed for recycling without going through the processor. Black films were usually films exposed to light. Clear films were films usually used as a cleaner for the processor. They were placed in the processor without exposure to light.

As shown in Table1, this group constituted 21.7% of the total reject films at Site1 and 35.4% at Site 2.

Table 5 Radiographer involvement in repeated films

Radiographer	Exam	Reported films	Repeats	Positioning	Dark and light	Good	Misc	Repeats assisted by student	% repeats
Total SR1	771	1404	108	15	85	3	5	43	
Total JR1	732	1358	48	93	36	13	6	29	
Total site 1	1503	2762	256	108	121	16	11	72	9.3
% SR1	51.3	50.8	42.2	13.9	70.2	18.8		59.7	
% JR1	48.7	49.2	57.8	86.1	29.8	81.3		40.3	
Total SR2	997	2093	150	19	93	33	5	47	
Total JR2	538	1156	83	45	17	20	1	8	
Total site 2	1535	3249	233	64	110	53	6	55	7.2
% SR2	65.0	64.4	64.7	31.8	84.5	62.3		85.5	
% JR2	35.0	35.6	35.3	68.2	15.5	37.7		14.5	

Exam, examinations; SR1, senior radiographers at Site 1; SR2, senior radiographers at Site 2; JR1, junior radiographers at Site 1; JR2, junior radiographers at Site 2.

Table 6 Positioning errors in relation to body region

Examination	Site 1	Site 2
Chest	30	21
Extremities	18	11
Abdomen	10	6
Head	11	5
Pelvic girdle	9	3
Shoulder girdle	6	4
Spine	23	13
thorax	2	1
Total	109	64

Table 7 Positioning errors in relation to the spine

Examination	Site 1	Site 2
Cervical	3	5
Odontoid	10	2
Thoracic	1	1
Lumbar	6	2
Sacrum	3	3
Total	23	13

Table 8 Supervised student involvement in repeated films

Supervising radiographer	No. repeated films	% of total repeats
Total SR1	43 (59.7%)	16.8%
Total JR1	29 (40.3%)	11.3%
Total site 1	72 (100%)	28.1%
Total SR 2	47 (85.5%)	20.1%
Total JR 2	8 (14.5%)	3.4%
Total site 2	55 (100%)	23.5%

SR1, senior radiographers at site 1; SR2, senior radiographers at site 2; JR1, junior radiographers at site 1; JR2, junior radiographers at site 2.

Suspected causes

Table 9 lists the various causes that contributed to the unnecessary repeated medical imaging examinations as identified through structured interviews.

Discussion

This study has revealed that a considerable number of medical imaging examinations are unnecessarily repeated within hospital departments. On close investigation, it was found that these repeats were caused by a variety of factors including poor technical judgement, non availability of radiologist for advice, patient movement or motion, equipment mishandling, disorganised practice, and poor supervision of students.

Exposure errors were found to be an issue that requires special attention. Despite the general perception that repeat films are attributable to inexperienced junior radiographers, it was found that most repeats related to exposure factors were linked to senior radiographers. They were found to rarely consult an exposure chart and never to measure patient size.

Investigators' attention was particularly drawn to the peculiar methods used by a number of radiographers in selecting exposure. Some had their original course study notes in their pockets with exposures written from their training days. Despite having newer methods and techniques available (such as high kVp techniques) they relied greatly on the methods originally taught to them and used these whenever supervising current students. Another traditional method was the notion of 'skull equals pelvis equals half a knee and so on'. Although this method has no scientific evidence, advocates believe that it works. Unfortunately, patients do not present with the same size of pelvis or abdomen and the proportional relationship between body parts differs between patients.

To overcome exposure errors it is recommended that medical imaging departments undertake a yearly exposure chart review with radiographers taking a lead role in the process. Strict methods should be employed to ensure that follow up monitoring is undertaken to prevent further unnecessary examinations.

The investigation also revealed that a large proportion of all repeat examinations were attributed to poor positioning technique. In x-ray rooms where there is automatic exposure selectors, the positioning techniques used were causing improper body part alignment with the photo-timer. That was found to be largely due to a poor understanding of the design of the bucky stand.

Through a process of observing radiographers at both sites it was noticed that improper detection of the right density of body part in question is caused by failing to follow manufacturer's recommended positioning technique, especially for chest x-rays. The present investigation shows that more than 30% of the repeats are for chest x-rays.

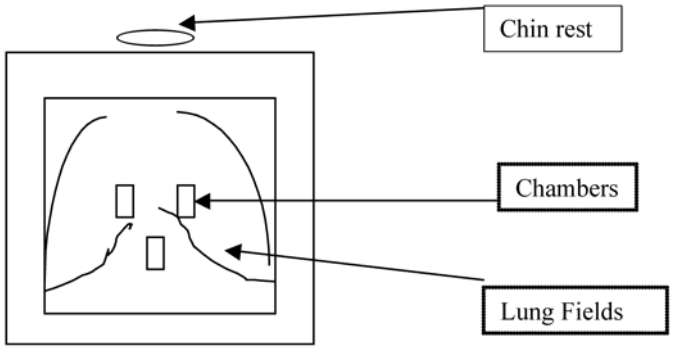

Figure 1 Appropriate positioning for a chest x-ray using ion chambers for auto exposures

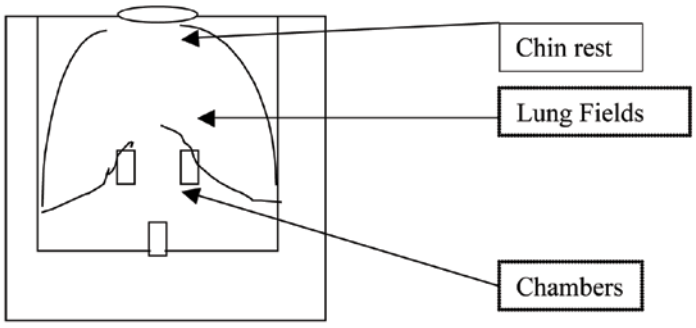

Figure 2 Inappropriate positioning for a chest x-ray using ion chambers for auto exposures

Most bucky stands are designed with the chin rest positioned on the outer topside of the Stand-Bucky. Radiographers automatically assume that when positioning a patient for chest x-ray, the patient's chin should be resting on the chin rest. This would be ideal for most tall to average size males (Figure 1). However for most female patients a smaller size cassette, that of a 35 x 35 cm size, is used to reduce unnecessary space on the film. Most radiographers compensate the difference in the size of the cassette by raising the cassette inside the bucky holder so that the patient

can still rest the chin on the chin rest. Raising the cassette and positioning the chest to the cassette places the ion chambers in a position to detect the density of the hilum and not the density of the lung fields (Figure 2) producing darker images.

To correct this problem, some radiographers try to adjust the sensitivity of the photo-chamber, which usually results in having light films. The same problem applies to large size male patients when the 43 x 35 cassette is used cross wise.

The investigation found that positioning errors were largely associated with junior radiographers. This was an indication that the problem may be due to lack of experience, training and improper supervision. The errors were found to be mainly due to the rotation of the body part in question or poor alignment with the cassette.

Cervical spine examination and in particular performing odontoid views, attracted the attention of the investigation team. In two cases the radiographer repeated the odontoid process view three times without achieving a successful result. When the radiographer was interviewed, it was ascertained that this view was being performed by majority of radiographers in the erect position. According to the *Merrill's Atlas of Radiographic Positions*[14] this view should, preferably, be performed with the patient in the supine position. While observing junior and senior radiographers performing the examination, it was noticed that as the lateral cervical spine view is performed in the erect position, radiographers go ahead and complete the remainder of the procedure in the erect position instead of laying the patient down for the AP and odontoid view. In the erect position, the orchestration of the trapezius muscle, sacrospinalis and sternomastoid differs from that found when the patient is supine. Therefore, it is much more difficult to get the odontoid in the right position and this leads to a large number of repeats. Reviewing the accepted images submitted for reporting, the radiologist determined that the images were still not of a good quality. To reduce the number of repeated odontoid views in the department it is recommended to have proper in-house training and staff need to be encouraged to follow appropriate techniques It was also identified that radiographers need to be reminded that supine position means having the patient lying down with the face upward.[15]

The large number of good films that were subsequently repeated at Site 2 were closely investigated. The investigators were unable to understand why many of those images were rejected and in many cases the radiographers were unable to explain their reasons for the repeat examination. It was found that the radiographer usually experienced difficulties in determining the quality of the image in order to make a proper assessment. As an example, some images were slightly over or underexposed and determined as unacceptable by the radiographer. However, the radiologist in such cases was satisfied with the image. A similar situation arose when, for example, some images were repeated because the body part in question was rotated or some of it was cut-off. In many of these cases the radiologist was satisfied that the information seen in the film was sufficient for diagnostic purposes.

One important observation was the significant difference in the number of good films that were rejected between the two sites. There were a relatively low number of good films rejected at Site 1 where the radiologist was present at most times and personally taking part in supervising the work and commenting on the quality of work as produced. Radiographers took special interest in consulting with the radiologist before a decision was made on whether to perform a repeat examination.

Table 9 Suspected causes of unnecessary repeated medical imaging examinations, observations, comments and conclusions

Type of error	Suspected causes
Exposure	In x-ray rooms where only manual exposure selection is available; the error is largely attributable to the selection of incorrect exposure factors, mainly due to the incorrect estimation of the patient's size. In x-ray rooms equipped with automatic exposure selection, the error is largely attributable to the incorrect positioning of the body part in question in relation to the ion chambers. Radiographers found not to usually consult an exposure chart or measure patient size.
Positioning	Not following the correct positioning technique as recommended by the manufacturer, and especially when taking chest x-rays (more than 30% of repeats are for chest x-rays). Not following the correct positioning technique as recommended by educational references such as The Merrill's Atlas, especially when taking odontoid views Junior radiographers largely attributed, and possibly due to lack of experience, training and improper supervision. Errors mainly due to the rotation of the body part in question or poor alignment with the cassette.
Good films	Availability of radiologist at the site for consultation and advice reduced the number of rejected good films.
Miscellaneous	**(1) Patient movement or motion** Errors due to patient movement or difficulty in holding breath. Error rate increased with severity of illness. **(2) Equipment mishandling and off centred images** Errors found to be due to a number of causes, including the bucky being off centre (bucky not pushed in correctly), the tube being off centre (tube not aligned with bucky centre), tomography not correctly set up, or films placed the wrong way (cassette placed crossways for an AP skull). **(3) Double exposure** Error due to disorganised practice and loss of concentration by Radiographer. **4 Over-collimation and over-lapped images** Errors due to the radiographer (for example, trying to fit a number of images on the one film; or, another example may be poor patient preparation resulting in jewellery remaining in the way) or equipment fault (for example, the lead shutters in the light beam diaphragm may need adjustment).
Supervised students	Close observation of the supervisory process showed that supervision from senior staff was rarely undertaken appropriately. In many cases the radiographer would start the case with the student but would not maintain the supervision throughout.
Green, black	Several causes were noted including, a faulty automatic cassette holder at Site 2, and clear films mishandling of films in the darkroom, and disorganised imaging practices.

On the other hand, at Site 2, the same radiologist was also the reporting radiologist, however, he spent a very limited time at the site and therefore radiographers had to rely on their own judgment for such decisions. In the absence of a radiologist, radiographers tended to be extra cautious and not risk accepting an image that could potentially be problematic. It was clear to the investigators that radiologist's involvement in supervising work production had a significant impact on the number of repeated examinations, 22%

of the total repeats at Site 2 compared to 6.5% at Site 1. It was also noted that the confidence of radiographers and their ability to assess image quality was higher due to their close relationship with the radiologist.

To reduce the number of unnecessary repeat examinations especially images of an acceptable diagnostic value, it is highly recommended to get the radiologist involved with the close supervision and training of radiographers.

Few rejected films were in the miscellaneous category, ranging from 2 to 4% of the total rejects at each site. Investigators found several factors for the cause of these errors such as: poor technical judgement, patient movement or motion, equipment mishandling, and disorganised practice.

The contribution of students to the number of repeats was also apparent. According to the protocols for student supervision at each site, student-assisted cases are under the full control and supervision of the senior radiographer. However, the investigation team observed that in practice this was not always followed appropriately. In many instances the senior radiographer would commence the case with the student and would not maintain supervision throughout. In some instances it was noted that students were coaching other students, a practice that should be avoided.

There were also a large number of green, black and clear films at both sites, and in particular at Site 2. The investigation found a number of likely causes that contributed to this which included a faulty automatic cassette holder at Site 2, mishandling of films in the darkroom and disorganised imaging practices. The radiographers provided a variety of reasons for this when interviewed by the investigation team. In some instances radiographers realise that they have selected the wrong exposure and open the cassette to overwrite the latent image, keeping the film to be used as a processor cleaner. Another explanation was that in some cases radiographers left unused cassettes in the room and that these cassettes may end up not being used. When the following shift starts, the next radiographers do not take the risk of using misplaced cassettes and therefore change the film before reuse.

One recommended solution is for medical imaging departments to provide a special carriage box on wheels made from two compartments; one side to be labelled ‘clear’ and the other ‘exposed’. This would help in sorting films as well as providing an excellent manual-handling tool that can prevent back injuries from carrying too many cassettes.

Conclusion

The present study has clearly shown the value of medical imaging departments undertaking internal auditing processes through repeat analysis studies for monitoring unnecessary repeated examinations. Repeats were found to have been caused by numerous factors including poor technical judgement, non availability of radiologist for advice, patient movement or motion, equipment mishandling, disorganised practice, and poor supervision of students. Strategies directed at these causes need to be developed within the medical imaging department to improve the situation. It is recommended that such strategies target specific areas of practice including, quality control, radiological techniques, training, supervision and continuing professional development. The role, knowledge and ongoing performance of the radiographer are critical in ensuring that all procedures are undertaken within the quality criteria and standards required. It is also recommended that the radiologist becomes a key person in future guidance and training of radiographers.

Ethics Committee approval

An application was submitted to the Ethics Committee. The committee’s reply was that no approval is required as long as patients’ names are kept confidential and as long as patients are not exposed to radiation for research purposes.

References

1 Cascade PN, Webster EW, Kazerooni EA. Ineffective use of radiology: the hidden cost. *Am J Roent* 1998; 170: 561–4.

2 Jessen KA. The quality criteria concept: an introduction and overview. *Rad Protect Dosimet* 2001; 94: 29–32.

3 Gray J, Winkler N, Stears J, Frank E, 1983. Quality Control In Diagnostic Imaging. An Ansen Publication, Maryland USA.

4 Kerr S, Vinjamuri S. The radiographer and role expansion in nuclear medicine. *Nuc Med Communications* 2001; 22: 899–902.

5 Hogge JP, Palmer CH, Muller CC, Little ST, Smith DC, Fatouros PP, de Paredes ES. Quality assurance in mammography: artifact analysis. *Radiog* 1999; 19: 503–522.

6 Gruber L. Practical approaches to obtaining hand radiographs and special techniques in hand radiology. *Hand Clinics* 1991; 71: 1–20.

7 Keenan LY, Muir C, Cuthbertson LM. Maximizing the benefit- minimizing the risk: the developing role of radiographers in performing intravenous injections. *Br J Radiol* 2001; 74: 684–9.

8 Kerr S, Vinjamuri S. The radiographer and role expansion in nuclear medicine. *Nuc Med Comms* 2001; 22: 899–902.

9 NHMRC, National Health and Medical Research Council, 1985. Recommendations for Minimising Radiological Hazards to Patients. Australian Government Publishing Service. Canberra, 1986.

10 Singh B, Arrand J, Joiner M, 1994. Hypersensitive response of normal human lung epithelial cells at low radiation doses. *Int J Radiat Biol;* 994.

11 Gray J, Winkler N, Stears J, Frank E, 1983. Quality Control In Diagnostic Imaging. An Ansen Publication, Maryland USA.

12 Gray J, Winkler N, Stears J, Frank E, 1983. Quality Control In Diagnostic Imaging. An Ansen Publication, Maryland USA.

13 Gray J, Winkler N, Stears J, Frank E, 1983. Quality Control In Diagnostic Imaging. An Ansen Publication, Maryland USA.

14 Ballinger P, 1991. Merrill’s Atlas of Radiograhic Positions and Radiologic Procedures, Seventh edition. Mosby USA.

15 Mallett M, 1979. Handbook of Anatomy and Physiology for Students of Medical Radiation Technology. 3rd edition Canada.