SESLHD PROCEDURE COVER SHEET

NAME OF DOCUMENT	Radiation Safety - Optimising Exposures in Diagnostic and Interventional Radiology
TYPE OF DOCUMENT	Procedure
DOCUMENT NUMBER	SESLHDPR/551
DATE OF PUBLICATION	March 2020
RISK RATING	Medium
LEVEL OF EVIDENCE	Standard 1: Governance for safety and quality in health service organisations
REVIEW DATE	March 2023
FORMER REFERENCE(S)	SESLHNPD/48 Radiation Safety – Optimise Exposures in Diagnostic and Interventional Radiology
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Caroline Skipper Director People and Culture
AUTHOR	Brent Rogers, SESLHD Radiation Safety Officer Erin McKay, RSL SESLHD St George Hospital
POSITION RESPONSIBLE FOR THE DOCUMENT	District Radiation Safety Officer SESLHD-RadiationSafetyOfficer@health.nsw.gov.au
KEY TERMS	Radiation safety; ionising radiation; x-rays; radiology; medical imaging
SUMMARY	Procedures to optimise patient exposure to radiation from diagnostic and interventional x-ray procedures.

Radiation Safety - Optimising Exposures in Diagnostic and Interventional Radiology

SESLHDPR/ 551

1. POLICY STATEMENT

The South Eastern Sydney Local Health District (SESLHD) is committed, through a risk management approach, to protecting employees, contractors, students, volunteers, patients, members of the public and the environment from unnecessary exposure to radiation arising from systems and processes which use radiation apparatus and radioactive substances, whilst maintaining optimum diagnostic and therapeutic quality, therapeutic efficacy and patient care.

This document provides procedures necessary to ensure compliance with this policy in relation to the protection of patients undergoing diagnostic or interventional radiological procedures.

2. BACKGROUND

Once clinically justified, each examination should be conducted so that the dose to the patient is the lowest necessary to achieve the clinical aim. The quality of the images and the complexity of the examination should be sufficient for the intended purpose of the procedure. Since patients may accrue direct benefits from medical exposures, it is not appropriate to impose strict limits on the doses received from fully justified examinations. However, patient dose surveys indicate wide variations in delivered dose to achieve satisfactory image quality indicating that there is significant scope for the implementation and optimisation of patient protection.

3. RESPONSIBILITIES

3.1 The Radiation Medical Practitioner (Radiologist):

The Radiation Medical Practitioner is responsible for the clinical management of the patient undergoing a diagnostic or therapeutic 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 while obtaining the necessary diagnostic images.

3.2 The Radiographer:

The Radiographer is responsible for performing the radiology procedures as prescribed by the radiation medical practitioner in accordance with the centre's written standard protocols, including any protocol modifications specified for a particular patient

3.3 The Radiation Safety Officer (RSO):

The RSO will oversee and provide advice on radiation safety within departments performing diagnostic or interventional radiology.

4. PROCEDURE

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

All staff must comply with NSW Health Policy Directive PD2017-032 *NSW Health Policy Directive: Clinical Procedure Safety*. To assist Departments in implementing this policy, posters and trolley slips have been developed and are available from NSW Health. Posters specifically for general radiology, interventional radiology and MRI are available.

The following procedures for ensuring correct patient, procedure and site in Radiology are common across NSW:

Step 1 - Referral Document

The referral document must be legible and must contain the patient's full name, date of birth and the name of the procedure.

Step 2 – Patient Identification

The patient should be asked to state (not confirm) their full name and date of birth or address. For inpatients, the wristband details (name and MRN) should be checked against the patient's referral. Questions should be asked in an open ended way, such as 'I need to check your details again, could you please tell me your name and date of birth.'

Step 3: Confirm Procedure and Site

The type of procedure and site should be checked by asking the patient a question such as 'could you also tell me what type of procedure you are to have'. If relevant, the radiographer should also ask about pregnancy status.

Step 4 - "Time Out"

Immediately prior to the start of the procedure the radiographer or radiologist should confirm that the patient identification matches that on the request form; and that the procedure and site are appropriate for the study requested.

4.2 Procedures for exposure optimisation

4.2.1 Radiography

In general, the optimisation process necessarily requires a balance between patient dose and image quality and it is important that diagnostic quality of the image is not lost in the cause of dose reduction. Images of unacceptable quality can result from unwarranted reductions in patient dose rendering the images non-diagnostic and ultimately leading to repeat examinations and higher patient doses. The clinical problem will dictate the requirement for image quality and lower image quality might be acceptable in some circumstances. Further, the size and shape of the patient will influence the level of dose required. Thus, the operator should:

- tailor the kVp, beam filtration and mAs to the patient's specific anatomy
- restrict the number of views per examination to the minimum necessary

- choose the most efficient image receptor required to achieve the diagnostic information (e.g., fast versus slow intensifying screen speed, correct matching of film and screens)
- avoid the unnecessary 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 image 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. Note that where the use of shielding will obscure the desired information relevant to the examination (e.g. ovarian shields in an abdominal X-ray) 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) and 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 Automatic Exposure Control (AEC) devices be utilised with digital imaging systems.

Additional information can be obtained from the [3]European guidelines which have been developed to provide specific advice on good technique when radiographing paediatric patients and adult patients, respectively, and from the [4]IAEA Radiation Protection of Patients website.

4.2.2 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 established 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
- diagnostic information being sought.

Whenever possible, automatic exposure control (AEC) which varies the current according to the attenuation through the patient should be employed. Dose reductions of 30% to 60% have been reported using AEC compared to protocols which use fixed mA.

4.3 Pregnancy and Protection of the Embryo/Foetus

Signs are required in prominent places throughout each department where x-rays are used advising patients to notify staff if they may be pregnant. Ideally, 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 PHYSICIAN OR RADIOGRAPHER
BEFORE YOUR X-RAY EXAMINATION

However, the posting of signs in no way absolves the 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 Radiologist should consider serum β-HCG testing before starting the procedure.

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.

4.3.1 Procedure when the patient is known to be pregnant

If it is clinically necessary for the patient to undergo the procedure while pregnant, the radiographer should select the radiographic technique factors, in consultation with the radiologist, so that the foetal dose is minimised.

The following information must be recorded in order for foetal dose estimates to be made:

- the patient's height and weight
- the particular x-ray apparatus used
- the part of the body irradiated and projection (eg, AP, LAT)
- the entrance field size
- the focus to surface distance (FSD)
- the x-ray filtration in mm of Aluminium and/or Copper
- 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.

4.3.2 Procedure when a patient is found to be pregnant AFTER a radiological procedure

Occasionally a patient will not be aware of a pregnancy at the time of an x-ray examination, and will naturally be very concerned when the pregnancy becomes known.

In such cases, the estimation of the radiation dose to the foetus/conceptus should be performed by the Radiation Safety Officer so that the patient and their obstetrician can then be better advised as to any possible risk. In many cases there is little risk as the irradiation will have occurred in the first three weeks following conception. In a few cases the foetus will be older and the dose involved may be significant. It is however extremely rare for the dose to be large enough to warrant advising the patient to consider termination.

4.4 Interventional Procedures

Unfortunately, there is a growing literature of case reports documenting inflammatory and cell-killing effect injuries to skin resulting from interventional radiology procedures. There are many different instances of such inflammatory and cell-killing effect injuries, with severity ranging from erythema to severe skin necrosis.

Acute radiation doses, delivered to tissues during a single procedure or closely spaced procedures, may cause:

a) erythema at 2 Gy

b) cataract at 2 Gy

c) permanent epilation at 7 Gy

d) delayed skin necrosis at 12 Gy.

The patient dose of concern is the absorbed dose in the area of skin that receives the maximum dose during an interventional procedure. The serious radiation-induced skin injuries are caused by prolonged irradiation of the same skin site resulting in absorbed doses that exceed the threshold for skin effects. To help avoid and monitor for these serious skin injuries, the basic steps below should be followed:

- The clinical protocol for each type of interventional procedure should contain a statement on the radiographic images (projections, number, and technique factors), fluoroscopy times, air kerma rates, and resulting cumulative skin doses and skin sites associated with the various parts of the interventional procedure which will specifically be for the fluoroscopy equipment installed at the facility. Each protocol would be for the nominal conduct of the interventional procedure at that facility, recognising that actual procedures will vary considerably due to the complexities of the specific case. This statement in the protocol provides the interventional physician baseline levels for patient skin dose that permits comparison to irradiation conditions and resulting skin doses occurring during actual procedures
- Each interventional physician should be trained to use information, displayed at the operator's position, on the level of 'patient skin dose' occurring during an actual procedure. The most useful display is the air kerma (in mGy or Gy) that has accumulated up to the current point during the procedure. The display

should be for a reference location that is a surrogate for the entrance skin surface of the patient. This will generally lead to an overestimate of the maximum cumulative skin dose, since it will be accumulated over all entrance skin sites. Additional useful displays are (a) the air kerma rate (in mGy per minute) during a fluoroscopic segment at the same reference location noted above, and (b) the total fluoroscopy time (in minutes). Such displays would permit ready comparisons with the local clinical protocol

- Interventionists should use the practical techniques detailed in 4.2.2 to control the cumulative absorbed dose in the skin
- When the maximum cumulative absorbed dose in skin for an actual procedure appears to approach, equal, or exceed the following values, it should be recorded in the patient record, along with the location and extent of the skin site: 1 Gy (for procedures that may be repeated); 3 Gy (for any procedure)
- All patients with estimated skin doses of 3 Gy or above should be followed up 10 to 14 days after exposure. The patient's physician should be informed of the possibility of radiation effects. If the dose is sufficient to cause observable effects, the patient should be counselled after the procedure.

4.5 Patient dose surveys and Diagnostic Reference Levels

Diagnostic reference levels (DRLs) are dose levels for medical exposures applied to groups of standard-sized patients or standard phantoms for common types of diagnostic examination and broadly defined types of equipment. These levels are expected not to be consistently exceeded for standard procedures when good and normal practice regarding diagnostic and technical performance is applied. DRLs are established by professional bodies such as the RANZCR and should ideally be based on Australian data, but may reference international dose levels.

Procedures where the dose repeatedly and substantially exceeds the DRLs might indicate an underlying fundamental problem that warrants investigation. However, DRLs should be applied with flexibility to allow higher doses if these are indicated by sound clinical judgement.

The choice of dose descriptor to use as a DRL depends on the type of examination. The DRL should be expressed as a readily measurable patient-related quantity for the specified procedure and usually for:

- general radiographic examinations, it is taken to be either the Entrance Skin Dose (ESD) or the Dose Area Product (DAP)
- fluoroscopic examinations, it is taken to be the DAP
- CT examinations, it is taken to be the Dose Length Product (DLP).

As part of its Quality Assurance program, each department should measure the appropriate dose descriptor for a range of common procedures. The DRLs for adults are usually defined for a person of average size (about 70 to 80 kg). When performing dose surveys, patients within this weight range should be selected. The range of measured values should be compared to the appropriate DRL. At least 75% of the measured values should fall at or below the DRL.

4.6 Patient Radiation Doses for Common Procedures

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

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

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 pyleogram (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

5. DOCUMENTATION

- Protocols for CT procedures
- Clinical protocols for interventional procedures.

6. AUDIT

The following records should be available for audit:

- Records of exposure of pregnant patients
- Survey of doses against the Diagnostic Reference Levels.

7. REFERENCES

[1] PD2017_032 *NSW Health Policy Directive: Clinical Procedure Safety*

[2] The Safety Guide for Radiation Protection in Diagnostic and Interventional Radiology (RPS 14.1), ARPANSA 2008

[3] European Society of Radiation,Clinical Decision Support

[4] IAEA Radiation Protection of Patients

8. REVISION AND APPROVAL HISTORY

Date	Revision No.	Author and Approval
June 2010	draft	Richard Smart, Area Radiation Safety Officer in conjunction with the Area Radiation Safety Committee
February 2011	0	Approved by Combined Clinical Council
January 2016	1	Periodic Review
November 2016	1	Review and updates approved by Executive Sponsor
March 2020	2	Review and updates approved by Executive Sponsor