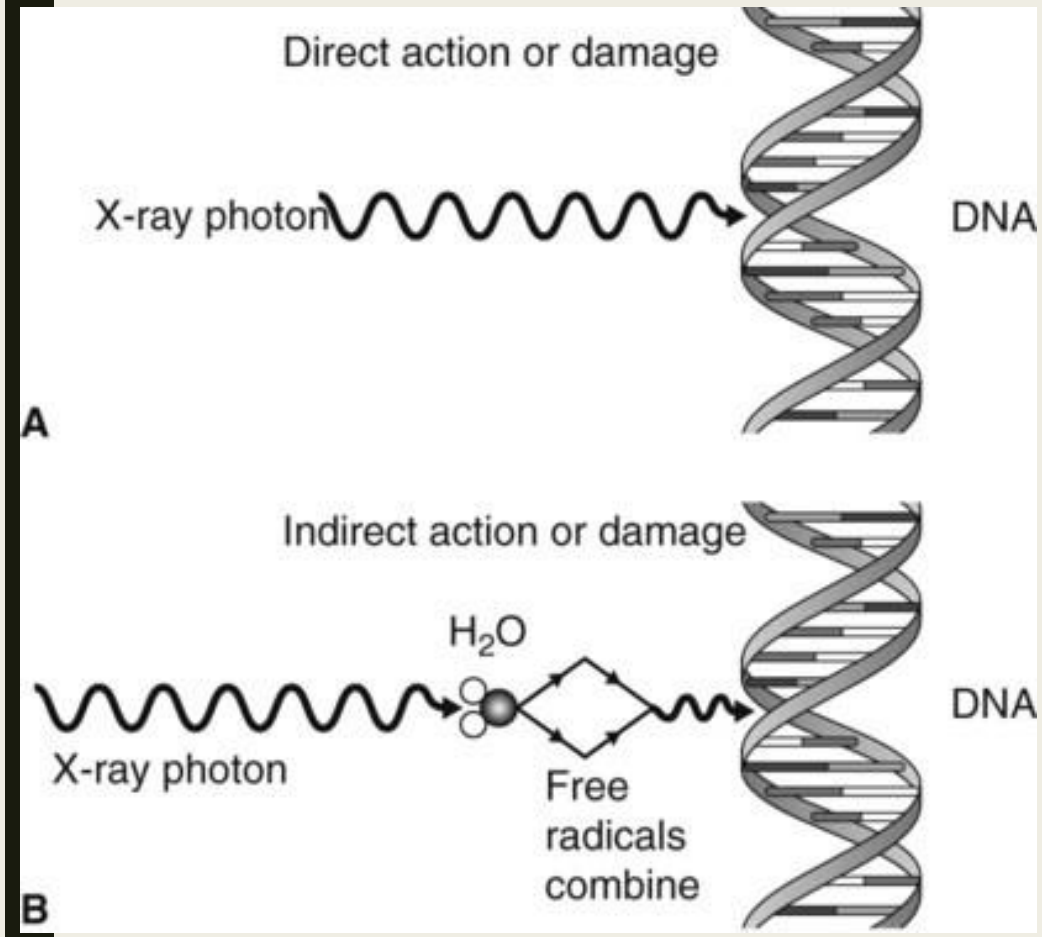
RADIATION PROTECTION

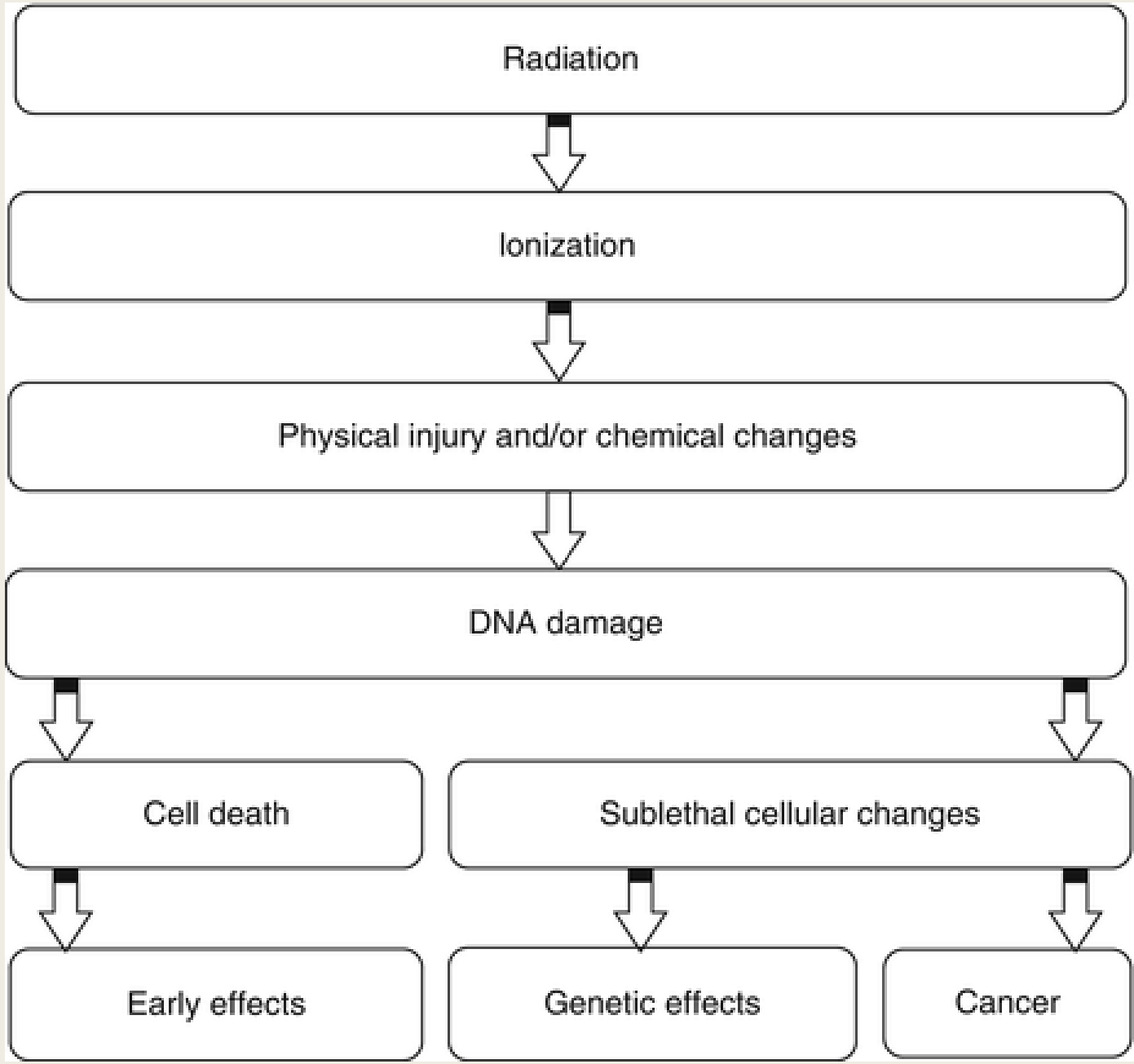
By Dr. Marwa Majid Al- adhab

Objectives

- Effects of radiation exposure and its types.
- Principles of radiation protection
- Hazard of X ray during pregnancy
- Advices concerning the diagnostic radiological examinations in women of reproductive age.
- Radiation protection of staff and public .
- Hazards of contrast media

- X-rays used in conventional radiography and CT, as well as gamma-rays and other radionuclide emissions, are harmful.
- Radiation effects occur as a result of damage to cells, including cell death and genetic damage
- Radiation is particularly harmful to dividing cells such as those found in the bone marrow, lymph glands and gonads.
- Genetically adverse mutations may occur following radiation of the gonads, resulting in congenital malformations and a genetic risk to the population.


Direct action or damage
X-ray photon
DNA
A
Indirect action or damage
H_2O
X-ray photon
Free radicals combine
DNA
B


Radiation
Ionization
Physical injury and/or chemical changes
DNA damage
Cell death
Sublethal cellular changes
Early effects
Genetic effects
Cancer

Two types of effects may result from radiation exposure:

- **Deterministic effects:** are due to cell death, severity of deterministic effects varies with dose and a dose threshold usually exists below which the effect will not occur. E.g. radiation burns, cataracts and decreased fertility
- **Stochastic effects:** the probability of the effect, not its severity is regarded as a function of dose. Theoretically, there is no dose threshold below which a stochastic effect will not occur. The most commonly discussed stochastic effect is increased cancer risk due to radiation exposure.


SCIENCEPHOTOLIBRARY
SCIENCEPHOTOLIBRARY

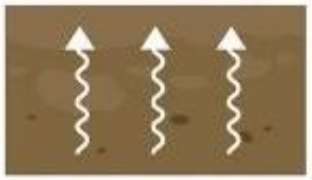
- Radiation dose from medical imaging techniques is usually expressed as effective dose. The concept of effective dose takes into account the susceptibilities of the various tissues and organs, as well as the type of radiation received. The SI unit of effective dose is joules per kilogram and is referred to as the sievert (Sv): 1 Sv = 1.0 J kg−1.

NATURAL RADIATION SOURCES

COSMIC RAYS

FOOD

SOLAR RAYS



RADON GAS

HUMAN-MADE RADIATION SOURCES

X-RAY

FOSSIL FUELS

RADIATION THERAPY

NUCLEAR WASTE

IEC 15Years | IAEA

Imaging test	Effective dose (mSv)	Equivalent number of CXRs	Equivalent time of background exposure	Equivalent hours of flying at 12 000 metres
CXR frontal	0.02	1	3 days	4
CXR lateral	0.04	2	6 days	8
Limb X-ray	0.02	1	3 days	4
Lumbar spine X-ray	1.5	75	6 months	300
AXR	0.7	35	3 months	150
CT head	2	100	8 months	400
CTPA	8	400	2 years	1200
CT abdomen	2–10	100–500	8 months–3 years	400–1800
DEXA bone densitometry	0.001	0.05	<1 day	<1
Mammogram	0.7	35	3 months	150

Legislation and principles of radiation protection

- The aim of radiation protection against ionizing radiation in diagnostic medical imaging is to restrict radiation dose to staff, patients and the general public to remain below the level at which deterministic effect occur and the probability of stochastic effects is limited to an acceptably low level.
- To achieve this three principles applied:

1- Justification: to limit the use of x-rays and other ionizing radiations to those situations where the benefit clearly outbalances the risks. Unnecessary radiation is to be deplored.

2- Optimization (ALARA principle)

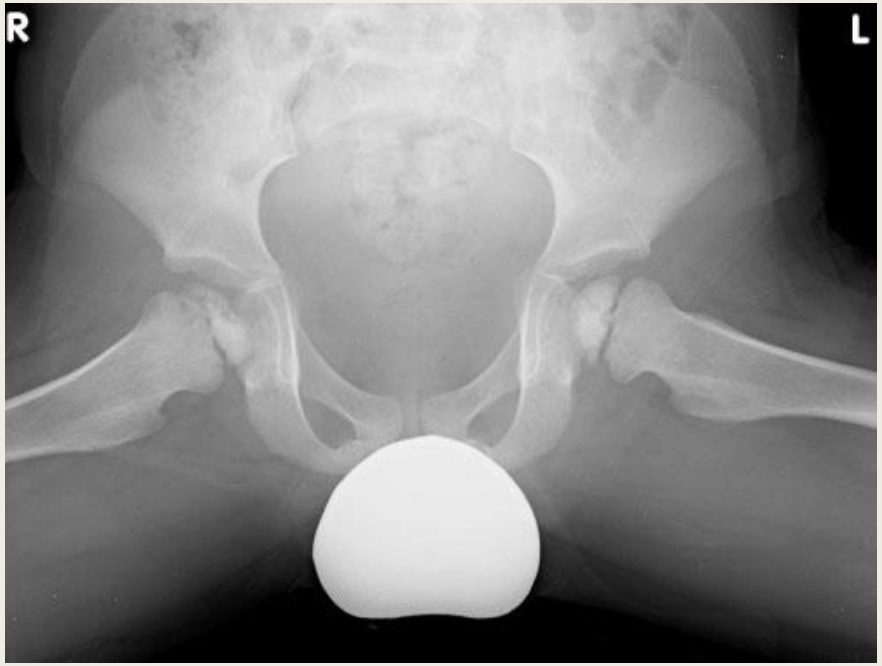
ALARA: ‘as low as reasonably achievable’ is applied through:

- The use of appropriate equipment and good technique – limiting the size of the x-ray beam to the required areas, limiting the number of films to those that are necessary, limit fluoroscopic screening time.
- Mobile equipment is only used when the patient is unable to come to the radiology department
- keeping repeat examinations to a minimum and ensuring that the examination has not already been performed.

- The avoidance of unnecessary requests for x-ray examinations, particularly those that involve high radiation exposure such as barium enema, lumbar spine x-rays and CT examinations. US or MRI should be used where possible. In other words, the imaging examination being requested must be justified on a case-by-case base
- Children are more sensitive to radiation than adults and are at greater risk of developing radiation-induced cancers many decades after the initial exposure, so in pediatric radiology, extra measures may be taken to minimize radiation dose including gonad shields , well collimation of x ray beam and adjustment of CT scanning parameters.


K.L TYPE
GONAD SHIELDS


E


R
L

3- Limitation:

- The total dose to any individual in a planned exposure situation should not exceed the dose limit specified by the legal authorities. This is to ensure that no individual is exposed to an unacceptable radiation risk.
- Usually applied to staff and public.

Type of limit	Occupational	Public
Effective dose	20 mSv per year, averaged over defined periods of 5 years	1 mSv in a year
Annual equivalent dose in		
Lens of the eye	150 mSv	15 mSv
Skin	500 mSv	50 mSv
Hands and feet	500 mSv	–

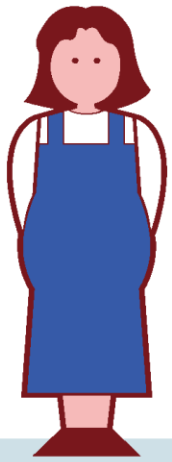
mSv millisievert, 1 sievert is equal to 100 roentgen equivalent in man (rem)

Radiation hazard of X ray during pregnancy

- Radiation to the developing fetus can have catastrophic effects. As well as the increased incidence of malformations induced in the developing fetus, it has been shown that the frequency with which leukaemia and other malignant neoplasms develop within the first 10 years of life is increased in children exposed to diagnostic x-rays while *in utero*, probably by about 40% compared with the normal population.

Effects on Fetuses

Deterministic Effects (Tissue Reactions) and Time Specificity



Period when important organs are formed
＝Period requiring careful attention to the use of drugs
＝Period when fetuses are vulnerable to radiation

Pre-implantation period
0 to 2 weeks after conception
- **Miscarriage**

Organogenesis period
2 to 8 weeks after conception
- **Dysplasia (malformation)**

Early fetal period
8 to 15 weeks after conception
- **Mental retardation**

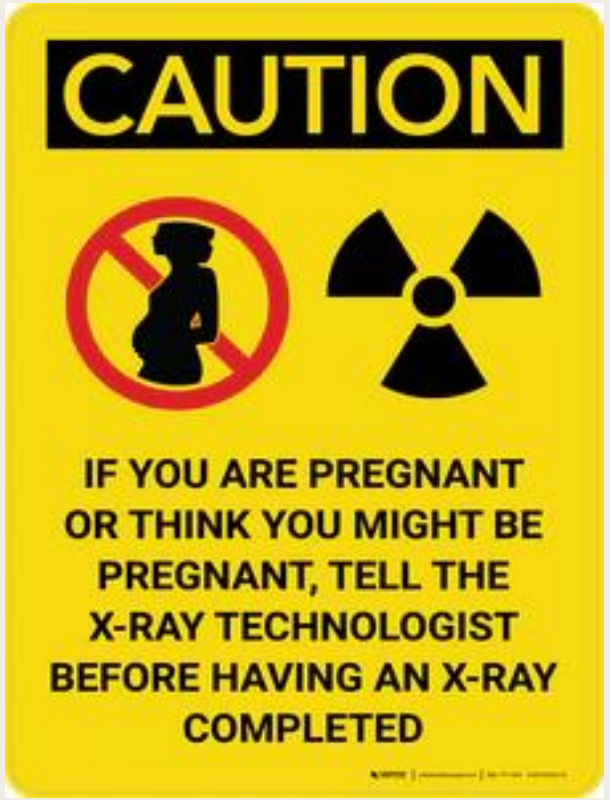
Late fetal period
15 weeks after conception to delivery

The threshold dose is 0.1 Gy or more.

* The time generally considered as two-week pregnancy is equivalent to zero weeks after conception.

General advices concerning the diagnostic radiological examinations in women of reproductive age:

- Radiation exposure of abdomen and pelvis should be minimized.
- All females of reproductive age asked if they could be pregnant prior to radiation exposure.
- Multilingual signs posted in the medical imaging department asking patients to notify the radiographer of possible pregnancy.


CAUTION
IF YOU ARE PREGNANT OR THINK YOU MIGHT BE PREGNANT, TELL THE X-RAY TECHNOLOGIST BEFORE HAVING AN X-RAY COMPLETED


خطر إشعاعي
Radiation Hazard
- لا يسمح للمرأة الحامل بالدخول.
- إذا كنت حامل أو هناك احتماليه بأن تكوني حامل, يرجى إخبار فني الأشعة بذالك على الفور.
- Pregnant Woman Should Not Enter.
- If You Are Pregnant or You Think You May Be, Please Inform The X-Ray Technologist First.


If there is any chance that you may be pregnant please inform the Radiographer before you are X-rayed.
PLEASE, MUM, TELL THEM I'M HERE!


NOTICE
PREGNANT PATIENTS
IF YOU ARE PREGNANT, OR THINK YOU MAY BE, PLEASE TELL THE X-RAY TECHNICIAN BEFORE HAVING AN X-RAY TAKEN.

- As organogenesis is unlikely to be occurring in an embryo in the first 4 weeks following the last menstrual period, this is not considered a critical period for radiation exposure.
- Organogenesis commences soon after the time of the first missed period and continues for the next three to four months. During this time, the fetus is considered to be maximally radiosensitive.
- Radiographic or CT examination of the abdomen or pelvis should be delayed if possible to a time when fetal sensitivity is reduced, i.e. post-24 weeks' gestation or ideally until the baby is born.
- Where possible, MRI or US should be used.

- When radiograph of areas remote from the fetus is required such as chest, skull, or hand, this may be done safely at any time during pregnancy with good collimation and properly shielded equipment.
- For nuclear medicine studies in the post-partum period, it is advised that breastfeeding be ceased and breast milk discarded for 2 days following the injection of radionuclide

Radiation protection of staff and public

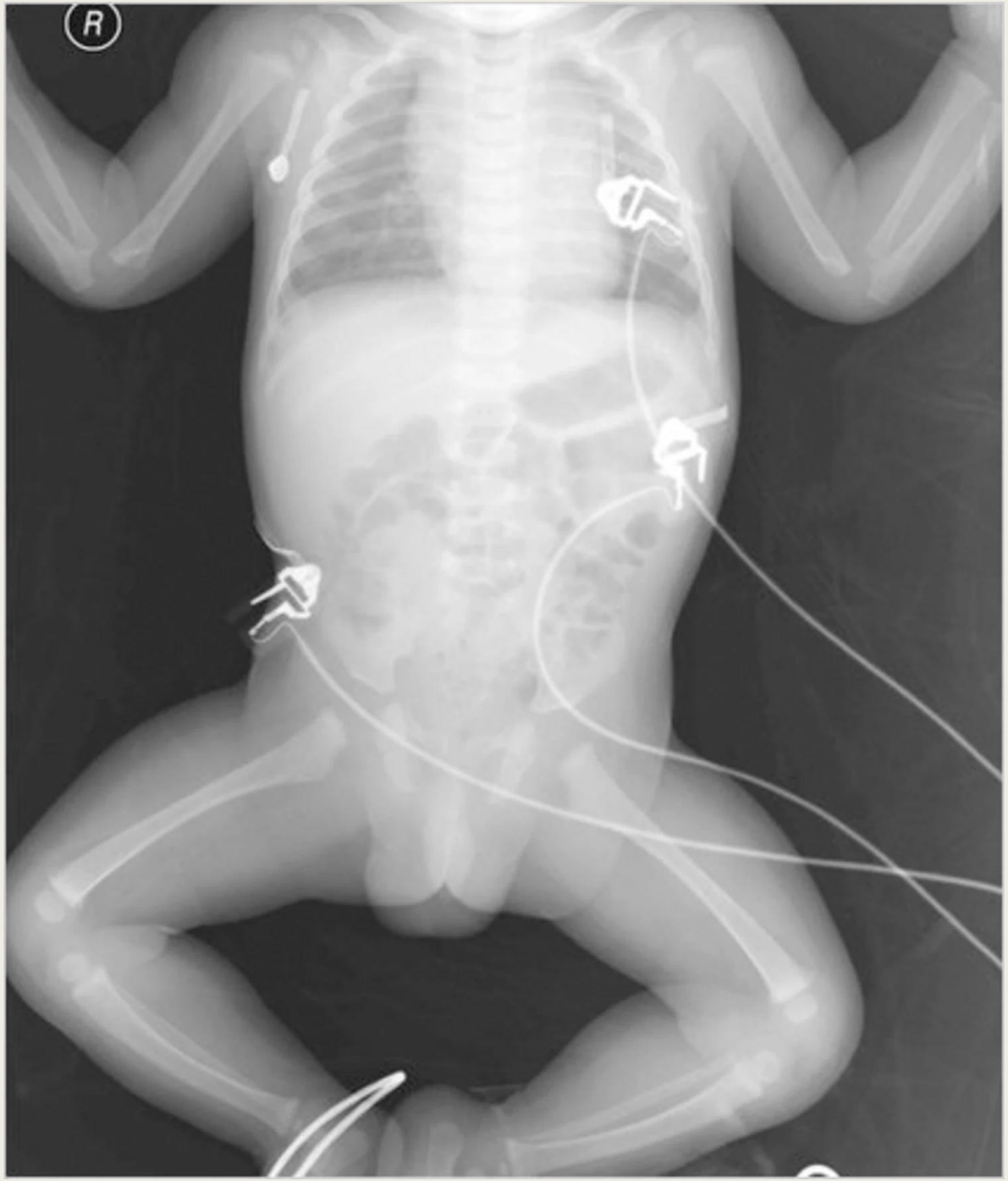
- Same principles of justification, optimization and dose limit.
- The presence of staff in a radiation area is only justified if they are essential to the procedure or if they are being trained.
- The public should be excluded from radiation areas unless they are accompanying a patient, e.g. a child, and their presence is essential
- Any thing reduce patient dose will also reduce staff dose (optimization).
- Staff should aware of three physical parameters that are essential for them: **distance, time and shielding.**

- **Distance**: the intensity of scattered radiation roughly decrease with square of distance from the source. So keeping distance is important.
- **Duration**: radiation exposure is directly proportional to the duration of exposure so may be minimized by conducting procedures as quickly as possible.
- **Shielding**: a barrier between the radiation source and the recipient will reduce the dose by an amount dependent on the (average) energy of the radiation and the composition and thickness of the barrier. Shielding is achieved by designing X-ray rooms with walls that contain lead shielding, by providing protective clothing and by use syringe shield in nuclear medicine.


Protective Collar
Protective Cap
Side Protective
Side Protective
mecan-medical.en.alibaba.com
Protective Scarf
Breast Protective

A baby sent for chest X ray

Spot two errors in acquiring the X ray



Contrast media

- The ability of conventional radiography and fluoroscopy to display a range of organs and structures may be enhanced using various contrast media.
- The most common contrast materials are based on barium or iodine.
- Barium and iodine are high atomic number materials that strongly absorb X-rays and are therefore seen as dense white on radiography.
- For demonstration of the gastrointestinal tract with fluoroscopy, contrast materials may be swallowed or injected via a nasogastric tube to outline the esophagus, stomach and small bowel, or may be introduced via an enema tube to delineate the large bowel.

- Gastrointestinal contrast materials are usually based on barium, which is non-water soluble. Occasionally, a water-soluble contrast material based on iodine is used for imaging of the gastrointestinal tract, particularly where aspiration or perforation may be encountered
- Iodinated water-soluble contrast media may be injected into veins, arteries, and various body cavities and systems. Iodinated contrast materials are used in CT, angiography (DSA) and arthrography (injection into joints).
- Gadolinium (Gd) is a paramagnetic substance that used as contrast agent in MRI

Hazards associated with the use of contrast material

- Anaphylactoid reactions to iodinated contrast media
- Contrast-induced nephropathy (CIN)
- Nephrogenic systemic sclerosis (NSF) due to Gd-containing contrast media.

Anaphylactoid reactions to iodinated contrast media

- Most patients injected intravenously with iodinated contrast media experience normal transient phenomena, including a mild warm feeling plus an odd taste in the mouth and rarely vomiting.
- More significant adverse reactions to contrast media may be classified as mild, intermediate or severe anaphylactoid reactions:
- Mild anaphylactoid reactions: mild urticaria and pruritis
- Intermediate reactions: more severe urticaria, hypotension and mild bronchospasm
- Severe reactions: more severe bronchospasm, laryngeal edema, pulmonary edema, unconsciousness, convulsions, pulmonary collapse and cardiac arrest

- Incidences of mild, intermediate and severe reactions with non-ionic low osmolar contrast media are 3, 0.04 and 0.004 per cent, respectively.
- Fatal reactions are exceedingly rare (1:170 000).

Certain predisposing factors known to increase the risk of anaphylactoid reactions including:

- History of asthma or atopy
- Previous anaphylactoid reaction to iodinated contrast media: (40 % risk of further reactions).


D

Contrast-induced nephropathy

- Contrast-induced nephropathy (CIN) refers to a reduction of renal function (defined as greater than 25 per cent increase in serum creatinine) occurring within 3 days of contrast medium injection. Most cases of CIN are self-limiting with resolution in 1–2 weeks. Dialysis may be required in 15% of cases.

Risk factors for the development of CIN include:

- Pre-existing impaired renal function, particularly diabetic nephropathy
- Dehydration
- Sepsis
- Age >60 years
- Recent organ transplant
- Multiple myeloma.

Nephrogenic systemic sclerosis (NSF)

- is a rare complication of some Gd-based contrast media in patients with renal failure.
- Onset of symptoms may occur from one day to three months following injection.
- Initial symptoms consist of pain, pruritis and erythema, usually in the legs. As NSF progresses there is thickening of skin and subcutaneous tissues, and fibrosis of internal organs including heart, liver and kidneys.
- Identifying patients at risk, including patients with known renal disease, diabetes, hypertension and recent organ transplant, may reduce the risk of developing NSF following injection of Gd based contrast media.

Side Effects of Gadolinium-Based Contrast Dyes

Common

Headache

Cold sensation when injected

Nausea

Dizziness

Rare

Itchy skin

Nephrogenic systemic fibrosis

References

- Farr’s physics for medical imaging.
- Imaging for students by David A. Lisle
- Diagnostic imaging by Peter Armstrong

THANK YOU