Exploring the Benefit/Risk of Radiation for Patients and Communication and Understanding for the Patient

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Overview

- Justification
- What is known about radiation risk
- Imaging Modalities and Risk
- Cumulative dose and Risk
- Communicating Risk

Justification

Justification of medical exposures

8. (1) A person shall not carry out a medical exposure unless it—

(*a*) shows a sufficient net benefit, weighing the total potential diagnostic or therapeutic benefits it produces, including the direct benefits to health of an individual and the benefits to society, against the individual detriment that the exposure might cause, and

(*b*) takes into account the efficacy, benefits and risks of available alternative techniques having the same objective but involving no or less exposure to ionising radiation.

SI 256

Referring

Table 9. Socratic questions[a] for referring clinicians when considering imaging procedures

What the referrer should answer	Preventable, wasteful medical exposures to radiation
Has it been done already?	Unnecessarily repeating investigations that have been already done
Do I need it?	Undertaking investigations when results are unlikely to affect patient management
Do I need it now?	Investigating too early
Is this the best investigation?	Doing the wrong investigation
Have I explained the problem?	Failing to provide appropriate clinical information and questions that the imaging investigation should answer

[a] Classical method to stimulate erudite thought, which has been used in radiology education (Zou et al., 2011)

Benefit

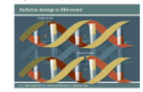
Protection of Patients

JUSTIFICATION - OPTIMISATION

As **L**ow **A**s **R**easonably **A**chievable

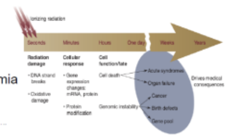
Exploring Radiation Risk

Radiation Effects

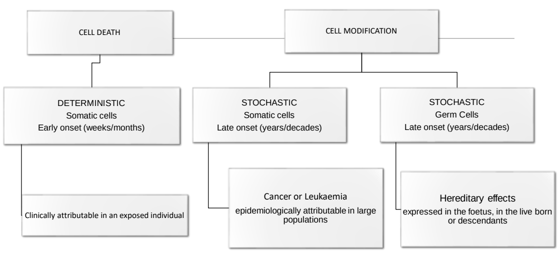


Ionising Radiation is associated with:

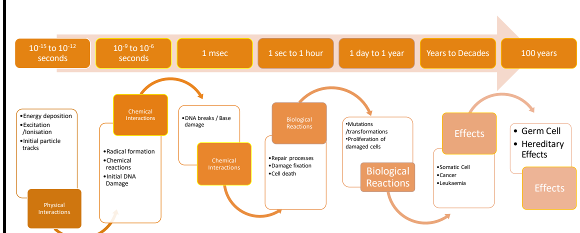
- ❑ Organ/tissue failure
- ❑ Heart disease, stroke
- ❑ Digestive disorders
- ❑ Respiratory disorders
- ❑ Hereditary effects
- ❑ Most forms of leukaemia
- ❑ Cancers
  - of many organs
    Lung, Breast, Colon, Thyroid….
  - **BUT** not others
    Prostate, Hodgkins, Multiple Myeloma…



Types of radiation induced health effects



Timing of events leading to radiation effects



Deterministic Effects

If a sufficient number of cells in an organ or tissue are killed, its function can be impaired. For doses greater than the threshold, the severity of the effect increases with the dose.

Threshold not normally reached in diagnostic imaging

Skin Injuries

Radiation-induced Skin Injuries from Fluoroscopy
http://www.fda.gov/cdrh/RSNAii.html

40 year old male who had

- coronary angiography
- coronary angioplasty
- 2nd angiography procedure due to complications
- coronary artery by-pass graft on a single day.

18-21 months after the procedure, tissue necrosis.

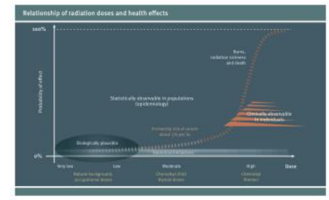
Deterministic effects

- Cedars-Sinai radiation overdoses went unseen at several points. The dosage -- eight times the programmed amount -- appeared on technicians' screens during CT scans. Doctors also missed the problem. 80 of 206 stroke patients who had received the overdose experienced hair loss. Experts say blind trust of medical machinery is a growing concern.
  - *Report on Overdose in CT*

"Band alopecia" CTA Brain perfusion

Stochastic effects

A stochastic effect is caused by damage to a cell that produces genetically transformed but reproductively viable descendents. Cancer and hereditary effects of radiation are considered to be stochastic. The probably of a stochastic effect, instead of its severity, increases with dose.



5% per Sv

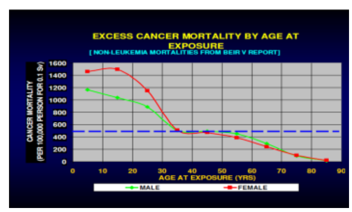
5 people from every 100 exposed to 1 Sv of radiation will (may) get a fatal cancer

or

Potenitally, 5 people in every 100,000 exposed to 1 mSv

Assumes a Linear No Threshold model, with risk linearly associated with dose

Low dose radiation & risk

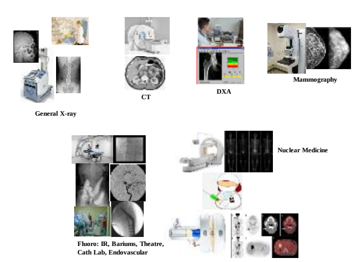


Dose, Imaging Modalities and Risk

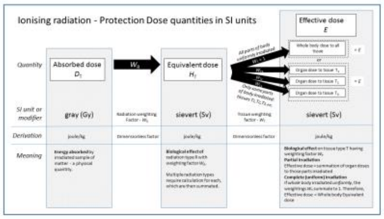
Imaging Modalities

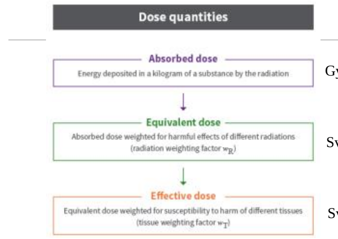
There is a wide range of imaging equipment and modalities, ranging from Nuclear medicine through the various X-Ray imaging systems

Dose vary between equipment and equipment types and are also affected by patient characteristics.



Radiation Units used in RP





Equivalent dose to Organ might be used to assess if threshold for deterministic effects exceeded; might be used as input to risk for cancer

Effective dose might be used to compare exposures between different imaging modalities; might be in basic risk estimates although large error bar limits value

Equipment exposure values

One problem for estimating dose is that Radiation equipment cannot provide a direct measure of patient dose: however, we can estimate patient dose based on the measures of radiation the equipment provides.

Radiographic and fluoroscopy systems report DAP values for exposures or exams

CT units provide at CTDI or DLP value for each exam

MGD (mGy) is measured or calculated by Mammography X-Ray units and is a measure of dose to the breast

Estimating patient dose from a radiographic exposure

Sample Effective Dose Estimate for PA chest

Tissue	***Average Tissue Dose (uSv, Equivalent Dose)***	***Weighting factor***	***Contribution to E (microSievert)***
lung	50	0.12	6
breast	50	0.05	2.5
esophogus	50	0.05	2.5
thyroid	50	0.05	2.5
Effective Dose (assume other tissues receive no dose)			**<u>13.5</u>**

Effective dose is also useful if we want to compare doses for different types of exams

Chest radiograph 0.02mSV

CT Chest 5.1mSv

5.1/0.02 = 255

Risk from different imaging scans

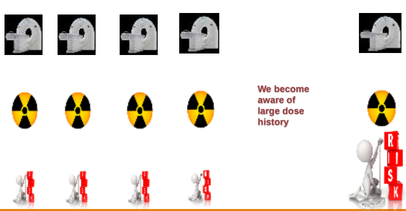
Symbol	Typical effective dose (mSv)*	Examples	Lifetime additional risk of fatal cancer/exam
None	0	US; MRI	0
☢	<1	CXR; XR limb, pelvis, lumbar spine; mammography	<1:20,000
☢☢	1–5	IVU; NM (eg, bone); CT head and neck	1: 20,000–1:4,000
☢☢☢	5.1–10	CT chest or abdomen; NM (eg, cardiac)	1: 4,000–1: 2,000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

Royal College of Radiologists (UK) Classification, 2012

Recurrent Imaging and Risk

Should the justification of medical exposures take account of radiation risks from previous examinations?

Cumulative Dose and Risk



Gambler's Fallacy

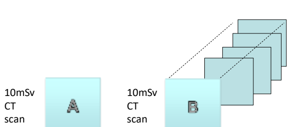
The way in which we model risk – stochastically – can cause confusion when the risk is repeated

There is a tendency to think heads more is a more likely outcome if last few throws of the coin were tails

Similarly, there can be a tendency think x-ray more risky if patient has had previous x-rays

Creates cognitive bias, but based on a fallacy

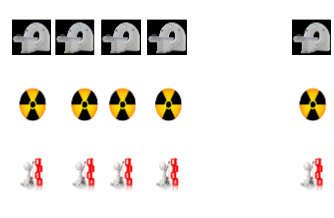
Justification and recurrent imaging



Dose Histories can be useful for prompting us to check previous imaging;

However, we need to be wary of the strong potential for dose history to create cognitive bias.

Errors in risk assessment due to cumulative dose have the potential to skew the justification process to the detriment of patient care



Communicating Risk

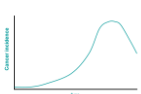
Explaining Risk

Deterministic
- Predictable and avoidable, if we limit. Straightforward to describe

Stochastic
- Semi-predictable, but unavoidable, so we have to minimise the risk. Long latency; probabilistic: difficult to explain

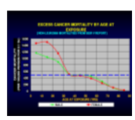
Effective Dose and Lifetime Risk for Cancer

Natural Incidence



Incidence of cancer in population is 1 in 3.

Term for Risk	Examination	Mean Effective Dose	Risk of Fatal cancer
Negligible	Dental Radiograph Panoramic dental	0.002 0.007	1 in 10 million 1 in 3 million
Minimal	Chest PA Radiograph Skull Radiograph	0.02 0.03	1 in 1 million 1 in 700,000
Very Low	Hip X-Ray Lung Perfusion Tc 99	0.3 1	1 in 60,000 1 in 20,000
Low	Chest CT Scan Bone Scan Tc 99	8 3	1 in 25,000 1 in 7,000



Medical Radiation risk @ 5% per Sv

Procedure	Typical Effective dose (mSv)	No. in a million risk
Dental X-Ray	0.011	0.5
Chest X-Ray	0.02	1
Abdomen X-Ray	0.7	34
Barium swallow	1.8	90
CT Abdomen	10	500
NM Bone Scan	4	200

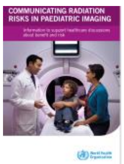
Examples of other One in a Million Risks

- Smoking 1 cigarette
- Travelling 50 miles by car
- Travelling 25 miles by air
- Rock climbing for 1.5 minutes
- Canoeing for 6 minutes
- Being aged 60 for 20 minutes (30 for 9 hours)
- Exposure to 20µSv

Perception of risk

Fig. A. How experts and public perceive risk

Example of communication



Box 3.2 Messaging: An example of two ways to present the facts related to radiation exposure risk

After a pelvic CT scan of a pregnant patient in the emergency department to evaluate trauma following a motor vehicle accident, she is seen by her primary care physician. Which statement delivers the most appropriate response to her question about the risk to the fetus?

A. "The CT that you had two weeks ago has perhaps doubled the risk that your child will develop cancer before age 19." [0.6% vs 0.3%]

B. "The CT was an important exam that allowed the physicians to rapidly evaluate and treat your injuries which otherwise could have placed your health and the health of your baby at risk. The risk of adverse outcome is very small and the likelihood of normal development is still nearly the same as it is for any child." [96.7% vs 96.4%]

56 / COMMUNICATING RADIATION RISKS IN PAEDIATRIC IMAGING – INFORMATION TO SUPPORT HEALTHCARE DISCUSSIONS ABOUT BENEFIT AND RISK

Communication in a clinical setting

Figure 15: Aspects to be considered when establishing a dialogue in a clinical setting

Summary

- Justification
- What is known about radiation risk
- Stochastic risks most relevant to diagnostic
- Interpreting risk ; communicating risk