ADVICE TO CEO OF ARPANSA ON MEDICAL RADIATION ISSUES
Prepared by

RADIATION HEALTH AND SAFETY ADVISORY COUNCIL

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INTRODUCTION

At the 26 November 2004 meeting, the CEO of ARPANSA requested the Radiation Health and Safety Advisory Council (Council) consider possible future developments over the next 10 years in the use of ionizing radiation in medicine in Australia and the challenges this may pose for radiation protection. The CEO advised he was seeking a brief high level overview of how changing technology and changing medical practice interacted in terms of the balance between the risks and benefits of radiation in medicine.

The largest dose of ionizing radiation that any Australian is likely to receive will arise from medical procedures. Such procedures, whether diagnostic or therapeutic, are expected to be undertaken in the interest of the patient, with the benefit arising from the procedure outweighing any risk from the dose, i.e. the procedure is justified.

Advances in medical imaging technology have seen tremendous improvements in diagnostic and therapeutic procedures resulting in improved health care standards. Rapid advances have seen enhanced capabilities of existing systems as well as the introduction of new imaging modalities. The ability to acquire, process, display and store images digitally has revolutionized virtually all aspects of radiography and radiology. This improved effectiveness of technology means that more people can be exposed in less time, so that justification of exposure and optimisation of protection will become more important. This trend is likely to continue over the next 10 years.

The total population dose of radiation from medical diagnostic procedures is increasing, mainly due to the increase in computed tomography (CT) scanning. Changes in technology and changes in medical practice may in the near future mean that doses to patients from accepted and standard procedures increase, and Council's primary concern is that risks and doses to patients are managed carefully. Issues have already arisen from digital radiology, changes to CT technology, use of CT in paediatric practice and fluoroscopy in interventional radiology. The application of nuclear medicine continues to increase. Changes to other modalities such as magnetic resonance imaging (MRI) may also need to be considered in the context of technological advances.

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TERMS OF REFERENCE

The following Terms of Reference were agreed by Council.

1. Prepare a short paper discussing Council's view of the likely future developments in the use of ionizing radiation in medicine in Australia and the challenges this may pose for radiation protection, including justification.

2. Council should try to look into the future (say up to a decade) to see what may be lying ahead and to see what, if any, changed approaches to radiation protection philosophy in relation to medicine might need to be thought about.

3. Council should draw on the expertise in its own ranks as well as seeking input from the relevant professions, from researchers, from manufacturers and others. Changes to other modalities such as MRI might also need to be considered.

EXPERT ADVICE SOUGHT BY COUNCIL

In addressing the Terms of Reference Council sought advice from a range of experts in medical radiation who gave presentations and took part in general discussion. Council benefited from their expertise and gained information on current issues relevant to medical radiation in an environment where technology is changing rapidly.

Presentations were received from:

1. Professor Brian Tress, Professor of Radiology, University of Melbourne, who spoke on issues arising in diagnostic and interventional radiology;
2. Professor Andrew Scott, Director, Centre for PET, Dept of Nuclear Medicine, Austin Health & Director Tumour Targeting Program, Ludwig Institute for Cancer Research, who spoke on developments in nuclear medicine;
3. Dr John Heggie, Director of Medical Engineering & Physics, St Vincent's Hospital, who addressed Council on medical radiation issues from a physicist's perspective, including optimisation of exposure;
4. Assoc Professor Graeme Dickie, Director of Radiation Oncology, Royal Brisbane Hospital (and a member of Council) addressed Council on issues in radiation oncology, including the range of treatment options and technological developments in treatment and planning in radiation oncology; and
5. Mr John Robinson, Lecturer, Diagnostic Radiography, School of Medical Radiation Sciences, University of Sydney, who gave a presentation to Council on emerging issues in the training of medical radiographers and nuclear medicine technologists.

Papers prepared for Council:

Council discussed a paper titled "Medical Imaging: Developing and Future Issues in Radiation Protection" which was prepared by the South Australian Environment Protection Agency. The paper gave the perspective of the regulator in South Australia and highlighted the impact of digital radiology on medical imaging, the growth in CT scanning and related issues. The paper included discussion of problems arising from wider exposure latitude, post-processing, automatic exposure control (AEC)

variations, fast processing, ease of deleting images, training, and the possible need for increased shielding where patient throughputs have increased.

KEY THEMES ARISING FROM COUNCIL DISCUSSION

From the broad range of salient points raised in discussion with presenters, there were several recurring themes and issues, particularly the impact of new technology, training, accreditation and an understanding of occupational and patient exposures by the medical profession. It is Council's view that these areas all warrant further consideration.

NEW TECHNOLOGY AND EMERGING ISSUES

In reviewing issues arising from new technology it became evident that the pace of change is very rapid, making it difficult for users to maintain up to date knowledge. In particular, there have been rapid advances in computer technology, such as in computational speed and digital storage. In looking forward, Council recognises that further significant advances are likely over the next 5-10 years, but while the trend will continue the detail of likely advances cannot be predicted.

The following points illustrate the breadth of Council's discussion and highlight areas where further deliberation is necessary to identify work that may be needed in the near future to address the balance between risk and benefit. This includes techniques for the optimisation of protection.

Diagnostic Radiology

- The use of CT is continuing to increase mainly because it is able to provide better clinical information and to do so more easily and more rapidly than previously. It is also widely accessible. As the technology has improved the indications for use have expanded. CT gives a higher radiation dose than other common diagnostic procedures and hence it is the largest and an increasing source of population radiation dose.
- With computer technology, there is post-acquisition manipulation of data. A wide range of exposure factors can be used without any apparent difference in clinical information. Thus a wide range of doses can be given without any clinical difference. The use of optimised protocols and the establishment of diagnostic reference levels (DRLs) are important to minimise dose to patients. Optimisation includes tailoring techniques to clinical requirements, i.e. choosing technical factors specific to patient size, employing engineering controls such as mA modulation technology and comparing doses with DRLs. Dose reductions of the order of 30% can be achieved through optimisation.
- Increased beam width and increased workload particularly for multi-slice CT scanners has led to a need for additional shielding at some centres.
- Paediatrics is of special concern as the dose from CT to children may be higher than to adults, and children are much more sensitive to the effects of radiation. Optimisation of settings for children is very important. This has

been shown to be particularly important in centres that do not specialise in paediatrics, for example in regional areas. While the indications are more limited, paediatric CT may be extremely valuable for some cases.

- An increase in paediatric dose has been noted in domestic and international literature. Council understands the NHMRC has recently funded a 3 year research project on this subject jointly between Westmead and Adelaide hospitals.
- As the technology has improved the indications for use of imaging modalities has changed. Education of the referring doctor about the indications, benefits and risks is important. This includes the concept of justification. Further issues arise with the commercialisation of whole-body CT scanning and CT calcium scoring for heart disease and their use for population screening.
- The need for a survey of doses from multi-slice CT was raised in discussion. An earlier ARPANSA survey titled "Radiation Doses from Computed Tomography in Australia" (TR123 Nov 1997), has examined doses from single slice CT only.
- Sometimes radiological procedures are inappropriately used, for example self-referral for whole body CT scanning.
- MRI has also increased rapidly but does not involve ionizing radiation. However, some of the newer generation MRI units utilise much stronger magnetic fields than were previously used. .
- Digital radiography provides significant clinical advancement. The image can be adjusted to allow for overexposure and still give a reasonable image, it can lead to higher doses which may be tolerated rather than optimised. Automatic exposure control variation can also go unnoticed due to post processing. Further, additional post processing algorithms are likely to enhance the ability to work with overexposures. It is recognised that the wider exposure latitude of digital radiography systems will often eliminate the need to retake images which, with film technology, would have been under- or over-exposed. However, fast digital processing can mean that it is quicker and easier to take repeat exposures. This may lead in some circumstances to lack of attention in setting up with a 'one size fits all' scenario being adopted for exposures.
- The issue of whether there is an appropriate Australian Standard for constancy testing of multi-slice CT was raised in discussion.
- The need to establish principles for the implementation of new technology where no Australian Standard exists was also discussed.

Nuclear Medicine

- Over 500,000 nuclear medicine studies are undertaken in Australia per year and the rate is increasing by approximately 10% per year. Areas of developing technologies include positron emission tomography (PET), and combined modality imaging (eg PET/CT & single photon emission computed tomography/CT (SPECT/CT), molecular imaging and radionuclide therapy. Combined PET/CT gives higher resolution scans, more accurate detection and more precise localisation of tumours. SPECT/CT provides more accurate attenuation correction of the SPECT images and facilitates more accurate

anatomical localisation of SPECT-detected abnormalities. Dual isotope/dual modality imaging is also developing.

- PET is projected to increase, especially as new ligands are developed. New indications include dementia, and therapy monitoring. The number of PET centres will increase markedly over the next 10 years.
- Due to the high energy of the radiation from the radionuclides used in PET, staff radiation exposure is often higher than that from other radionuclides used in nuclear medicine.

Radiation Oncology

- Radiotherapy remains a useful treatment method for cancer and its utilisation is increasing. There have been rapid changes in technology particularly in radiotherapy planning, treatment delivery and treatment verification.
- Many diagnostic modalities are being integrated directly into the radiotherapy planning process. CT is commonly used and most radiotherapy departments now have a CT within their department. MRI and PET are also increasingly being integrated into the treatment planning process. Positional calibration between the treatment and imaging equipment is critical to ensure that the radiation is delivered to the desired treatment volume.
- As computers have improved radiotherapy treatments are becoming more complex. Newer techniques of delivery of radiotherapy include conformal radiotherapy, intensity modulated radiotherapy (IMRT), stereotactic radiotherapy and stereotactic radiosurgery.
- Imaging is being integrated into the verification aspect of treatment position using what is termed cone beam or image guided techniques.
- As radiotherapy techniques become more complex it is difficult to rely on a manual checking process to detect and minimise errors. A rigorous ongoing quality assurance process is essential.

TRAINING

The rapid advance of technology has created difficulties for training to keep pace with developments. Technological change has also led to additional groups of medical specialists using radiation equipment. The need for appropriate training was discussed by many of the presenters. The complexity of this issue is illustrated in the following discussion points.

- Training of staff is considered very important to ensure they keep up with the rapid changes in technology. The need for appropriate training applies to new graduates as well as existing staff to ensure they understand the correct procedures for all equipment they will be operating.
- A range of 'other specialists' *(or specialists other than radiologists*) including cardiologists, vascular surgeons, urologists, gastroenterologists, neurosurgeons, neurologists, and orthopaedic surgeons are now using radiological techniques. The shortage of radiologists and the use of radiology tools by the above specialties raises the need for radiation safety training to

groups other than what previously were regarded as the radiation specialties. The use of fluoroscopy by non-radiologists, needs to be addressed as soon as possible as part of professional qualification or training with involvement of the Colleges.

- PET/CT and SPECT/CT necessarily lead to higher doses and raise regulatory and professional questions of who operates the equipment and who interprets the images.
- While there is accredited training for current CT users, as CT scanners spread outside radiology departments, the need for accredited training for all CT users and operators will need to be addressed. Some of the areas where CT is expanding are nuclear medicine departments (hybrid scanners), cardiac catheterisation laboratories and radiation oncology. Regulatory authorities are involved in licensing to ensure appropriate training of individuals using and operating CT outside a radiology department. There can be significant variations in the requirements applied in different jurisdictions.
- In interventional cardiology and radiology there are documented cases of full thickness burns and radiation epilation. There is a need for quality technical training on use of the equipment, radiation safety training, and professional supervision and operation by a radiographer.
- Rapid technological advances raise issues about training of radiographers, nuclear medicine technologists and radiation therapists as well as medical specialists. It has become difficult for undergraduate programs to deal with this rapid change. Lecturers may also find it difficult to keep up to date if new technology is introduced in the workplace separate from the educators. If training is not effective, higher patient doses from improper operation of the equipment are likely to occur.
- The issue of postgraduate training for those already in the workplace is important, particularly if there have been new developments since their original training. The majority of training on new equipment is driven by and conducted by the manufacturer on site and uses a 'train the trainer' approach. Scheduling of additional training by manufacturers for existing purchasers may not be optimum with preference given to training for new purchasers. There are limited opportunities for training in small regional centres, making it difficult to keep skills up to date. The role of universities, colleges and professional bodies such as the Australian Institute of Radiography (AIR) and their ability to address continuing professional development and other training needs requires further discussion.
- Selected universities have developed short courses, e.g. the one semester course for nuclear medicine technologists in CT at University of Sydney. Council understands that as new technology becomes mainstream such short courses are likely to be included in the main course syllabus.
- Some time ago Council initiated a project in consultation with the Cardiac Society of Australia and New Zealand to circulate a questionnaire to cardiology centres aimed at obtaining more information on radiation protection knowledge of cardiologists. This project has proved difficult to progress.

RADIATION DOSE TO WORKERS

It is now very rare for health care workers to receive significant doses of radiation. Appropriate shielding of x-ray rooms with improved technology and interlocks with the equipment have created a safe working environment.

- Radiologists and radiographers rarely receive any radiation dose apart from those involved in fluoroscopy and interventional procedures.
- Radiation oncologists and radiation therapists rarely receive any significant dose apart from some forms of brachytherapy.
- In nuclear medicine the dose to staff is usually low because of the low activities involved with diagnostic procedures. Nuclear medicine involves the use of unsealed radionuclides leading to the potential for radiation exposure to staff. The highest risk areas are therapeutic procedures and higher dose diagnostic procedures such as cardiac imaging. The expected increase in utilization of PET may increase staff exposures.
- The group with the greatest potential to receive significant doses of radiation are those involved with x-ray fluoroscopic procedures. The length of time of the fluoroscopy determines the dose. The groups most at risk are interventional radiologists, interventional cardiologists and vascular surgeons. For some procedures the radiation dose to patients may be very large. Other groups using fluoroscopy include neurosurgeons, orthopaedic surgeons, urologists and gastroenterologists. Protection of such staff includes use of shielded clothing.

SUMMARY AND CONCLUSIONS

Council is aware of the rapid advances in the field of medical radiation and its increasing utilisation, means that the population radiation dose from medical diagnostic procedures is increasing. The challenge is to ensure that the increased patient dose is managed satisfactorily. Council's consideration of medical radiation issues has highlighted a number of areas that merit further discussion. Any further work would need to be undertaken within a framework of specific terms of reference.

One important area identified for priority consideration is paediatric CT which has the potential for high risks.

Consideration should also be given to doses to non-radiologist operators of fluoroscopic equipment and implementation of optimisation to keep doses low in practice. With the rapid changes in technology leading to non-radiologists using radiation equipment, the need for appropriate safety training has become particularly important.

Medical procedures using radiation, whether diagnostic or therapeutic, are expected to be undertaken in the interest of the patient, with the benefit arising from the procedure outweighing any risk from the dose. Advances in technology have significantly enhanced medical diagnosis and treatment, but in some areas radiation doses have

increased. Justification of exposure and optimisation of protection remain, and will become more important in ensuring medical exposures have a net benefit to the patient.

Different regulatory approaches by the States and Territories to classification of new technology radiation equipment can result in different controls being applied to licensing and training for the use and operation of such equipment across Australia. This should be addressed and warrants early discussion.

Magnetic field strengths of MRI equipment are also increasing substantially. There is potential for this to lead to health effects if this trend continues in the future.

Council acknowledges there are several areas of medical radiation that are outside the responsibility of ARPANSA. However, ARPANSA can still seek to strongly influence the debate. Council recognises that many other parties will also need to be involved in addressing these challenges.

Council would like to emphasize that comments made herein are based on member knowledge and limited consultation. Council invited speakers well recognized in their area of expertise. Those speakers addressed Council as individuals giving their own impressions, not as representatives of outside bodies. Council did not attempt to have discussion with professional bodies or all State and Territory regulatory agencies.

Council considers it is appropriate at this stage to forward advice to the CEO on its discussion to date to allow an opportunity for consideration of the issues raised and the initial recommendations. Council acknowledges that issues relating to medical radiation may be of greater breadth than those discussed in this paper.

COUNCIL RECOMMENDATIONS

The following recommendations are considered to be steps forward in addressing what is a complex issue which has wide ranging implications for many and varying parties.

1. ARPANSA directly engage in a process of consultation with professional bodies and regulators to discuss appropriate training for persons working in the medical radiation field. This may be assisted by medical colleges or professional organisations. In some cases training may need to be linked to a requirement for authorisation to operate radiation equipment.

2. ARPANSA directly engage with professional bodies in relation to the issue of managing the increasing radiation dose to patients by offering to present papers and participate in panel discussions at conferences organised by medical colleges and professional organisations.

3. ARPANSA expedite publication of the draft Codes of Practice on radiology, radiotherapy and nuclear medicine.

4. ARPANSA consider the development of a range of information on radiation protection to assist the medical profession, including:

   - Preparation of articles for general practitioner publications/magazines. The articles could provide information that would help general practitioners in understanding radiation dose aspects of procedures for which they may write referrals. This would assist in selecting the most appropriate procedure to request.
   - Collation of information on relevant Standards, Codes and Guidance on medical radiation protection, both within Australia, and internationally that may assist in further consideration of medical radiation issues.
   - Utilising the ARPANSA web site to draw together sources of information on optimisation techniques and the dose reductions that can be achieved, particularly for CT and paediatric CT scanning.

5. ARPANSA maintain a watching brief on studies both domestically and internationally relating to paediatric doses.

6. ARPANSA encourage medical associations whose members sometimes use radiation to develop and use their own Codes of Conduct on the use of ionizing radiation. Council notes the recent Code of Conduct for Orthopaedic Surgeons prepared by the Australian Orthopaedic Association.

7. ARPANSA consider undertaking a survey of doses from multi-slice CT scanners. Council noted the earlier survey, "Radiation Doses from Computed Tomography in Australia" (TR123 Nov 1997), which covered doses from single slice CT scanners. Council sees benefit in undertaking a further survey of doses, as the technology has changed.