بنام خداوند جان و خرد

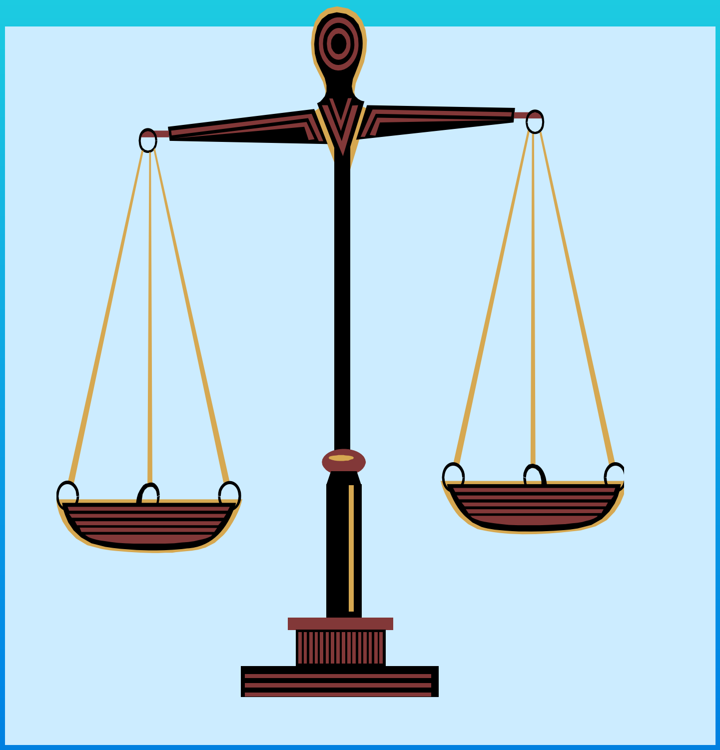
اصول کلی حفاظت بیمار و کارکنان

در بخش رادیولوژی

پریناز محنتی

استاد گروه فیزیک پزشکی

optimization of
Patient Examination



Diagnostic Objective **Medical Exposure**

Protection from What?

- Unnecessary examination or treatment (justification)
- Unnecessary exposure (optimization)
- Inadequate examinations, which can lead to incorrect or incomplete diagnosis (optimization)

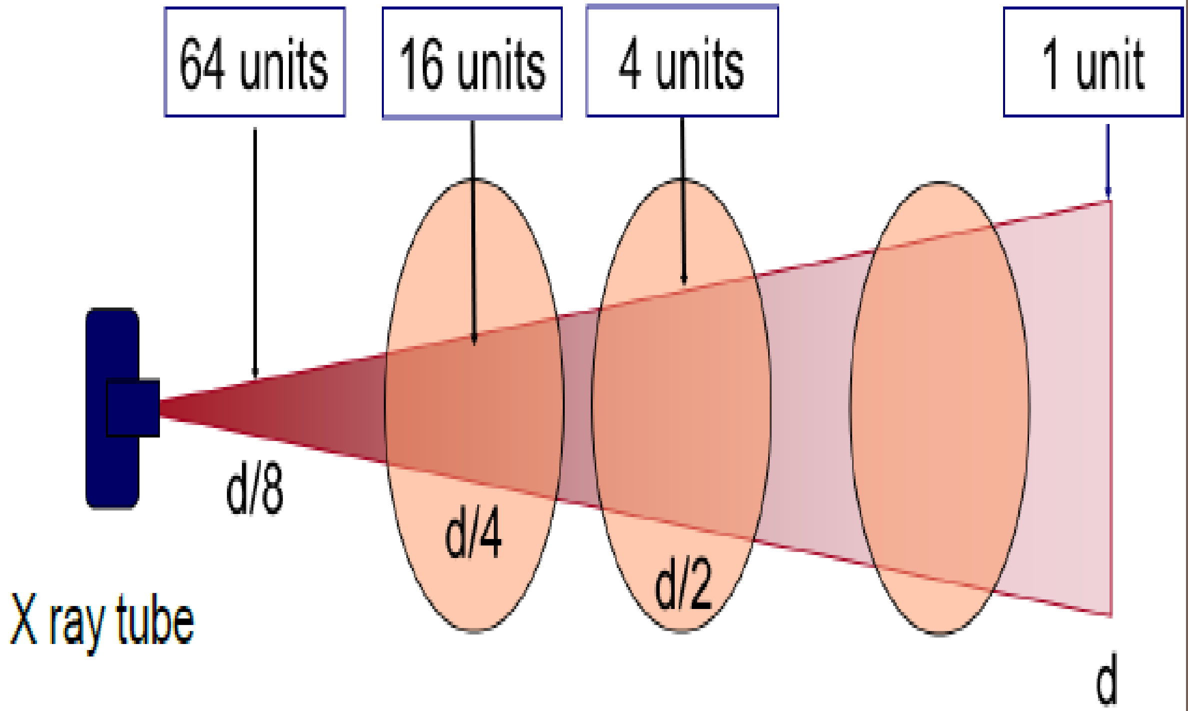
Patient protection objective

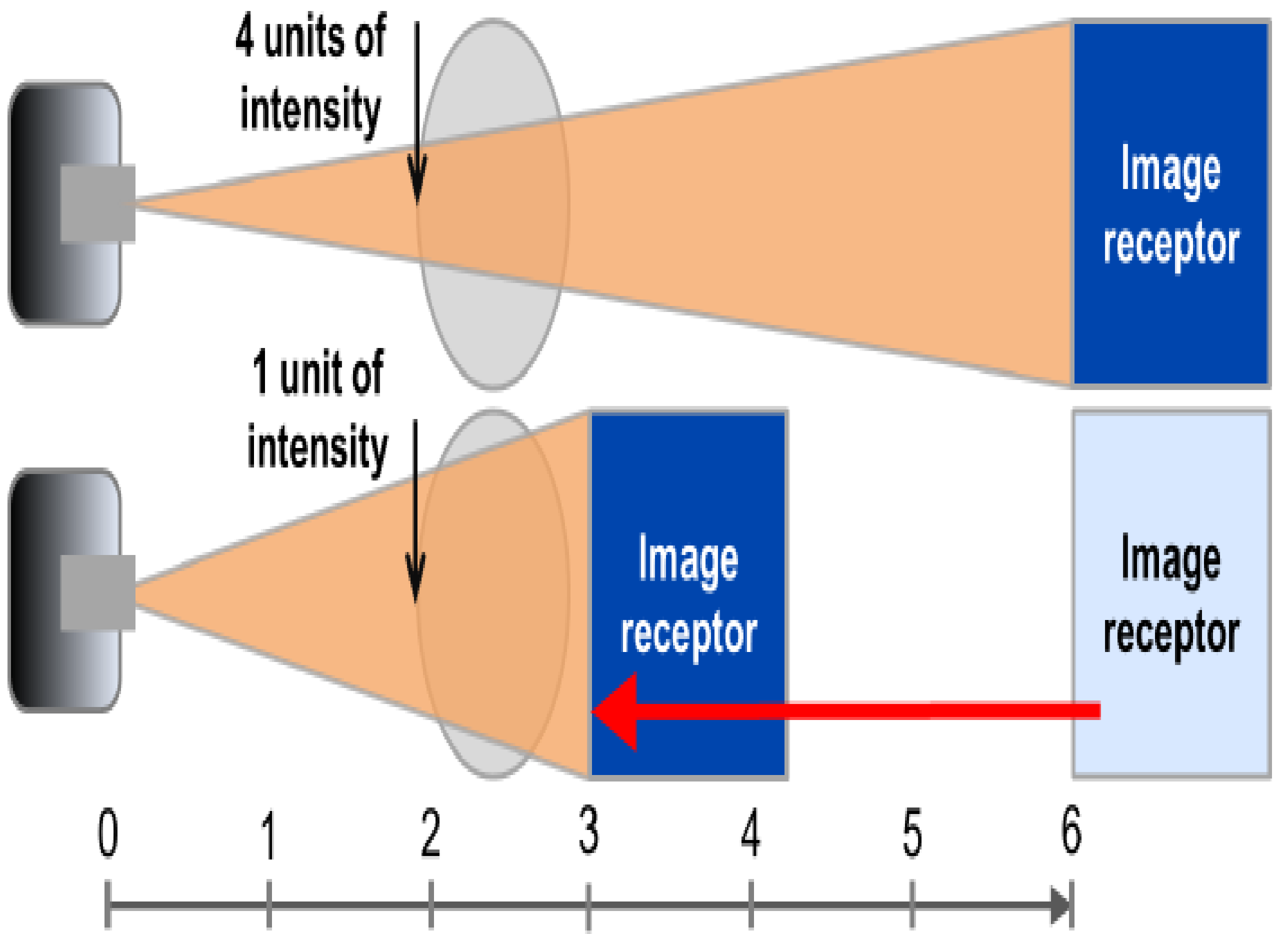
- 1. **To clarify the main goals of patient exposure monitoring and its elements.**
- **2. To understand the patient radiation exposure monitoring workflow and available standards for data recording and collecting.**
- **3. To learn about analytical uses of exposure data and their use for improving patient radiation protection.**
- **4. To summarize the essential features and challenges for the implementation of automatic patient radiation exposure monitoring systems.**

10 pearls:

Radiation Protection of *patient* in Radiology

1. Maximize distance between the X ray tube and the patient to the extent possible

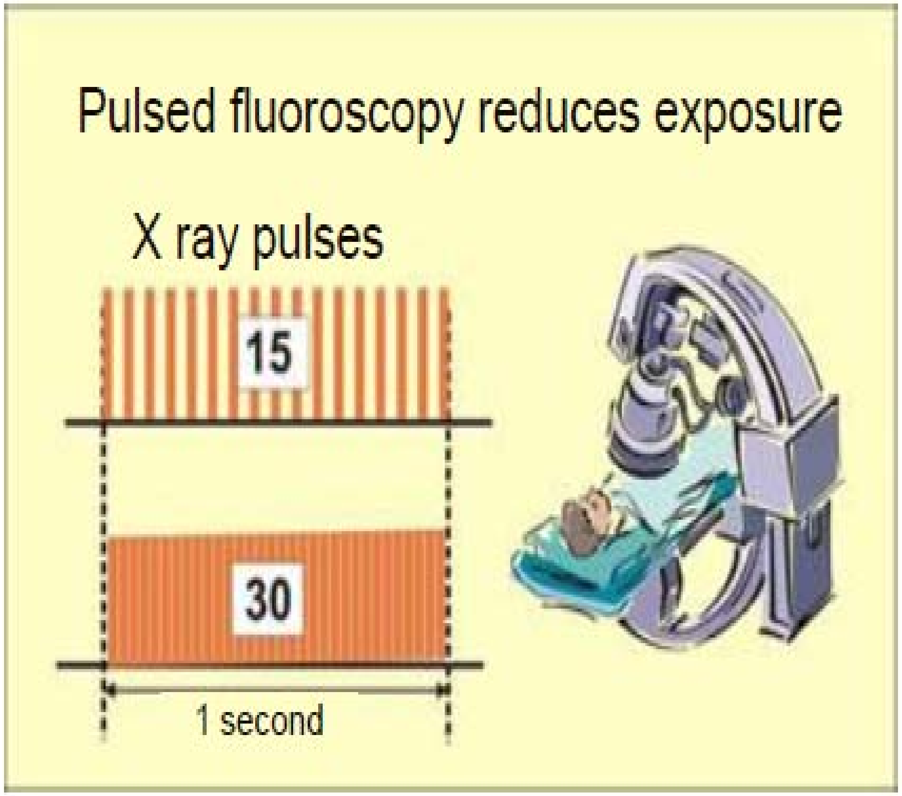




2. Minimize distance between the patient and the image receptor

3. Minimize fluoroscopy time

Keep records of fluoroscopy time and DAP/KAP (if available) for every patient



4. Use pulsed fluoroscopy with the lowest frame rate possible to obtain images of acceptable quality

5. Avoid exposing the same area of the skin in different projections

Vary the beam entrance port by rotating the tube around the patient

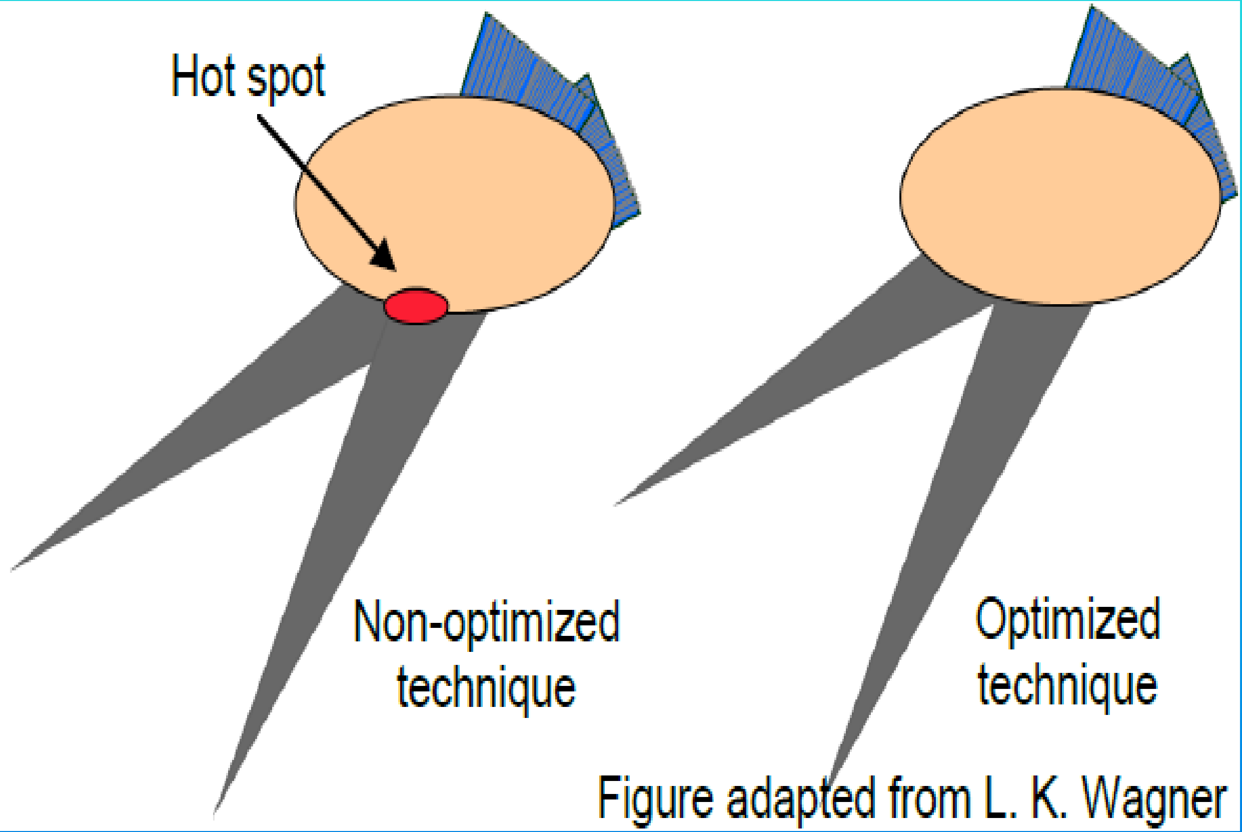
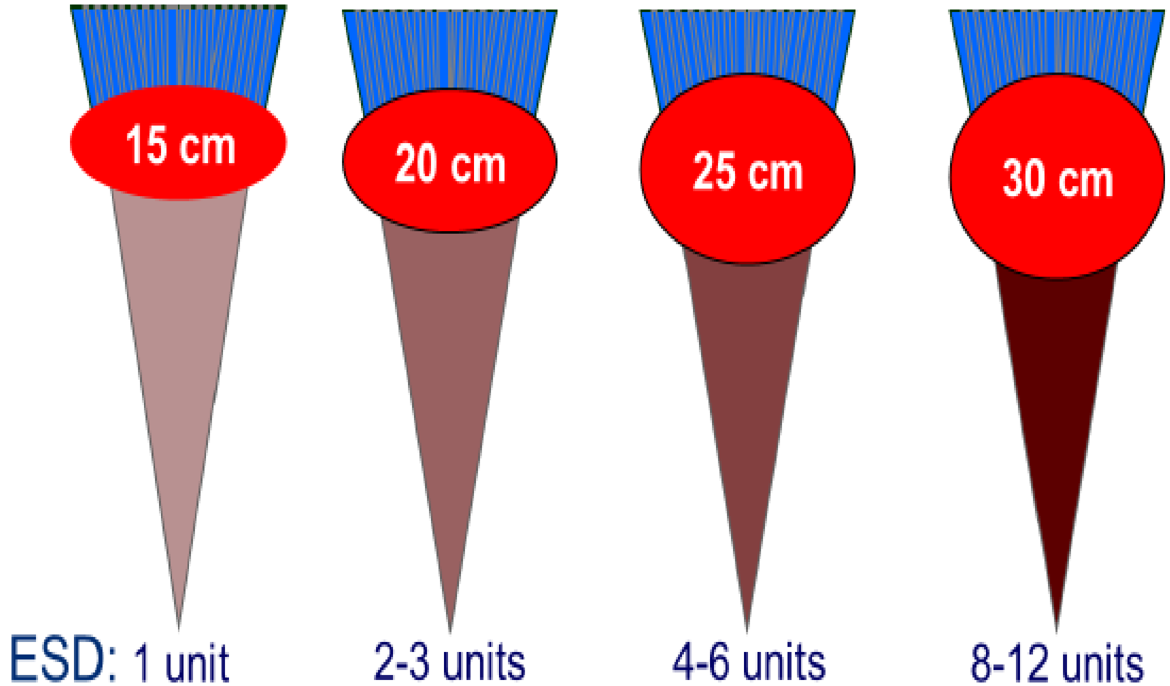
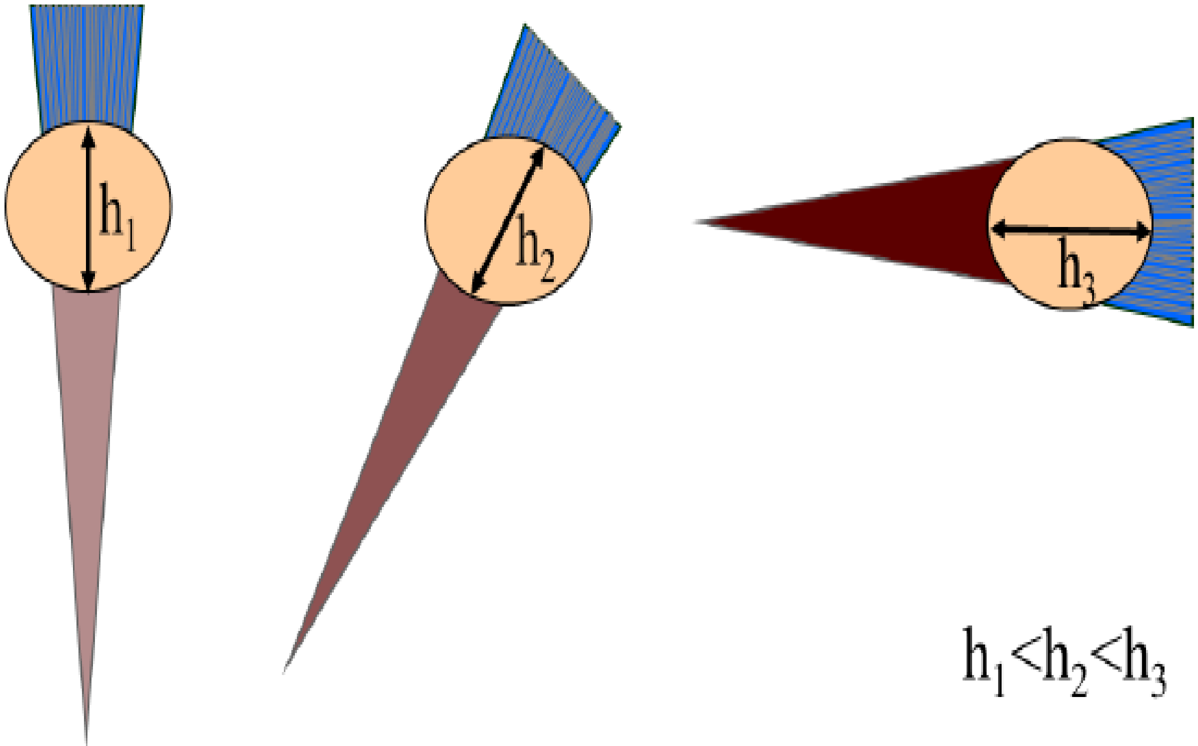


Figure adapted from L. K. Wagner

6. Larger patients or thicker body parts trigger an increase in entrance surface dose (ESD)





7. Oblique projections also increase ESD

Be aware that increased ESD increases the probability of skin injury

INTENSIFIER Field-of-view (FOV)	RELATIVE PATIENT ENTRANCE DOSE RATE FOR SOME UNITS
12" (32 cm)	100
9" (22 cm)	177
6" (16 cm)	400
4.5" (11 cm)	711

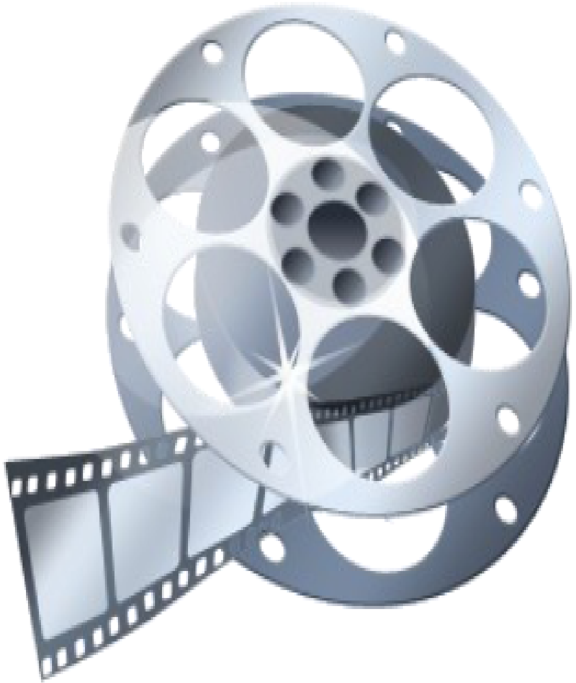
8. Avoid the use of magnification

Decreasing the field of view by a factor of two increases dose rate by a factor of four

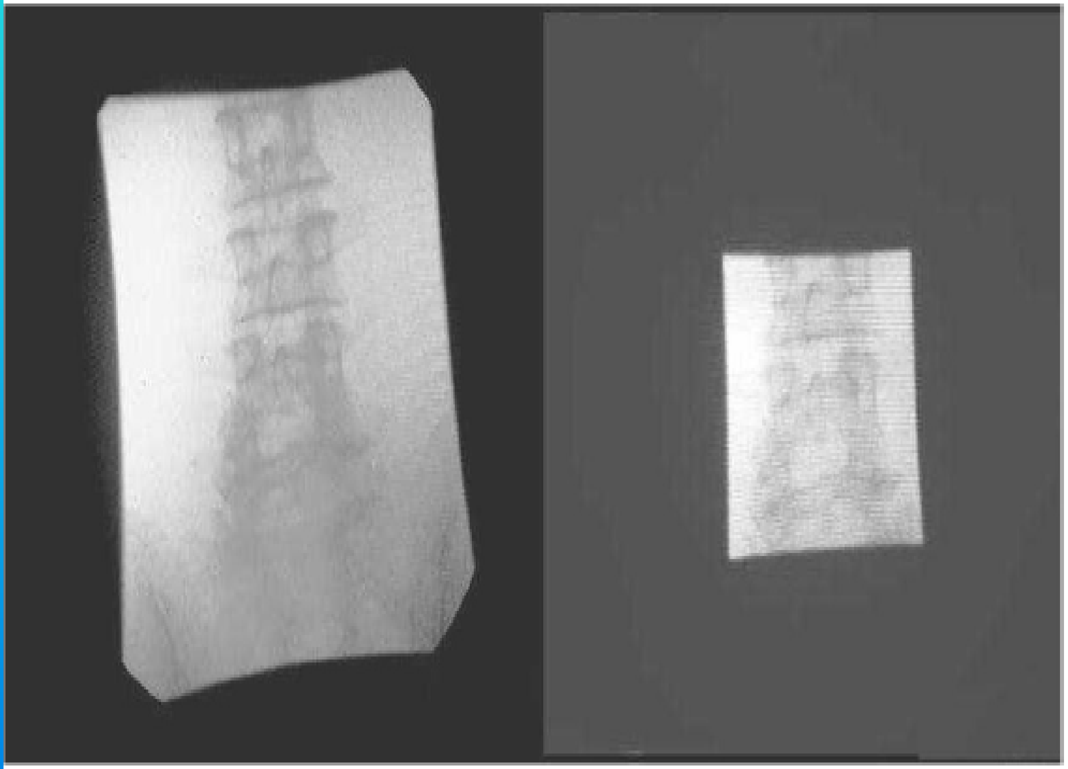
9. Minimize number of frames and cine runs to clinically acceptable level

Avoid using the acquisition mode for fluoroscopy

Cine dose rate ≈ (10-60) × normal fluoroscopy dose rate



Documentation should be performed with last image hold whenever possible and not with cine images



10. Use collimation

Collimate the X ray beam to the area of interest

Using radiation protection shield

Using radiation protection shield

- Lead shields
- Bismuth shields

Composite

- Bismuth Silicon

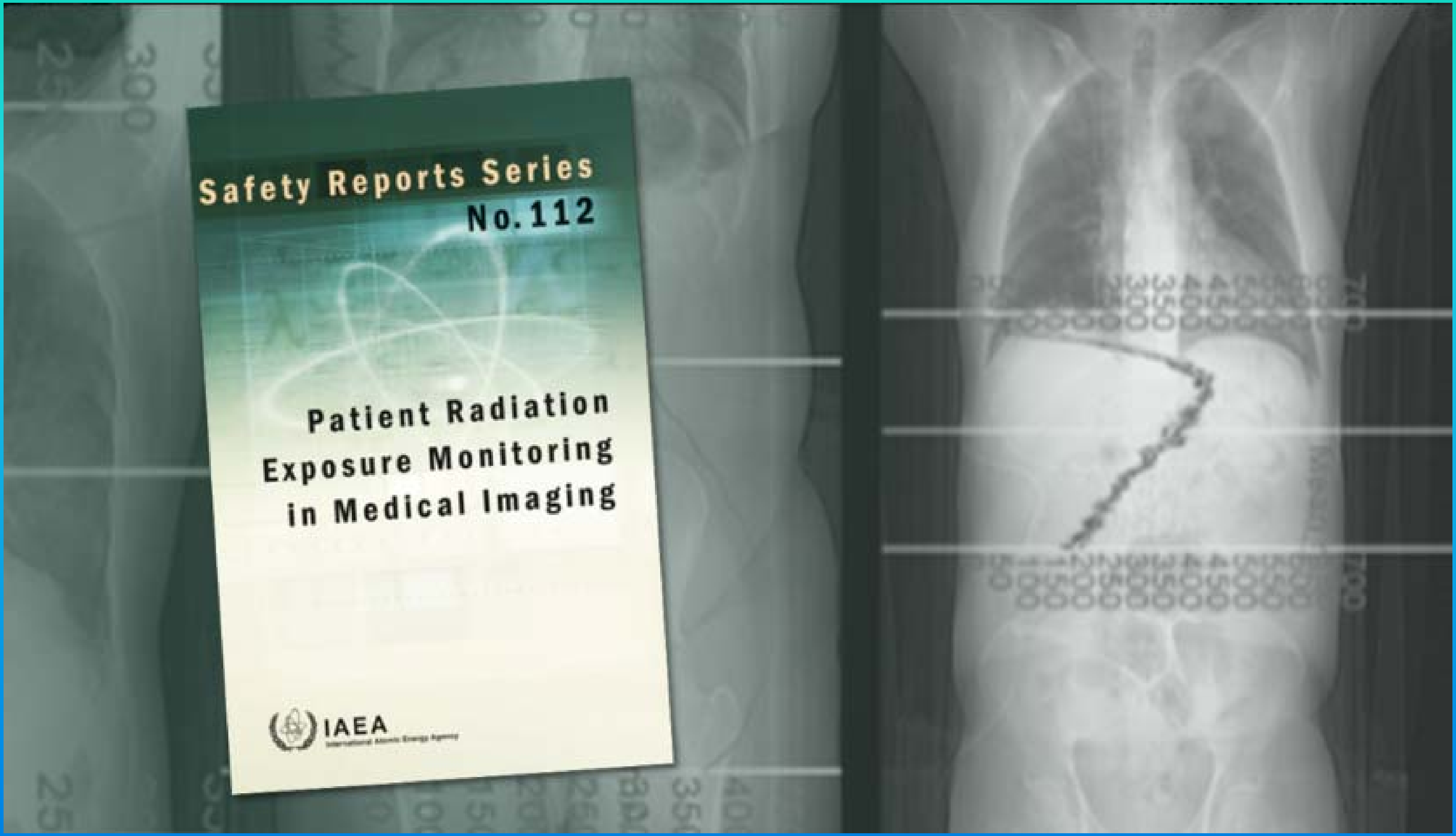
- Bismuth Polyurethane

IAEA

RPOP
Radiation Protection of Patients

به امید رعایت اصول حفاظت بیمار

در تمام بخش های رادیولوژی


Safety Reports Series
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Exposure Monitoring
in Medical Imaging
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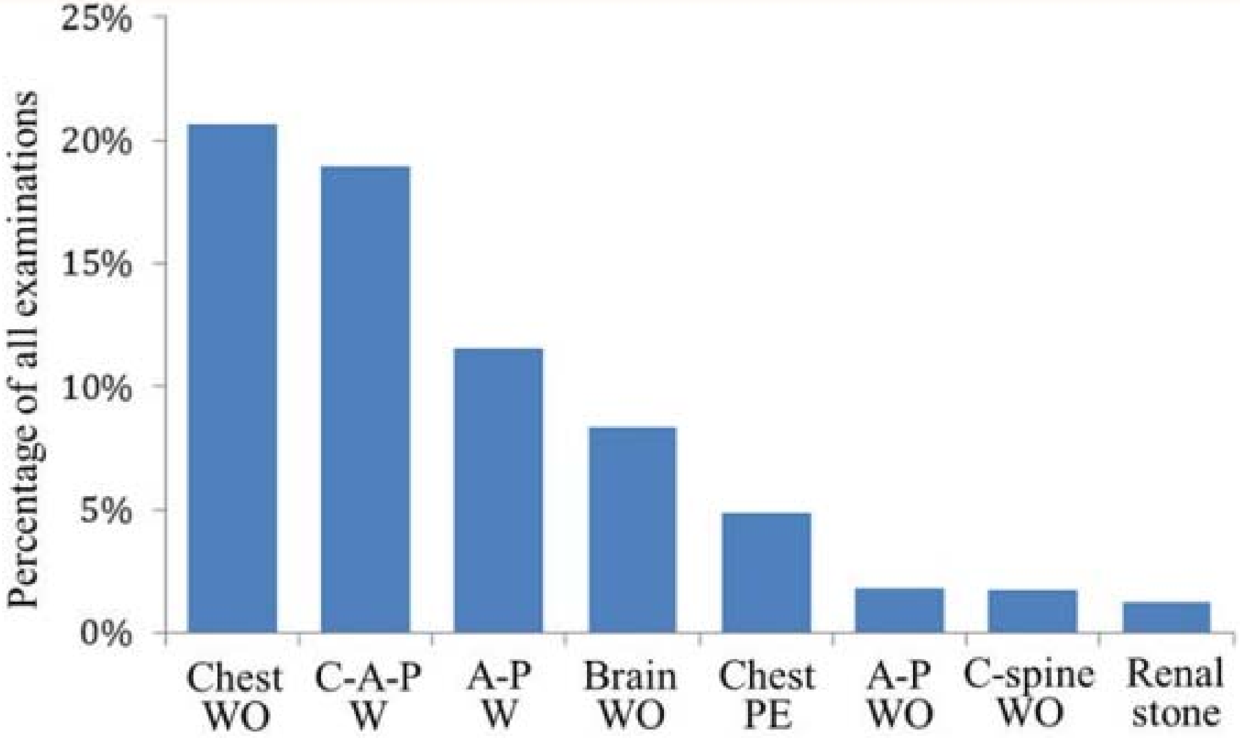


FIG. 18. Frequency of the most common CT examinations performed at one institution (chest WO: chest examination without contrast; C-A-P W: chest–abdomen–pelvis examination with contrast; A-P W: abdomen–pelvis examination with contrast; brain WO: brain examination without contrast; chest PE: chest pulmonary embolism examination; A-P WO: abdomen–pelvis examination without contrast; C-spine WO: cervical spine examination without contrast; renal stone: renal stone examination) (courtesy of E. Samei, Duke Medical Center, USA).

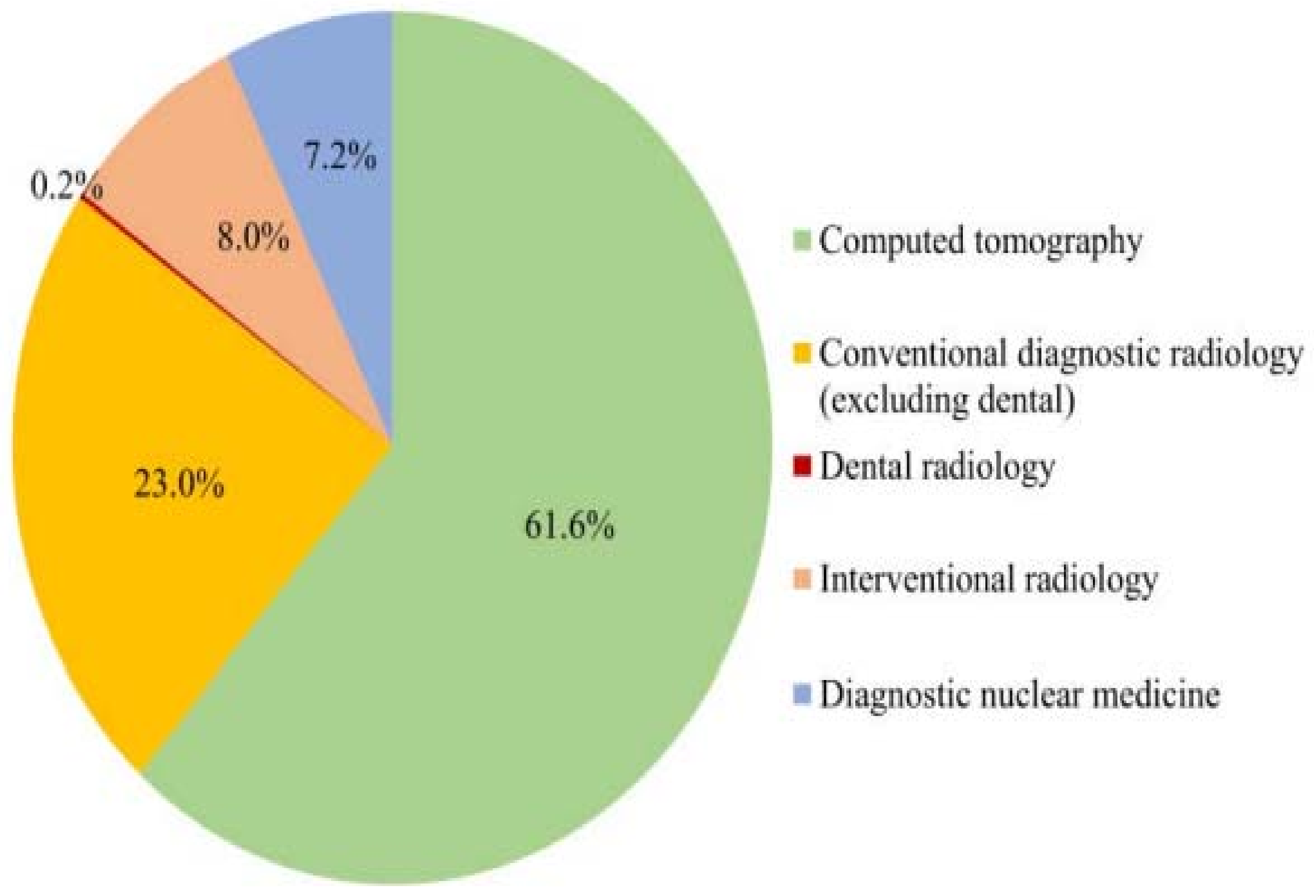


FIG. 22. Relative contributions of the five main groups of medical radiological examinations to the overall collective effective dose (based on data from Ref. [2]).

10 pearls: Radiation Protection of *staff* in Radiology

Reduction patient dose always results in staff dose reduction

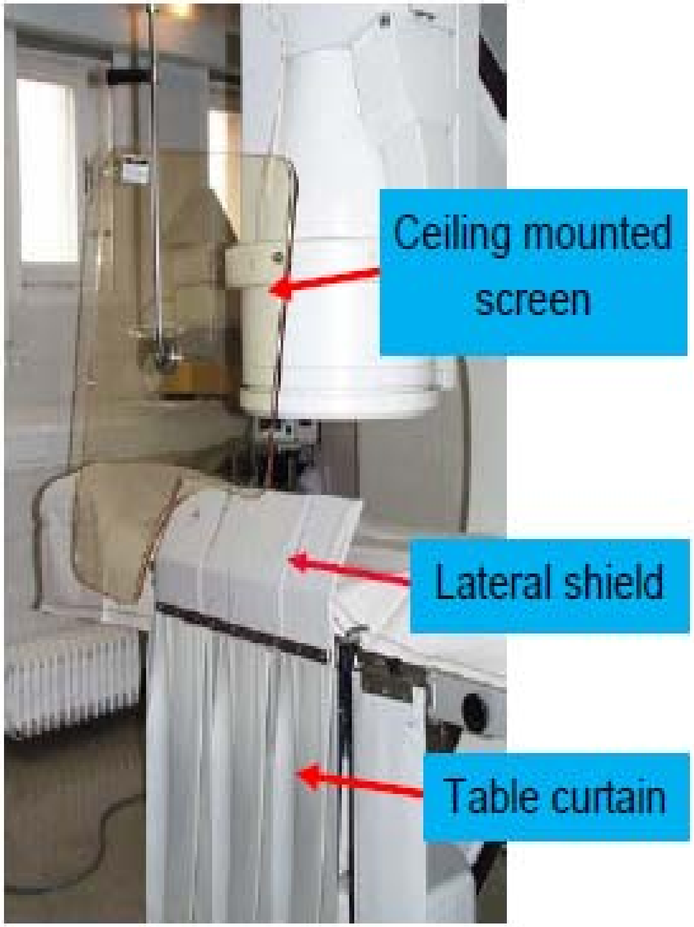
1. Use protective devices!

Advisable skirt type lead apron to distribute weight

0.25 mm lead equivalence but with overlap on front to make it 0.5 mm on the front and 0.25 mm on the back **(Provides >90% protection)**

Lead glass eyewear with side protection

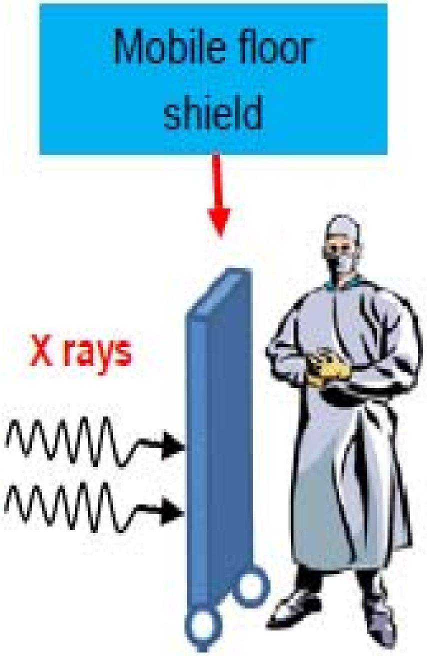
Thyroid protection



3. Use ceiling suspended screens, lateral shields and table curtains

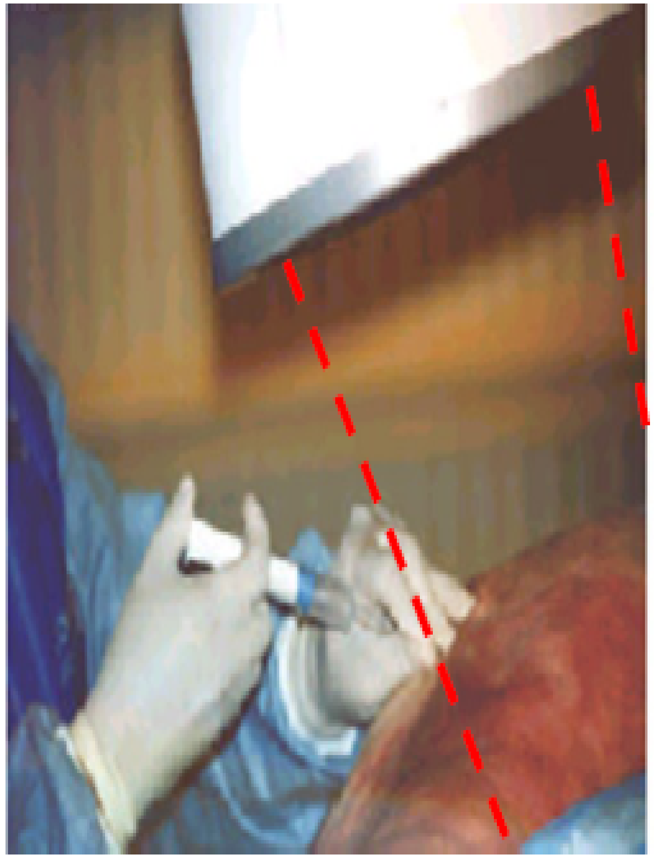
They provide more than 90% protection from scattered radiation in fluoroscopy

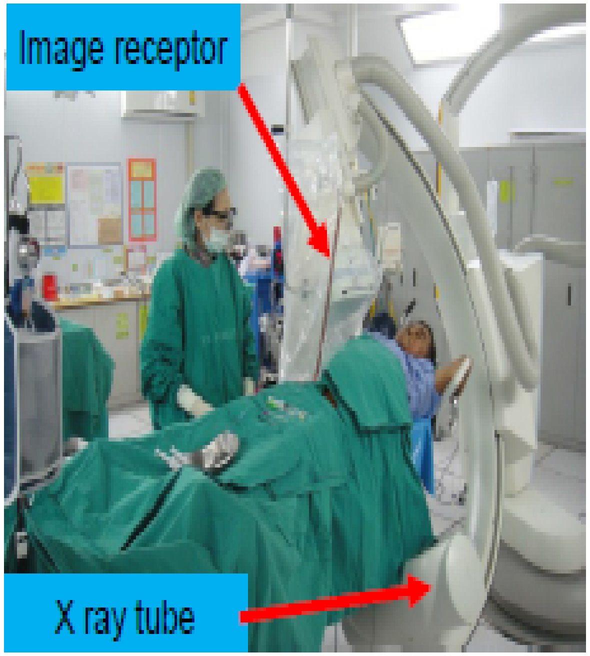
Mobile floor shielding is advisable when using cine acquisition



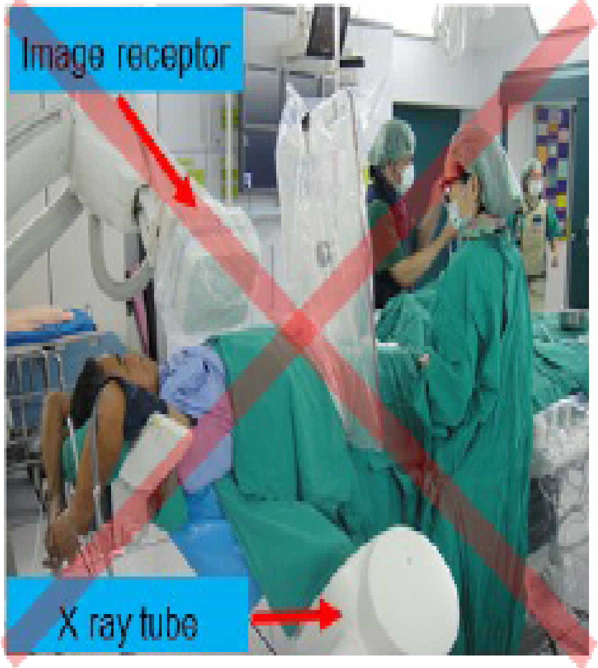
4. Keep hands outside the primary beam unless totally unavoidable

Hands inside the central area of the primary beam will increase exposure factors (kV, mA) and doses to patient and staff





Right!



Wrong!

5. Only 1-5% of radiation falling on the patient's body exits the other side

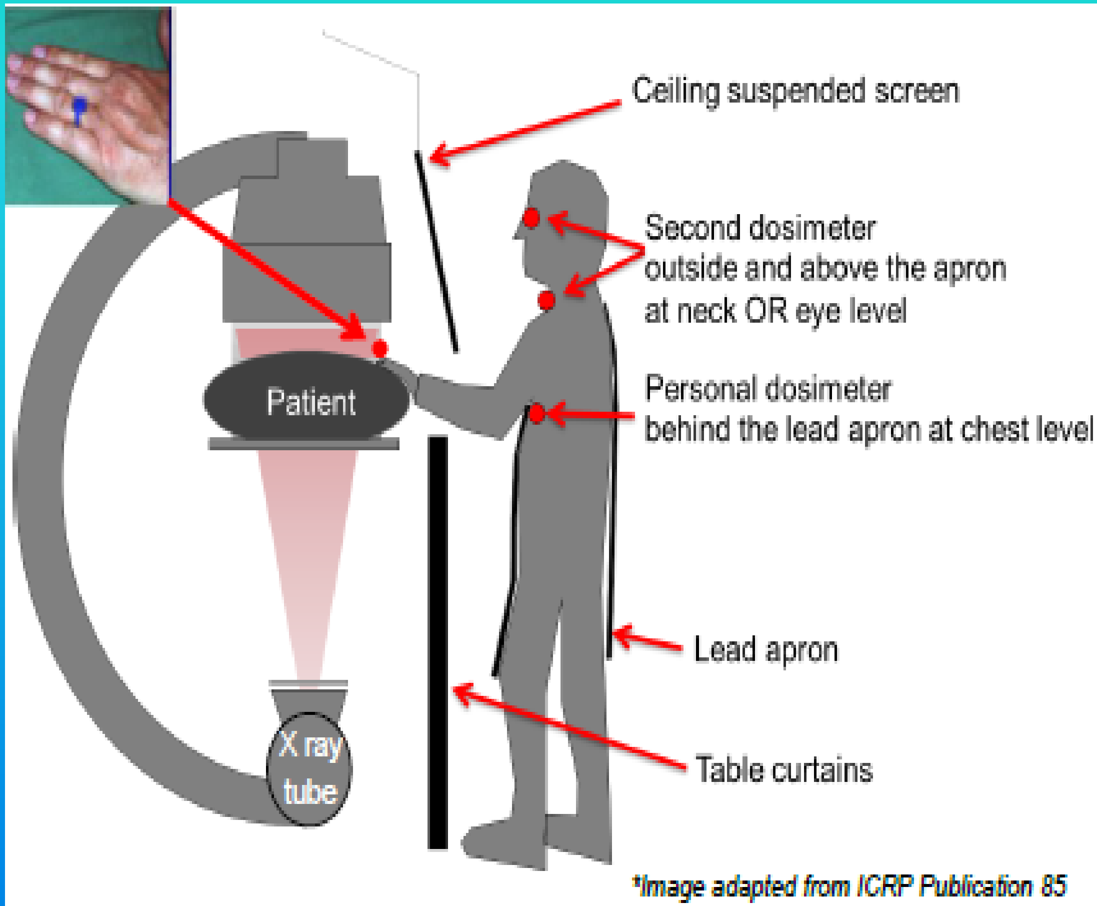
Stand on the side of the *transmitted* beam (i.e. by the *detector*), which contains only 1-5% of the incident radiation and its respective scatter

6. Keep X ray tube under the patient table and not over it

Undercouch systems provide better protection from scattered dose

Right!

Wrong!



7. Use personal dosimetry

Use at least two dosimeters

- One inside the apron at chest level
- One outside the apron at neck or eye level
- Additional finger ring dosimeter for procedures requiring hands close to primary beam

Real time dosimetry systems are useful

8. Update your knowledge about radiation protection

9. Address your concerns about radiation protection to radiation protection specialists (medical physicists)

10. REMEMBER!

- Quality control testing of fluoroscopy equipment enables safe and stable performance
- Know your equipment! Using the equipment's features appropriately will help reduce doses to patients and staff
- Use injector devices

Summary points to remember

- Be aware of the indications - use procedure that employs ionizing radiation only when risk-benefit considerations are clearly in favour of benefit;
- Keep X-ray tube at practical away from the patient and image intensifier as close to patient as possible;
- Use ALARA (as low as reasonably achievable) principle;

Summary points to remember

- Use personal protective devices: lead apron, lead glass eye wear, thyroid shield and other shielding in particular for eye, legs.
- Ensure that they are well maintained and of proper lead equivalence. Know which side to stand (better away from X-ray tube and be on image intensifier side). Use TDS (Time, distance, shielding) principle.

Summary points to remember

- Use inverse square law: step behind wherever possible;
- Use patient dose management techniques: collimation, filter, lesser magnification, pulsed fluoroscopy, lesser number of pulses, avoid or reduce use of oblique views;
- Ensure that equipment is tested for QC and radiation output is not more than standard as compared to published values;

Summary points to remember

- Pregnancy and otherwise: Cut down irradiation of fetal/abdomen (non-target area) by collimation and shielding of primary beam;
- Dosimetry: Use dosimeter for yourself and staff;
- Patient dosimetry: record dose area product meter (DAP) values or other dose indicator. If DAP is not available, record at least fluoro time and number of images, along with kVp, mAs;
- Avoid unnecessary personnel inside the X-ray room.

ISEMIR

Information System on Occupational Exposure in Medicine, Industry and Research

به امید رعایت موازین حفاظت پرتوی

توسط کارکنان پرتوکار

GOAL OF RADIATION PROTECTION

- Avoid deterministic effects ✓
- ✓ جلوگیری از اثرات قطعی
- Reduction of stochastic effects ✓
- ✓ کاهش اثرات احتمالی

Principles of Radiation Protection

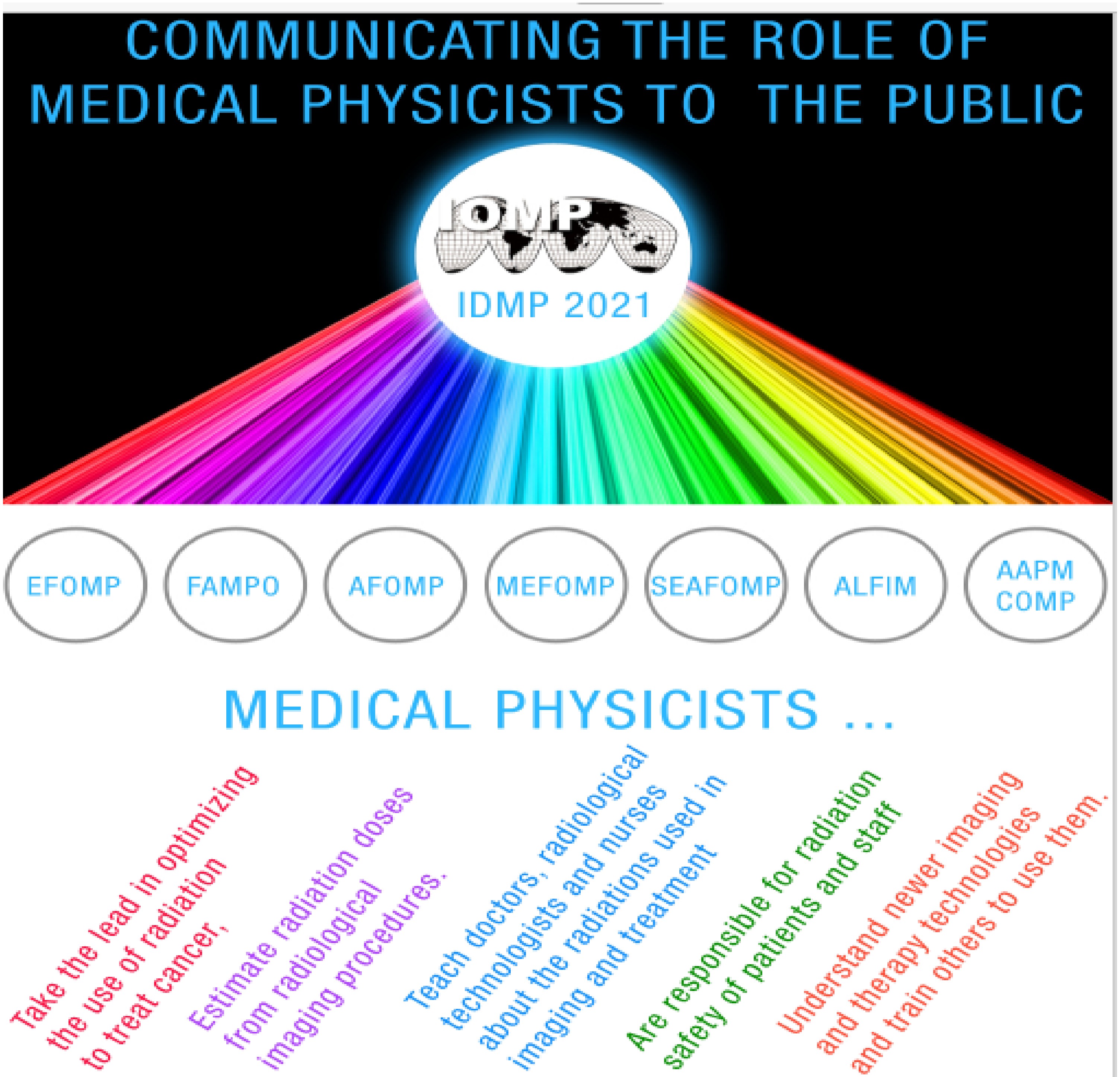
- توجیه پذیری فعالیت (Justification)
- بهینه سازی حفاظت (Optimization)

ALARA= **A**s **L**ow **A**s **R**easonably **A**chievable

- حدود دُز فردی (Dose Limits)

- ✓ **Medical Radiation**
- ✓ **Occupational Radiation**
- ✓ **Public Radiation**

Radiation Safety Officer (RSO)


COMMUNICATING THE ROLE OF
MEDICAL PHYSICISTS TO THE PUBLIC
IOMP
IDMP 2021
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FAMPO
AFOMP
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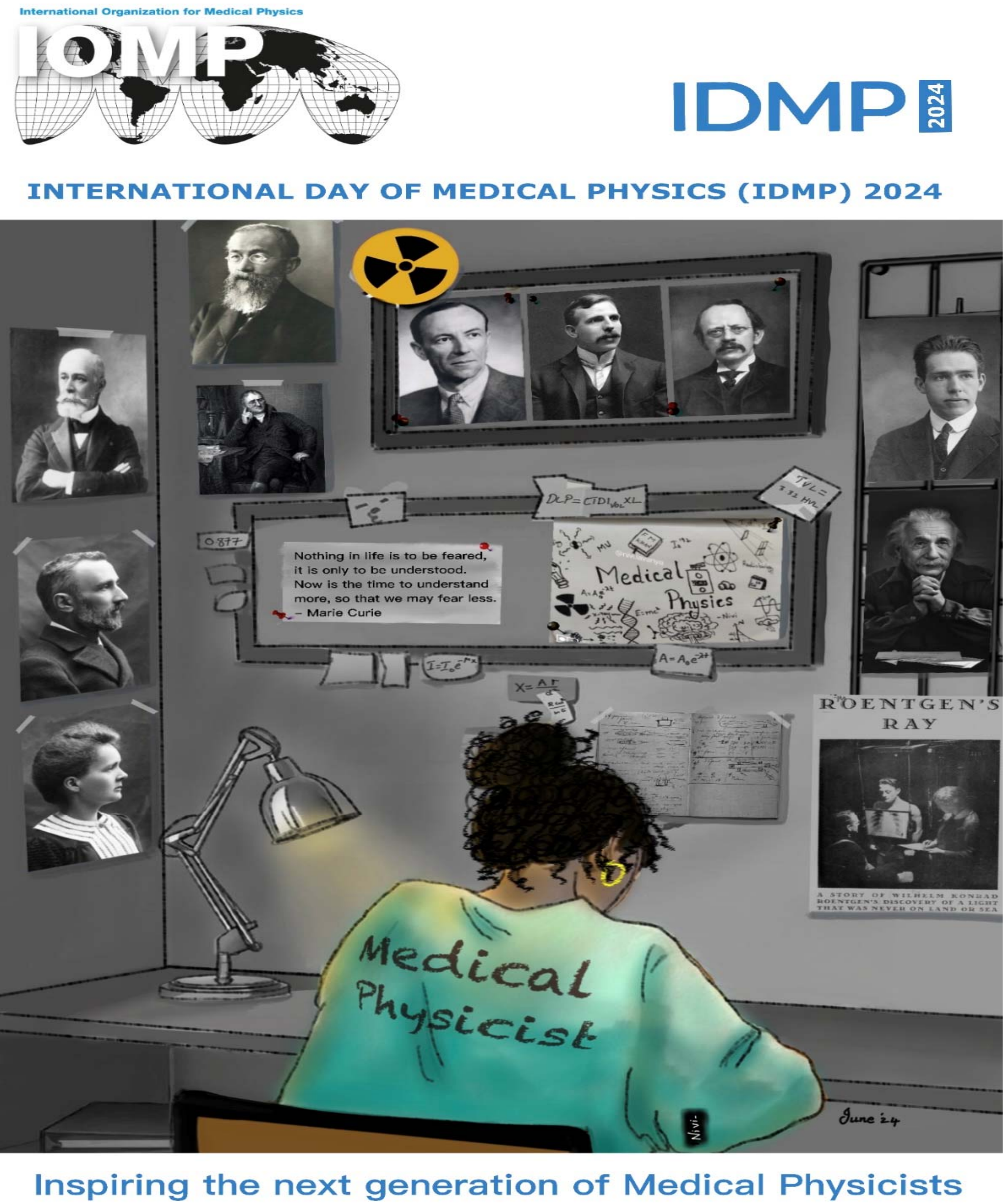
MEDICAL PHYSICISTS ...
Take the lead in optimizing the use of radiation to treat cancer,
Estimate radiation doses from radiological imaging procedures.
Teach doctors, radiological technologists and nurses about the radiations used in imaging and treatment
Are responsible for radiation safety of patients and staff
Understand newer imaging and therapy technologies and train others to use them.



https://www.dkfz.de/en/hiro/idmp_en/IDMP2024/idmp2024_en.html#section1

تبریک روز جهانی رادیولوژی و فیزیک پزشکی

بنام خدا

بنام بالاترین

بهترین

زیباترین

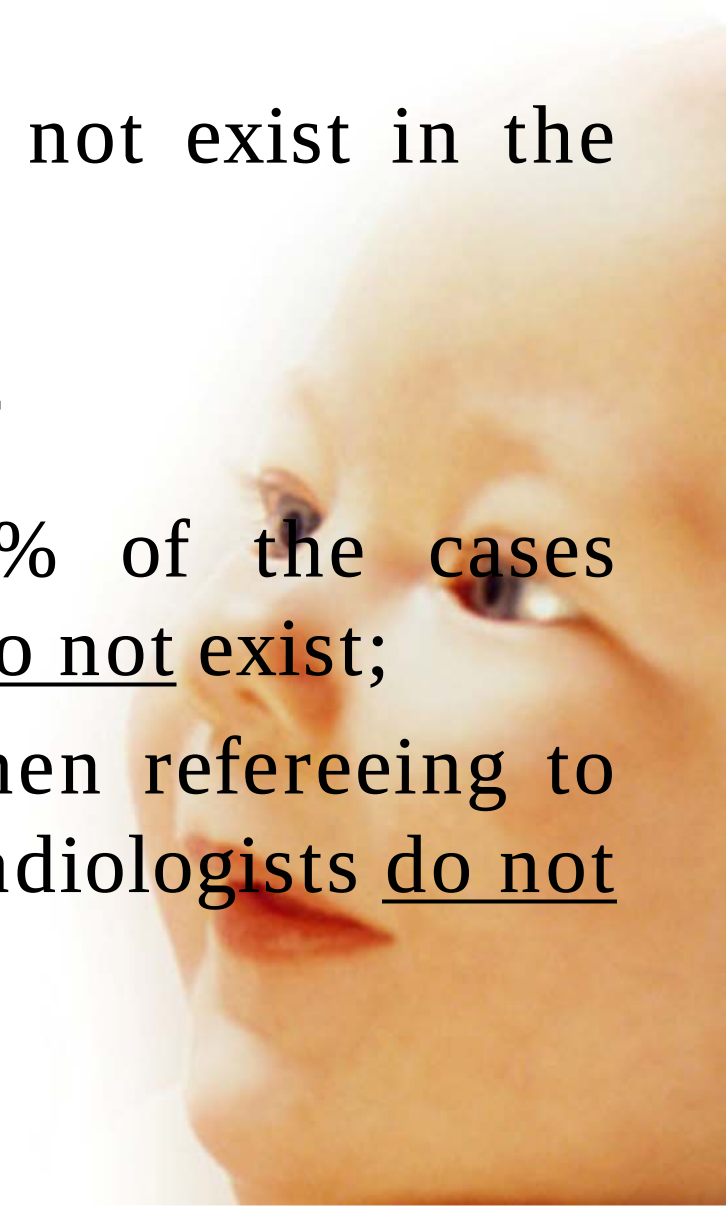
حفاظت پرتوی در تصویربرداری کودکان

دکتر محنتی
گروه فیزیک پزشکی

Why pediatrics are sensitive to radiation?

مقالات مربوط به پرتوگیری کودکان

- Dedicated pediatric CT rooms do not exist in the country
- The average frequency of pediatric CT examinations (0-18y) is 4.9% of
- all X-ray examinations In 17% of the cases dedicated protocols for children <u>do not</u> exist;
- Previous images are required when refereeing to CT in 86% of cases but 100% of radiologists <u>do not</u> require patient dose records

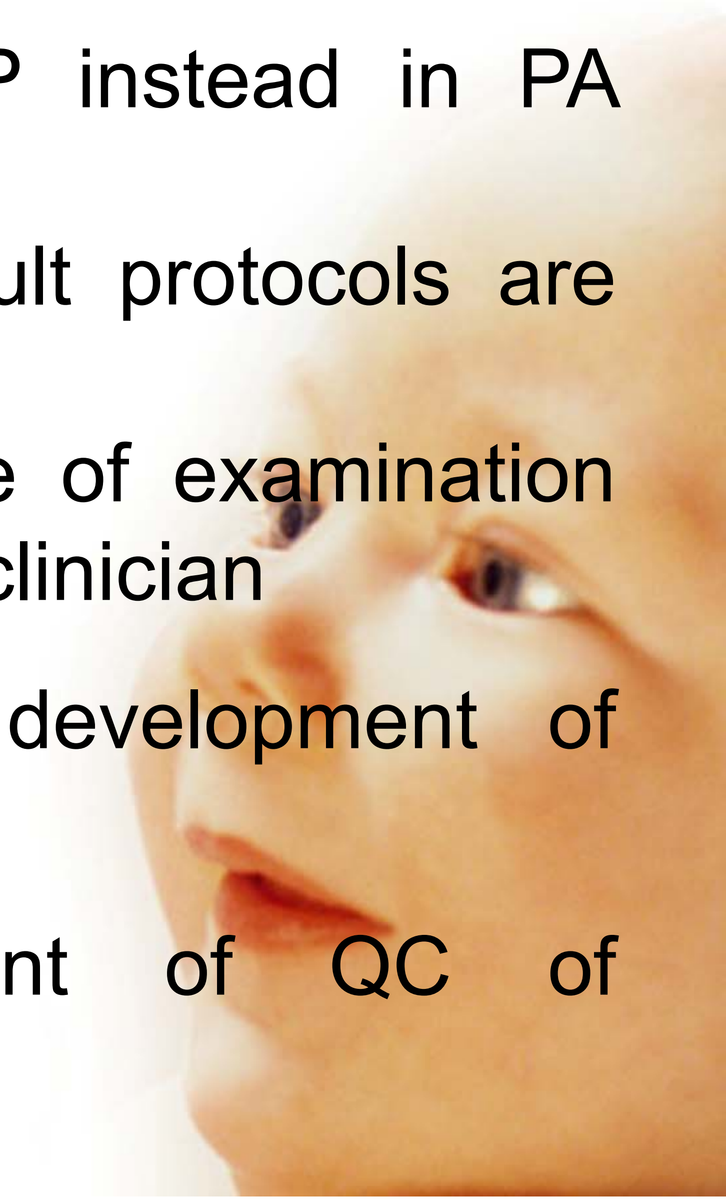


مقالات مربوط به پرتوگیری کودکان

- scout image is performed in AP instead in PA projection
- for children older than 10 ys adult protocols are used
- no agreement on the first choice of examination between radiologist and refereeing clinician

- It is necessary to implement development of dedicated protocols and guidelines

- Try to encourage improvement of QC of equipments



مقالات مربوط به پرتوگیری کودکان

CT dose study within IAEA RER9093

Main problems found – children protocols available but not used in some hospitals, protocols not optimized, no eye shielding used

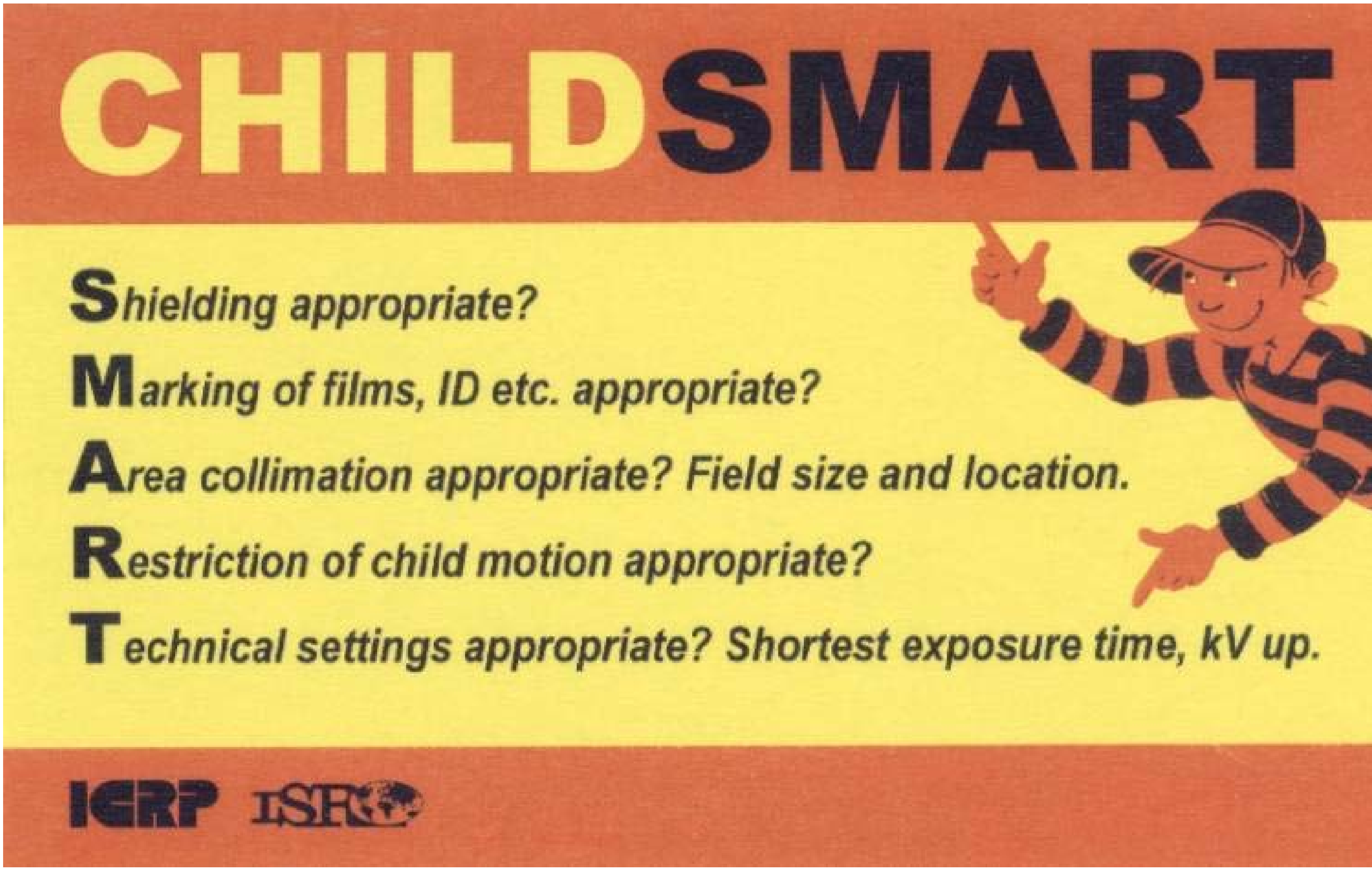
Actions to do

- Requirements on CT units regarding children
  - AEC & children protocols available
- Requirements on general radiology units regarding children
  - Short exposure times available ≤ 10 ms, kerma reproducibility of the setting better than 5 %

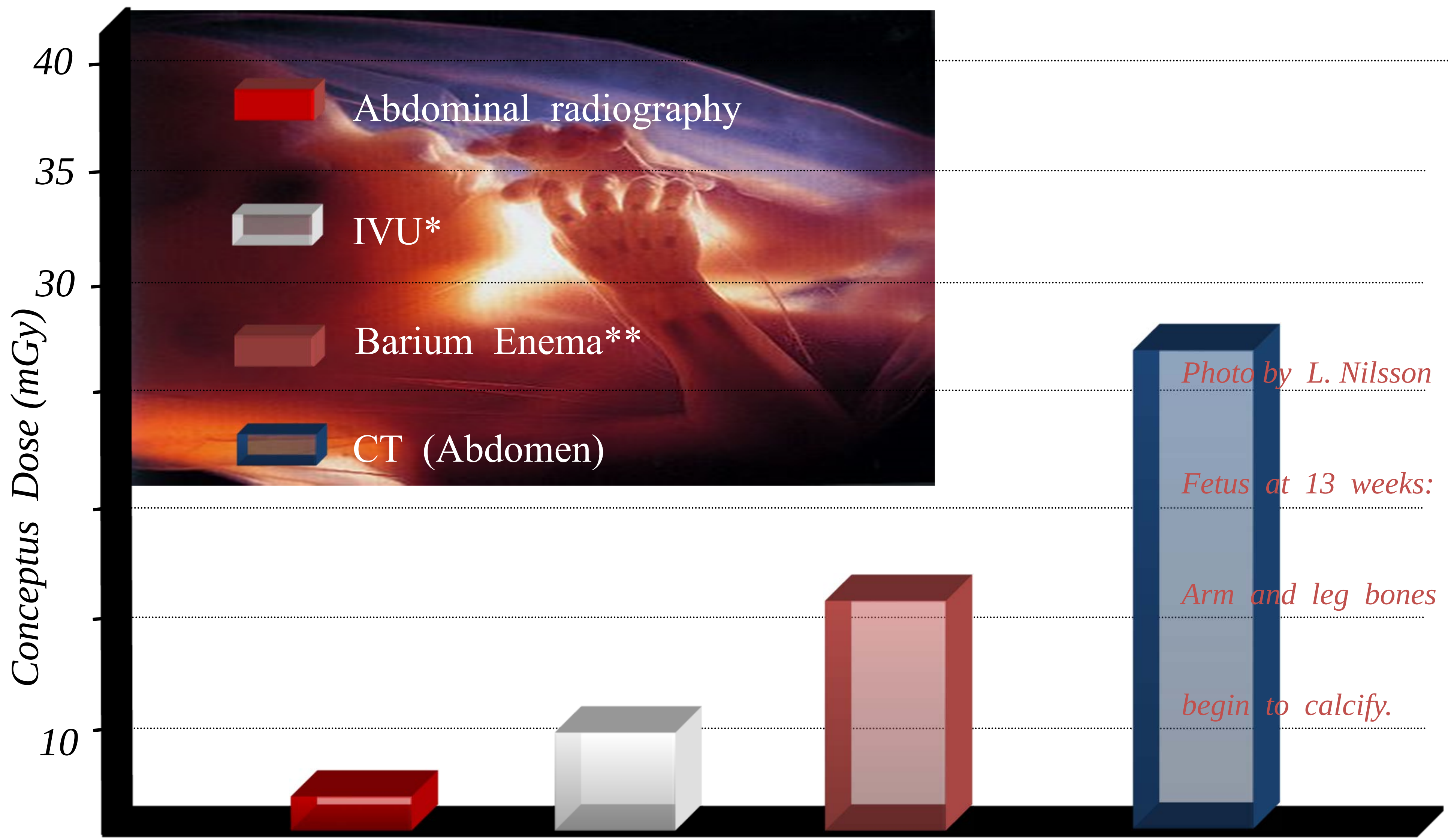
Requirements on dental units/practice regarding children

  - Child size of protection tools
  - Reproducibility of children exposure seting better than 5 %
  - Kerma for children exposure seting 4 times lower than for adult

ICRP-ISR "smart" message for pediatrics



Conceptus dose from abdominal X-ray examinations



** J. Damilakis et al, Radiat Prot Dosim 1997, **J. Damilakis et al, Invest Radiol 1996*


بسم الله الرحمن الرحيم

حفاظت پرتوی در تصویربرداری زنان

پریناز محنتی
دانشیار گروه فیزیک پزشکی

Why women are sensitive to radiation?

Radiation exposure

As fears of a meltdown in Japan rise, so do the fears of radiation exposure. What does radiation do to the human body?

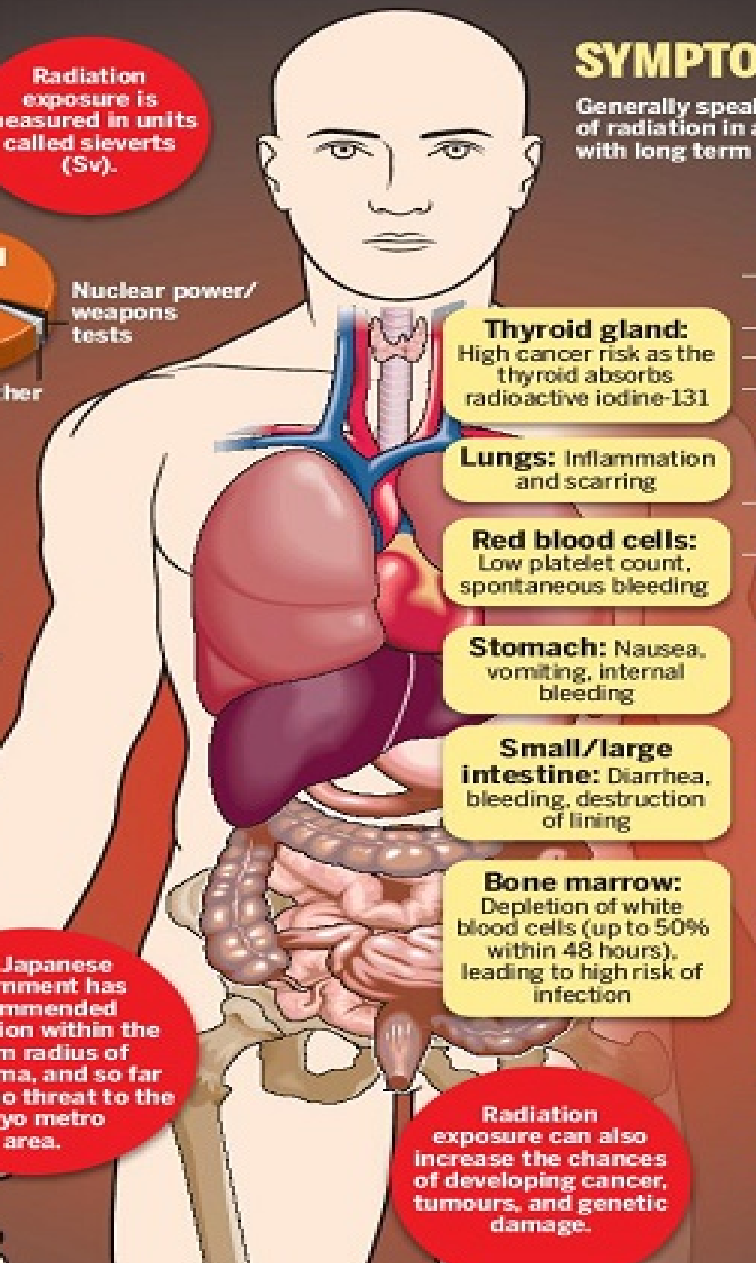
BACKGROUND RADIATION

Everybody is exposed to both naturally-occurring and artificial background radiation; levels typically range from 0.0015 – 0.0035 Sv/year:

Radiation exposure is measured in units called sieverts (Sv).

COMPARING EXPOSURES

10 Sv	Fatal within weeks
6	Typical levels in Chernobyl workers who died within a month
5	A single dose would kill half of those exposed within a month
1	A single dose could cause radiation sickness and nausea
0.4	Detected level at Fukushima (as of Tuesday morning in Japan)
0.35	Exposure of relocated Chernobyl residents
0.10	Recommended limit for people working with radiation every 5 years
0.01	Full-body CT scan
0.002	Typical natural radiation per year
0.0004	Mammogram x-ray
0.0001	Chest x-ray
0.00001	Dental x-ray



Thyroid gland: High cancer risk as the thyroid absorbs radioactive iodine-131

Lungs: Inflammation and scarring

Red blood cells: Low platelet count, spontaneous bleeding

Stomach: Nausea, vomiting, internal bleeding

Small/large intestine: Diarrhea, bleeding, destruction of lining

Bone marrow: Depletion of white blood cells (up to 50% within 48 hours), leading to high risk of infection

The Japanese government has recommended evacuation within the 30 km radius of Fukushima, and so far there is no threat to the Tokyo metro area.

Radiation exposure can also increase the chances of developing cancer, tumours, and genetic damage.

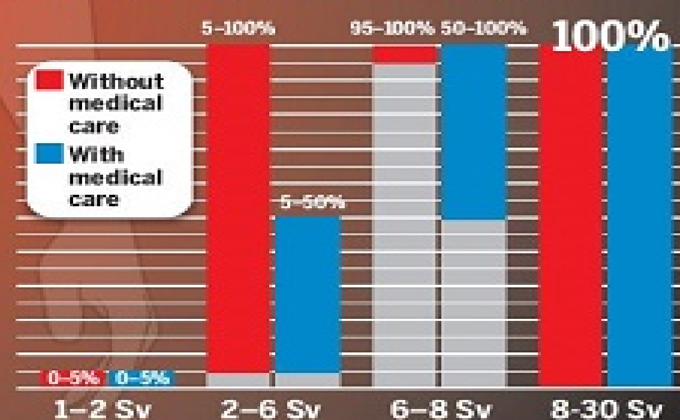
SYMPTOMS OF RADIATION EXPOSURE

Generally speaking, radiation sickness is brought on by a large dosage of radiation in a short period of time, but it has also occurred with long term exposure.

Early symptoms, exposure levels and time to symptom onset

	1–2 Sv	2–6 Sv	6–8 Sv	8–10 Sv
Nausea, vomiting	6 hrs.	2 hrs.	1 hr.	10 min.
Diarrhea	–	8 hrs.	3 hrs.	1 hr.
Headache	–	24 hrs.	4 hrs.	2 hrs.
Fever	–	3 hrs.	1 hr.	1 hr.
Later symptoms				
Dizziness, disorientation	–	–	1 wk.	Immediate
Weakness, fatigue	4 wks.	1–4 wks.	1 wk.	Immediate
Hair loss, bloody vomit and stools, infections, poor wound healing, low blood pressure	–	1–4 wks.	1 wk.	Immediate

CHANCES OF DEATH BASED ON EXPOSURE LEVEL



Sources: guardian.co.uk; World Nuclear Association; Wikipedia; Graphic News

توجه:

در صورت باردار بودن مسئول بخش را مطلع سازید.

IF YOU ARE pregnant PLEASE NOTIFY THE STAFF

پرتو گیری اندامهای تناسلی

- پرتوگیری درمردان با دوز 250 cGy باعث عقیمی موقت بمدت یک یا دوسال می شود
- 600 cGy باعث عقیمی دائمی می شود.
- درزنان دوز 50 cGy باعث عقیمی موقت و 400 cGy باعث عقیمی دائمی می شود.
- در دزهای تشخیصی بالا مانند ستون فقرات کمری، فلوروسکوپی ناحیه لگنی، پرتودرمانی حداقل شش ماه فاصله برای بارداری در نظر گرفته شود.

Table 2.19 Doses (mGy) to ovaries/uterus from various diagnostic procedures.

Procedure	Dose (mGy)
Diagnostic x rays	
Lumbar spine	7.2
Abdomen	2.2
Upper G.I. tract	1.7
Barium enema	9.0
Intravenous pyelogram	5.9
Nuclear medicine	
Brain scan, ^{99m}Tc DTPA, 740 MBq	5.8
Bone scan, ^{99m}Tc phosphate, 740 MBq	4.5
Thyroid scan, $^{99m}TcO_4$, 185 MBq	1.1
Renal scan, ^{99m}Tc DTPA, 740 MBq	5.8
Abscess/tumor scan, ^{67}Ga citrate, 111 MBq	8.8

Source: NCRP, 1994, Commentary 9. When doses to ovaries and uterus differ, the higher value is given.

Radiography of areas remote from the fetus, such as the chest, skull, or extremities, is safe at any time during pregnancy, provided that the x-ray equipment is properly shielded and the x-ray beam is collimated to the area under study.

The administration of ^{131}I to a pregnant mother will cause a high dose

OVERVIEW OF RADIATION EFFECTS ON THE EMBRYO AND FETUS

1. *Lethal effects*, induced by radiation before or immediately after implantation of the embryo into the uterine wall or induced after increasingly higher doses during all stages of intrauterine development, to be expressed either before birth (prenatal death) or at about the time of birth (neonatal death)
2. *Malformations*, characteristic of the period of major organogenesis, in which the main body structures are formed, and especially of the most active phase of cell multiplication in the relevant structures
3. *Growth disturbances without malformations*, induced at all stages of development but particularly in the latter part of pregnancy

تابش گیری لگن در زنان باردار

1. Large doses of radiation (2.5 Gy [250 rad]) delivered to the human embryo before 2 to 3 weeks of gestation are not likely to produce severe abnormalities in most children born, although a considerable number of the embryos may be resorbed or aborted.
2. Irradiation between 4 and 11 weeks of gestation would lead to severe abnormalities of many organs in most children.
3. Irradiation between 11 and 16 weeks of gestation may produce a few eye, skeletal, and genital organ abnormalities; stunted growth, microcephaly, and mental retardation are frequently present.
4. Irradiation of the fetus between 16 and 20 weeks of gestation may lead to a mild degree of microcephaly, mental retardation, and stunting of growth.
5. Irradiation after 30 weeks of gestation is not likely to produce gross structural abnormalities leading to a serious handicap in early life but could cause functional disabilities.

پرتوگیری جنین

- هفته 11-16 سبب ناهنجاریهای خفیفی در چشم و اسکلت و دستگاه تناسلی می شود
- هفته 16-20 درجه خفیفی از میکروسفالی، عقب ماندگی ذهنی
- پرتوگیری در سه ماهه آخر مخاطره سرطان دوران کودکی راتا 40 درصد افزایش میدهد.
- تابش گیری داخل رحمی از دزهای کم تشعشع موجب افزایش شیوع سرطان خود بخود در 10-15 سال اول زندگی با فاکتور 1/5 تا 2 برابر می شود.
- حداکثر مقدار دز مجاز جنین 0/5 میلی سیورت در ماه میباشد ولی دز 0/1 گری در طول دوره حساس بارداری بعنوان نقطه هشدار و برای مقادیر بیشترجهت اجتناب از تولد فرزند معلول سقط درمانی با نظر پزشک پیشنهاد میگردد.

پرتوگیری جنین

- تاخیر در رشد، مرگ در مرحله جنینی، مرگ پس از تولد وناهنجاریهای مادرزادی از عوارض پرتوگیری جنین می باشد.
- احتمال وقوع عوارض و صدمات پرتوی به مقدار دوز دریافتی و مرحله بارداری بستگی دارد.
- پرتوگیری قبل از دو یا سه هفتگی سبب ناهنجاری مادرزادی نمی شود ولی احتمال سقط را افزایش می دهد(.0/05 تا 0/15 گری)
- پرتوگیری بین هفته چهارم تا یازدهم سبب ناهنجاریهای مادر زادی می شود.
- احتمال عقب ماندگی ذهنی به ازای یک گری 40 درصد افزایش می یابد. پاسخ خطی-غیر آستانه ای است.

نمونه هایی ازاثرات پرتوی در مرحله اندامزایی

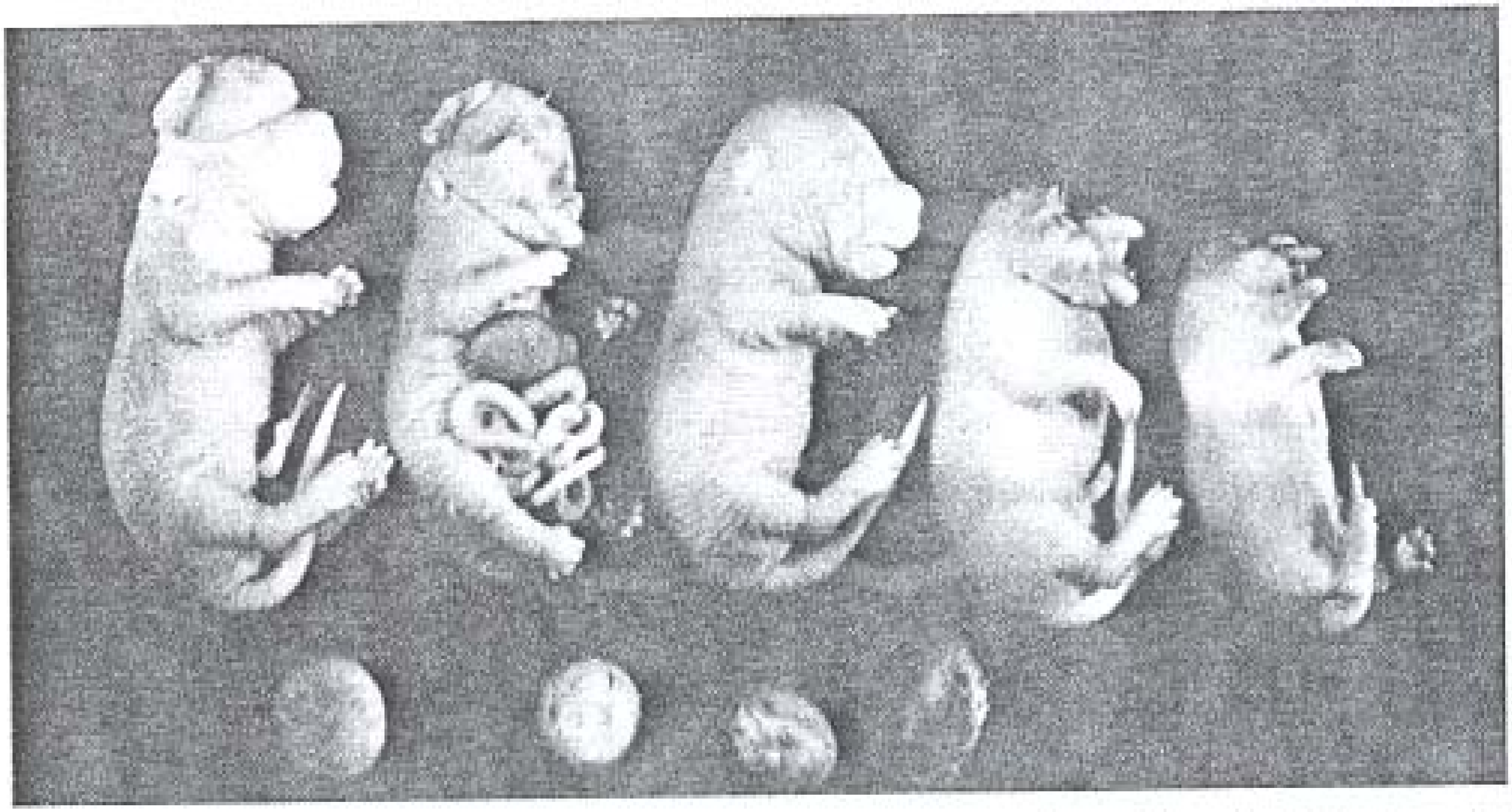


Figure 12.4. Litter from a female mouse irradiated with x-rays and sacrificed at 19 days. At least four different anomalies are demonstrated in this litter. There are four resorbed fetuses (below) and five fetuses alive. From left to right, the first shows exencephaly; the second, exencephaly and evisceration; the third is apparently normal; and the remaining two are anencephalics with stunting. (Photograph by Dr. Roberts Rugh.)

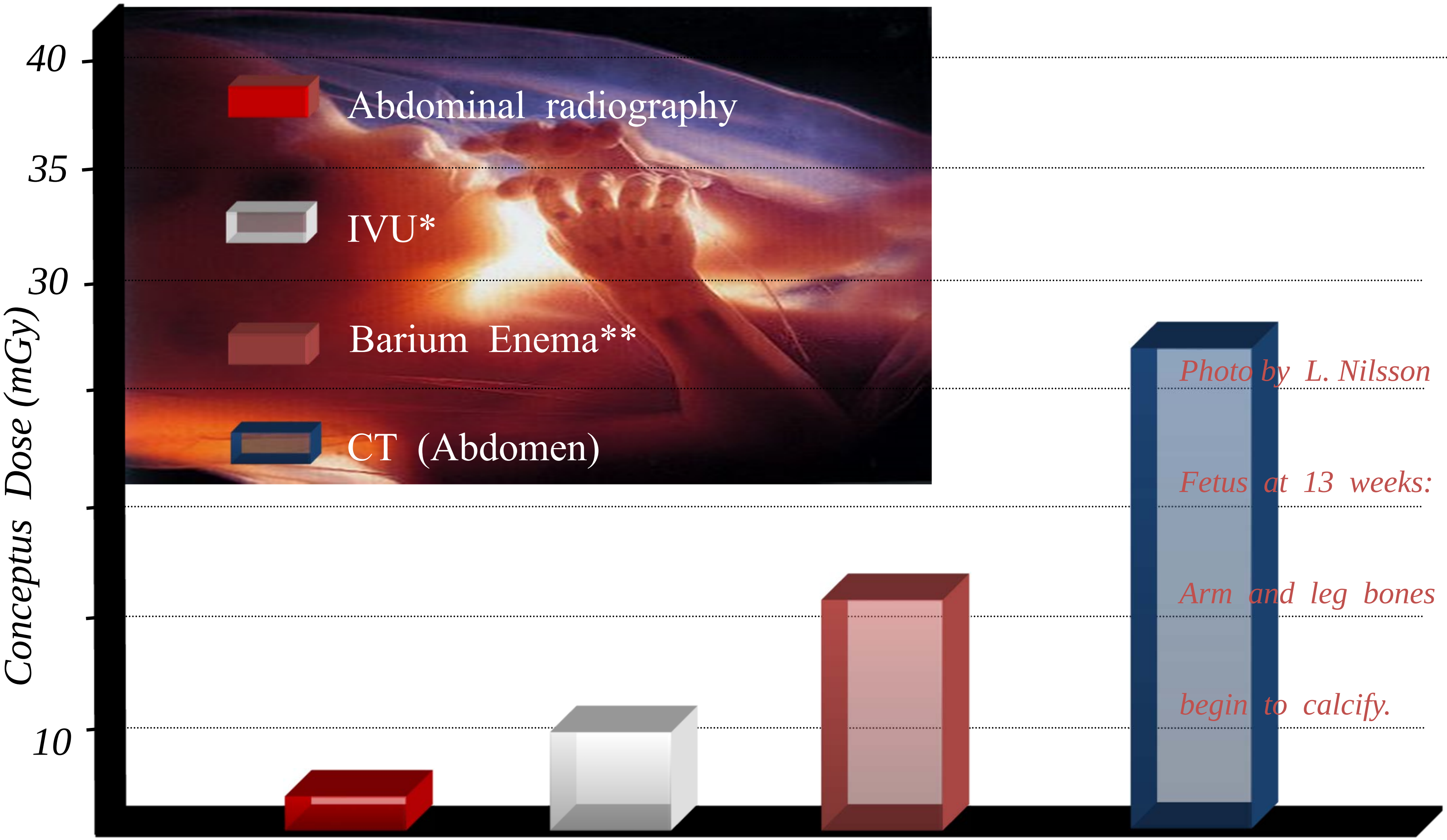
سرطان در دوران کودکی بعد از تابش گیری در داخل رحم

TABLE 12.3. *Childhood Cancer and Irradiation* In Utero

Number of children with leukemia or cancer before age 10 y	7,649
Number x-rayed in utero	1,141
Number of matched controls	7,649
Number of controls irradiated in utero	774
Number of films	1 to 5
Fetal dose per film	0.46–0.2 rad (4.6–2 mGy)
Relative cancer risk estimate assuming radiation to be the causative agent	1.52

Based on Stewart A, Kneale GW: Radiation dose effects in relation to obstetric x-rays and childhood cancers. Lancet i:1185–1188, 1970.

Conceptus dose from abdominal X-ray examinations



** J. Damilakis et al, Radiat Prot Dosim 1997, **J. Damilakis et al, Invest Radiol 1996*

IAEA SURVEY IN PEDIATRIC CT

- **PHASE A and B (**partly**) – 115 CT rooms in 27 countries**

- Armenia – 1
- Bosnia and Herzegovina – 3
- Bulgaria - 12
- Croatia – 3
- Check – 6
- Estonia – 2
- Lithuania – 3
- Macedonia, FYR – 5
- Malta -1
- Moldova – 5
- Serbia – 2
- Slovenia – 1
- Slovakia – 5

- Algeria – 4
- Brazil – 5
- Costa Rica - 1
- Iran – 10
- Kuwait – 5
- Lebanon – 2
- Malaysia – 1
- UAE – 15
- Pakistan – 6
- Paraguay – 3
- Sudan – 3
- Syria – 7
- Tanzania – 3

RESULTS

- Pediatric CT
  (0 – 100) % of total number of CT in the department
- Number of examinations in one year
  0 – 23 000 (adults)
  0 – 4 800 (children)
- Highest number of pediatric CT:
  Pakistan (4800/y); Syria (2005/y); Slovakia (1900/y); Kuwait (1176/y); Croatia (1180/y); Moldova (936/y); others (<600/y).

Summary

- Moderate doses of radiation can produce catastrophic effects on the developing embryo and fetus.
- The effects depend on the stage of gestation, the dose, and also the dose rate.
- Gestation is divided into preimplantation, organogenesis, and the fetal period. In humans, these periods correspond to about 0 through 9 days, 10 days through 6 weeks, and 6 weeks through term, respectively.
- The principal effects of radiation on the developing embryo and fetus are growth retardation; embryonic, neonatal, or fetal death; congenital malformations; and functional impairment such as mental retardation.
- Irradiation during preimplantation leads to death of the embryo. Growth retardation or malformations are not seen in animals at this time. The human data are consistent with this conclusion.
- In animals, embryos exposed to radiation in early organogenesis exhibit the most severe intrauterine growth retardation, from which they can recover later (*i.e.*, temporary growth retardation). Irradiation in the fetal period leads to the greatest degree of permanent growth retardation.
- In animals, lethality from irradiation varies with stage of development. The embryonic 50% lethal dose is lowest during early preimplantation; at this stage, embryos killed by radiation suffer a prenatal death and are resorbed. In organogenesis, prenatal death is replaced by neonatal death—death at or about the time of birth. During the fetal stage the 50% lethal dose approaches that of the adult.

Summary

- In animals, the peak incidence of teratogenesis, or gross malformations, occurs if the fetus is irradiated in organogenesis.
- Contrary to what is observed in experimental animals, radiation-induced malformations of body structures other than the central nervous system are uncommon in the Japanese survivors irradiated *in utero*, although they have been reported in patients exposed to therapeutic doses of medical radiation.
- In the Japanese survivors, irradiation *in utero* resulted in small head size (microcephaly) and mental retardation.
- Mental retardation occurred primarily at 8 to 15 weeks of gestational age, with a smaller excess at 16 to 25 weeks. It is thought to be caused by radiation effects on cell migration within the brain.

Summary

- Cells killed before 8 weeks of gestational age cause small head size without mental retardation.
- Small head circumference was three times more common than mental retardation.
- Data on atomic-bomb survivors indicate that microcephaly can result from an air dose (kerma) of 0.1 to 0.19 Gy (10–19 rad)
- The incidence of severe mental retardation as a function of dose is reported to be apparently linear without threshold at 8 to 15 weeks, with a risk coefficient of 0.4 per Gy (0.4–100 rad). The incidence is about four times lower at 16 to 25 weeks. The data are consistent with a dose threshold of 0.12 to 0.2 Gy (12–20 rad).
- A variety of effects have been documented in experimental animals after irradiation during fetal stages, including effects on the hematopoietic system, liver, and kidney, all occurring, however, after quite high radiation doses.
- The effects on the developing gonads have been well documented both morphologically and functionally. Doses close to 1 Gy (100 rad) are needed to produce fertility changes in various species.

Summary

- There is an association between exposure to diagnostic x-rays *in utero* and the subsequent development of childhood malignancies.
- The original study of diagnostic x-ray exposure *in utero* and subsequent malignancies was done by Stewart and Kneale at Oxford University, but the same association was observed in the United States by MacMahon. If x-rays are the causative agent, these studies imply that radiation at low doses *in utero* increases the spontaneous cancer incidence in the first 10 to 15 years of life by a factor of 1.5 to 2.
- It has been argued for years whether radiation is the causative agent or whether there are other factors involved.
- Doll and Wakeford in 1997 summarized all of the evidence for and against and concluded that an obstetric x-ray examination, particularly in the third trimester, increased the risk of childhood cancer by 40%. The risk is increased by a dose of only 10 mGy (1 rad). The excess absolute risk is about 6% per gray, which is not very different from the risk estimates from the atomic-bomb survivors for adult exposure.
- Once a pregnancy is declared, the maximum permissible dose to the fetus is 0.5 mSv (0.05 rem) per month. Until a pregnancy is declared, no special limits apply to the mother other than those applicable to any radiation worker.
- Once a pregnancy is declared, the duties of a radiation worker should be reviewed to ensure that this limit is not exceeded.
- A dose of 0.1 Gy (10 rad) to the embryo during the sensitive period of gestation (10 days to 26 weeks) often is regarded as the cut-off point above which a therapeutic abortion should be considered to avoid the possibility of an anomalous child. The decision to terminate a pregnancy should be flexible and must depend on many factors in addition to dose.


از توجه شما متشکریم