Information on Radiation Dose in Medical Exposures

Justification

The use of radiological investigations is an accepted part of medical practice justified in terms of clear clinical benefits to the patient, which should far outweigh the small radiation risks. However, even small radiation doses are not entirely without risk. A small fraction of the genetic mutations and malignant diseases that occur in the population can be attributed to background radiation. Diagnostic medical exposures – the major source of man-made radiation – account for one-sixth of the total radiation dose to the population.

Optimisation

Best practice and legislative requirements require that all exposures to ionising radiation are justified, and that doses are optimised. One important means of reducing the radiation dose is to avoid undertaking procedures unnecessarily (especially repeat examinations). The legislation also introduces the concept of diagnostic reference levels (DRLs). These levels are based on dose data for a range of commonly requested procedures collected from a large number of Irish hospitals, and are regularly updated. All departments are required to set local DRLs for a range of standard examinations, and monitoring of performance against these levels is an important component of dose optimisation.

Radiation Dose

The effective dose for a radiological investigation is the weighted sum of the doses to a number of body tissues, where the weighting factor for each tissue depends on its relative sensitivity to radiation-induced cancer or severe hereditary effects. It thus provides a single dose estimate related to the total radiation risk, based on the dose distribution within the body. Typical adult effective doses from a range of common diagnostic procedures are shown in Table 1[1, 2] and can range over a factor of about 1,000 from the equivalent of 1–2 days of background radiation (eg, 0.015 mSv for a chest radiograph) to several years (eg, for CT of the abdomen).

Low-dose examinations of the limbs and chest are among the most common radiological procedures, but relatively infrequent high-dose examinations such as body CT make the major contribution to the collective population dose. The doses from some CT examinations are particularly high and the use of CT is still rising. CT contributes 68% of the collective dose from all X-ray equipment and practice. It is thus particularly important that requests for CT are thoroughly justified, taking into account the age and sex of a patient and that those techniques that minimise dose while retaining essential diagnostic information are adopted.

	Diagnostic Procedure	Typical Effective Dose (mSv)	Equivalent number of chest x-rays	Approx. equivalent period of natural background radiation[4]
Radiography and Fluoroscopy	Limbs and joints (except hip)	<.01	<1	<2 days
	Chest (single PA)	0.015	1	1.5 days
	Skull	0.07	5	7.3 days
	Thoracic spine	0.4	30	1.4 months
	Lumbar spine	0.6	40	2 months
	Mammography (2 views)	0.5	35	1.75 months
	Pelvis	0.3	20	1 months
	Abdomen	0.4	30	1.4 months
	Intravenous urogram	2.1	140	7.3 months
	Barium swallow	1.5	100	5 months
	Barium enema	2.2	150	8 months
CT	CT head	1.9	130	7 months
	CT chest	14	1,000	4 years
	CT kidneys, ureters, bladder, KUB for renal stones	6.4	460	2 years
	CT abdomen	16	1,100	4.5 years
	CT abdomen and pelvis	13	930	4 years
	CT colonography	16	1,100	4.5 years
	CT chest, abdomen & pelvis	19	1,400	5.5 years
Nuclear Medicine	Lung ventilation (Tc-99m DTPA aerosol)	0.6	45	2 weeks
	Lung perfusion (Tc-99m)	1	70	3.5 months
	Kidney (Tc-99m)	0.7	50	2.5 months
	Thyroid (Tc-99m)	1	70	3.5 months
	Bone (Tc-99m)	3	200	1 year
	Dynamic cardiac (Tc-99m)	6	400	1.7 years
PET CT	PET-CT head (F-18 FDG)	7	460	2 years
	PET-CT body (F-18 FDG)	18	1,200	5 years

Table 1. Typical effective doses from diagnostic medical exposure (adapted from the UK RCR iRefer guidelines[1] and adjusted to take account of the Average radiation dose from ***natural*** background in Ireland approx. 3.5mSv (EPA (2014)[4])

It is estimated that the additional lifetime risk of developing cancer, attributable to chest, abdominal and pelvic CT examination in an adult may be as high as one in 1,000. However, the overall risk of cancer induction in the general population is nearly one in two; the excess risk of a single CT examination is very small by comparison and should be more than offset by the clinical gain.

The HSE recommends the use of the UK referral guidelines, iRefer[1], to assist in the selection of the most appropriate imaging procedure for a particular clinical condition. In these referral guidelines, the doses have been grouped into broad bands to help the referrer understand the order of magnitude of radiation dose of the various investigations (Table 2).

Symbol	Typical effective dose (mSv)*	Examples	Lifetime additional risk of cancer induction/exam
None	0	US; MRI	0
☢	<1	CXR; XR limb, pelvis, lumbar spine; mammography	<1:20,000
☢☢	1–5	IVU; NM (eg, bone); CT head and neck	1:20,000–1:4,000
☢☢☢	5.1–10	CT KUB; NM (eg, cardiac)	1:4,000–1:2,000
☢☢☢☢	>10	Extensive CT studies, some NM studies (eg, some PET-CT)	>1:2,000

Table 2. Band classification of the typical doses of ionising radiation from common imaging procedures [1]

[Key: US=ultrasound; MRI=magnetic resonance imaging; CXR=chest X-ray; XR=X-ray; IVU=intravenous urography; NM=nuclear medicine; CT=computed tomography; PET-CT=positron emission tomography co-registered with CT.]

Typical effective doses for radiological examinations and associated risks are based on data supplied by CRCE, Public Health England

Cancer risks from radiation vary considerably with age and sex, with higher risks in infants and females. Cancer risk indicated in this table is averaged for adults. As risks for children are higher, the examinations indicated may need to be moved to a higher risk band, when carried out for children; ie, CT head and neck for a child may move to the third Band rather than the second. As in the case of adults, this should be taken in the context of the average lifetime risk for cancer induction and must be balanced against the benefit of the investigation.

Conclusion

Radiation safety legislation[3] requires that the radiation dose administered to a patient during a procedure is captured as part of the medical report. One of the reasons that this mandate exists is so that the level of risk to the patient from the exposure can be put into context for the referrer[2]. Existing technology within most radiology departments is not yet at a point that facilitates easy capture and presentation of individual dose information for the hundreds of thousands of patients that have imaging examinations every year. This functionality can be integrated into modern RIS/PACS systems using information from the x-ray system and this then allows for inclusion of exposure specific information for an individual patient into the radiology report. When used in tandem with a dose tracking/ dose management system, exposures can be benchmarked against those typical for a particular examination and outliers identified. The HSE plans to integrate this functionality into NIMIS within the next two years. Until that time, referrers are reminded that they should use the information in Tables 1 & 2 to understand the radiation dose that is typical for a particular exam type. This information should be used in the prior justification of individual patient exposures, taking into account the clinical benefits of the exposure balanced against the associated detriments.

References

1. iRefer 2017. Guidelines: Making the best use of clinical radiology. Royal College of Radiologists. 2017. Retrieved from https://www.irefer.org.uk/
2. Guidance on the Dose Band Auto-text Changes Introduced to the NIMIS RIS/PACS System for Adult Services NRPR (2022)
3. S.I. 256 of 2018. European Union (Basic Safety Standards for Protection Against Dangers Arising from Medical Exposure To Ionising Radiation) Regulations 2018
4. EPA 2014. Radiation Doses Received by the Irish Population 2014. Radiological Protection Institute of Ireland