SOP RSC 3.1 Optimisation of Exposures in Radiology

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The Radiation Safety Committee
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Purpose

Within the NSW Government (2013) Protection from Harmful Radiation Regulation there is provision to protect patients from unnecessary doses of radiation during research using diagnostic radiology procedures. The minimal doses of radiation required for diagnostic purposes may not be exactly known, and hence procedures are required that allow such research to occur, while at the same time offering protection of the patient from undue radiation.

In general, the minimal radiation required is a balance between patient or patient dose and image quality. If the image is compromised by reducing the dose to protect the patient or patient, then this may ultimately lead to repeat examinations and therefore higher patient or patient doses. The dose required will be determined by the image quality required for the research project and the size and shape of the patient.

Typical uses of diagnostic radiology are plain and contrast radiography, fluoroscopy, and CT procedures. Adaptation of normal protocols is a necessary part of diagnostic radiology to minimise radiation and to take into account different anatomical shapes, sizes, and ages, as well as patients who are pregnant.

Scope

The Researcher

Prior to research commencing, the principal investigator must obtain approval from:

- the University Radiation Safety Committee (RSC); and
- the University Human Research Ethics Committee.

OR

- under circumstances where the owner and person responsible for the radiation equipment being used for the research is not the University, but an outside organisation or institute, before commencing research the principal investigator must submit the approvals from that organisations or institute's equivalent committees to the Research Office for minuting at the appropriate University committees.

The Radiation Medical Practitioner (The Radiologist)

The Radiologist is responsible for the clinical management of the patient undergoing a diagnostic procedure. This includes providing advice to the patient on the procedure that is to be performed, and ensuring that the imaging protocol to be followed has been optimised so as to minimise the radiation exposure to the patient, while obtaining the necessary diagnostic images.

The Radiographer

The radiographer is responsible for performing the radiology procedures as prescribed by the radiation medical practitioner in accordance with justifiable imaging protocols, including any protocol modifications specified for a particular patient.

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Radiation Safety Committee

The RSC will oversee and provide advice on radiation safety within schools/departments performing diagnostic radiology.

Details of procedure

Procedures for the correct identification of the patient, procedure, and sites

All clinical research staff shall comply with the Australian Commission on Safety and Quality in Healthcare.

A series of protocols have been developed to support matching of patients to their care in the areas of radiology, nuclear medicine, radiation therapy and oral surgery for national use.

A series of protocols have been developed for specific clinical areas.

PROCEDURES FOR EXPOSURE OPTIMISATION

Radiography

The radiographer will:

- tailor the kVp, beam filtration, and mAs to the patient's specific anatomy;
- restrict the number of exposures per examination to the minimum necessary;
- choose the most efficient image receptor required to achieve the diagnostic information
- avoid the universal use of anti-scatter grids, most particularly in the context of radiography and fluoroscopy of patients under the age of 18 years;
- collimate the primary X-ray beam to within the size of the image receptor in use, and only expose the clinically relevant region of interest. This has the added benefit of simultaneously improving image quality and lowering dose;
- avoid the use of extremely short source to clinical target distances, as this can lead to unnecessarily high skin doses;
- shield radiosensitive organs such as the gonads, lens of the eye, breast, and thyroid whenever feasible, unless they are the clinical target; and
- (Note: where the use of shielding will obscure the desired information relevant to the examination (e.g. ovarian shields in an abdominal radiograph) the use of such shielding is discouraged;
- Note: protective drapes do not guard against radiation scattered internally within the body and only provide significant protection in cases where part of the primary X-ray beam is directed towards structures outside the immediate area of interest)
- exercise extra care when using digital radiography systems with wide dynamic ranges, such as Computed Radiography (CR), Direct Digital Radiography (DDR), and image intensifiers/flat panel detectors. Choosing the appropriate image processing parameters is just one aspect of the procedure that the operator needs to consider. Patient dose may be increased to excessive levels without compromising image quality in the phenomena known as 'exposure creep' and it is therefore recommended that radiographers carefully monitor exposure indices to ensure that over exposure is not occurring.

Additional information can be obtained from the European guidelines which have been developed to provide specific advice on good technique when radiographing paediatric patients and adult patients, respectively, and from the IAEA Radiation Protection of Patients website.

Fluoroscopy

The radiographer will:

- use automatic brightness control (ABC), low frame rate, pulsed fluoroscopy, and last image hold (LIH) routinely when they are available;
- optimise the radiographic geometry (i.e. avoid geometric magnification) as poor technique combined with poor geometry can cause patient skin doses to be unnecessarily elevated such that deterministic effects may occur. The X-ray tube should be kept at recommended distance from the patient, and the imaging receptor as close to the patient as possible;
- use the largest image intensifier or flat panel field size collimated down to the region of interest that is consistent with the imaging needs. That is, avoid electronic magnification (i.e. use of small field sizes). Electronic magnification results in dose rates to the patient that may be several times higher than those that apply when the largest field size is chosen;
- choose the lowest dose rate options available commensurate with image quality requirements. This may mean keeping tube current as low as possible by keeping the tube voltage as high as possible, or using pulsed fluoroscopy if it is available;
- avoid the universal use of anti-scatter grids. Remove the grid when examining small patients or when the imaging device cannot be placed close to the patient;
- minimise the fluoroscopy time. However, operators should be aware that elapsed fluoroscopy time is not a reliable indicator of dose. Patient size and procedural aspects such as locations of the beam, beam angle, image receptor dose rate, and the number of acquisitions can cause the maximum skin dose to vary by a factor of at least ten for a specific total fluoroscopy time;
- choose the lowest frame rate and shortest run time consistent with diagnostic requirements during digital image acquisition procedures (e.g. digital subtraction angiography (DSA) and cardiac angiography);
- consider employing additional strategies, including the use of additional or k-edge beam filtration, and radiation-free collimator adjustment whenever possible;
- consider options for positioning the patient or altering the X-ray field or other means to alter the beam angulation when the procedure is unexpectedly long so that the same area of skin is not continuously in the direct X-ray field (skin sparing); and
- be aware that dose rates will be greater and dose will accumulate faster in larger patients. However, in complex procedures, operator choices and clinical complexity are more likely to affect patient dose than the physical size of the patient.

CT Procedures

CT procedures are increasingly common and give rise to some of the highest radiation doses in diagnostic medical imaging. Accordingly, all common CT procedures should follow protocols which have been optimised for patient dose and image quality. The operator of a CT scanner should tailor the technical factors of the examination (kVp, mAs, nominal collimated X-ray beam width, pitch, volume of patient scanned) to the:

- individual patient anatomy; and
- diagnostic information being sought.

Pregnancy and Protection of the Embryo/Foetus

The radiologist or radiographer will:

- enquire about the possibility of pregnancy in all female patients of childbearing age;
- indicate to the patient why there is a need to know, to avoid them taking offence and refusing to answer, or answering less than truthfully;
- use an interpreter if there is any possibility that a language barrier would prevent the patient from understanding the question;
- not proceed with diagnostic radiology in the abdominal region if there is any doubt about the status of pregnancy (Note: General radiographic examinations of the extremities, head and skull, mammography, and CT examinations of the neck and head can be undertaken on pregnant or possibly pregnant women without concern, as the scattered dose to the foetus is minimal);
- ensure signs are displayed in prominent places throughout each facility where X-rays are used advising patients to notify staff if they may be pregnant. These signs will be written in several languages relevant to the community. An example might read as follows:

IF IT IS POSSIBLE THAT YOU MIGHT BE PREGNANT,
NOTIFY THE RADIOGRAPHER BEFORE YOUR X-RAY EXAMINATION.

However, the posting of signs in no way absolves the researcher, radiographer, or the radiologist/physician/surgeon of their responsibility to enquire about the possibility of pregnancy in all female patients of childbearing age. When asking the patient about the possibility of pregnancy it is also important to indicate to the patient why there is a need to know, to avoid them taking offence and refusing to answer or answering less than truthfully. When language barriers exist, it may be useful to seek the service of an appropriate interpreter.

When doubt exists about the pregnancy status of an individual woman and moderate or high doses to the lower abdomen are involved, the Researcher/Radiologist should consider serum β-HCG testing before starting the procedure.

When the Patient is Known to be Pregnant

The radiographer will:

- consult with the researcher and radiologist to determine if the procedure is still required.
- consult with the researcher to determine the appropriate radiation exposure settings and procedures to minimise exposure of the foetus.
- keep written records of such consultations. Note the written record of consultation will include:
    - the patient's height and weight;
    - the particular x-ray apparatus used;

- the part of the body irradiated and projections employed (e.g., AP, LAT);
- the entrance field size;
- the focus to object distance (FOD);
- the x-ray filtration in mm of Aluminium;
- the kVp, mAs (or mA and time), and the number of exposures for radiographic studies;
- the kVp, mA, total screening time and, where available, the dose-area product (DAP) for fluoroscopic studies;
- the kVp, mA, slice thickness, rotation time, pitch, scan length, and the DLP (dose length product) for CT studies.

When a Patient is Found to be Pregnant After a Radiological Procedure

A medical physicist will:

- estimate the radiation dose to the foetus/conceptus
- advise the obstetrician or medical practitioner caring for the patient of the calculated dose and provide additional information if available to allow evaluation of any possible risk to the foetus/conceptus.

Patient Radiation Doses for Common Procedures

The tabulated numbers in Appendix 1 are guides only as the actual dose that an individual receives may vary substantially depending on the:

- patient's anatomy;
- equipment used; and
- exact type of examination undertaken.

Audit

Survey of doses against the Diagnostic Reference Levels

References and relevant links

PD2019_044 WHS Exposure to Ionising Radiation

https://www.safetyandquality.gov.au/sites/default/files/migrated/ECPCSCP_FactSheet.pdf

https://www.safetyandquality.gov.au/our-work/communicating-safety/patient-identification/patient-procedure-matching-protocols/ensuring-correct-patient-correct-site-correct-procedure-protocol-other-clinical-areas

Safety Guide – Radiation Protection in Diagnostic and Interventional Radiology

REVISION & APPROVAL HISTORY

Date	Revision No.	Author and Approval
Dec 2014	Version 1	William Bartolo, Bartolo Safety Management Service
May 2016	Version 2	William Bartolo, Bartolo Safety Management Service
Dec 2016	Version 3	Radiation Safety Committee, Charles Sturt University
Jan 2017	Version 4	William Bartolo, Bartolo Safety Management Service and Radiation Safety Committee, Charles Sturt University
Nov 2022	Version 5	Radiation Safety Committee, Charles Sturt University

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APPENDIX 1

Approximate effective doses arising from common radiological examinations in adults

Effective Dose Range (mSv)	Radiological Examinations
0 – 0.1	Extremities Skull Cervical spine Chest Bone densitometry
0.1 – 1.0	Thoracic spine Lumbar spine Abdomen Pelvis Pelvimetry Mammography (2 view)
1.0 – 5.0	Intravenous pyelogram (IVP) Barium swallow Barium meal CT head CT cervical spine CT chest (without portal liver phase)
5.0 – 10.0	Barium enema Angiography – coronary Angiography – pulmonary Angioplasty –coronary (PTCA) CT chest (with portal liver phase) CT renal (KUB) CT abdomen/pelvis – single- phase CT thoracic spine CT lumbar spine
>10	Angiography – abdominal Aortography – abdominal Transjugular intrahepatic porto-systemic shunt (TIPS) RF cardiac ablation CT chest/abdomen/pelvis CT abdomen/pelvis – multi-phase studies