IAEA Post Graduate Educational Course on Radiation Protection and safety of Radiation Sources

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Justification and Optimization of exposure in pregnant patients needing diagnostic examinations.

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Potential effects of ionizing radiation on the unborn child

They are related to :

- **the age and size of the conceptus**
- **The amount of the radiation dose delivered to the utero by the examination**

Radiation protection programs and protocols for the medical exposure of women in childbearing age

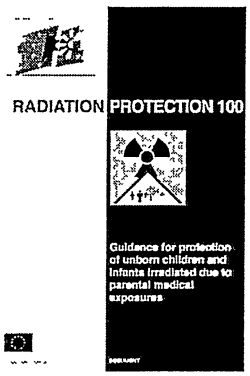
Objectives :

- **to ensure that radiation exposure is justified in order to avoid unnecessary or inadvertent exposure to the conceptus**
- **to ensure that radiation exposure to the conceptus is optimized and kept as low as reasonably possible**
- **to provide measurment and/or estimation of the embryo/fetal dose when needed and maintain a complete dose record**

Medical Exposure Directive 97/43 Euratom (MED 97)

Article 10 [1]

If pregnancy cannot be excluded, depending on the type of medical exposures, special attention shall be given to the justification, particularly the urgency, and to the optimization of the medical exposure taking into account the exposure both of the expectant mother and the unborn child.



Structure of the talk

- *Biological effects following irradiation to the utero*
- *Utero doses following common diagnostic procedures*
- *Investigation of the reproductive status of the patient and justification of the exposure*
- *Optimization of the exposure*
- *Conclusions*

Types of effects following irradiation in utero

1. Stochastic effects :	*Changes in cells that retain their ability to divide, leading to the development of a malignant clone. No threshold dose is assumed. The probability of occurrence is believed to be proportional to the dose.*
2. Deterministic effects:	*Decrease in or loss of organ function due to cell damage or organ killing. Threshold doses exist.*

Types of effects following irradiation in utero
1. Stochastic effects

Time after conception (weeks)	*Type of effect*	*Nominal risk per mSv*
0-3	---	---
4 → birth	*Cancer in childhood or in adult life*	15×10^{-5}

Types of effects following irradiation in utero
2. Deterministic effects

Time after conception (week)	*Type of effect*	*Threshold dose mSv*	*Nominal risk*
0-3	---	---	---
☆ 3-8	Malformation of organs	100	5×10^{-4} per mSv
☆☆☆ 8-15	Shift of intelligence quotient Severe mental retardation	> 100	Shift of 30IQ points/Sv 0.4 - at 1 Sv
15-25	Shift of intelligence quotient Severe mental retardation	> 100	Less marked

The ten - day rule

Women of childbearing age should be exposed to irradiation involving the pelvis or lower abdomen only during the first ten days after the start of a normal menstrual period.



- **Recommendations apply for examination that might cause a considerable dose (above 10 mSv) to the unborn child.**
- **They do not apply for low dose examinations, i.e. Below 1 mSv, equivalent dose to the unborn child.**
- **They are only applicable to pregnant or potentially pregnant women of childbearing potential from puberty to the menopause, normally older than 12 years and less than 50 years**

In *utero* doses following common diagnostic procedures (below 1 mSv); taken from NRPB surveys of diagnostic radiology and nuclear medicine (NRP98)

Examination	Fetal equivalent dose (mSv)	
	Mean	Maximum
Conventional X-rays		
Chest	< 0.01	< 0.01
Skull	< 0.01	< 0.01
Thoracic spine	< 0.01	< 0.01
Computed tomography		
Chest	0.06	0.96
Head	< 0.005	< 0.005
Pelvimetry	0.2	0.4
Nuclear medicine		
^{99m}Tc lung perfusion (MAA)	0.2	0.4
^{99m}Tc lung ventilation (aerosol)	0.3	1.2
^{51}Cr glomerular filtration (EDTA)	<0.01	0.01

In *utero* doses following common diagnostic procedures (greater than 1 mSv); taken from NRPB surveys of diagnostic radiology and nuclear medicine (NRP98)

Examination	Fetal equivalent dose (mSv)	
	Mean	Maximum
Conventional X-rays		
Barium enema	6.8	24
Intravenous urography	1.7	10
Lumbar spine	1.7	10
Computed tomography		
Abdomen	8	49
Pelvis	25	79
Nuclear medicine		
^{75}Seleno-cholesterol	---	14
^{67}Ga tumorous and abscesses	---	12
^{131}I thyroid metastases	---	22

Investigation of the reproductive status of the patient and justification of the exposure

Council Directive 97/43 Euratom (MED)
Article 3

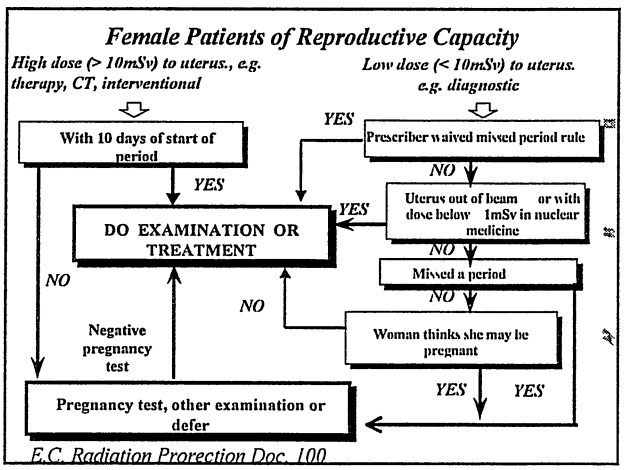
All individual medical exposures shall be justified taking into account the specific objectives of the exposure, the availability of previous diagnostic information, when appropriate, and the efficacy and availability of alternative techniques. Special attention shall be given for those exposures where there is no direct health benefit for the person undergoing the exposure.



- **The patient should be explicitly asked, orally or in writing, whether she might be pregnant or may have missed a period. The outcome of the questioning should be recorded.**
- **If the woman, the prescriber or the practitioner have no reason to assume pregnancy, the examination or treatment can be performed as planned.**



- **If there is any uncertainty concerning pregnancy the exposure should be postponed until after the next period or a pregnancy test may be performed.**
- **If there remains any doubt the woman should be treated as pregnant.**
- **There is no need to apply the ten-day-rule routinely. If an examination involves a high dose to the uterus, the ten-day-rule should be applied or a pregnancy test performed.**



E.C. Radiation Prorection Doc. 100



If the woman is to be treated as pregnant,
I. The examination should be made with special concern about the dose to the unborn child. Due attention should be given to possible consequences for the mother.
II. The dose to the unborn child should be estimated before the examination/treatment is carried out and, if relevant, reassessed afterwards.

***In emergency situations*, the primary objective is to obtain the diagnosis as expeditiously as possible.**

The requirements for immediate survival far outweigh the possibility of subsequent deleterious radiation effects.

- **Optimization of the exposure**
- **Minimization of the dose**

Council Directive 97/43 Euratom (MED)
article 4 (1)

All medical exposures for radiodiagnostic purposes shall be kept as low as reasonably achievable consistent, with obtaining the required diagnostic information, and taking into account economic and social factors

1. Reduction of Fetus' Dose in High Dose X-Ray Examinations

- Most efficient X-ray equipment
- Careful positioning of the patient
- Adjustment of the bladder volume
- Selection of the projections
- Reduced number of images

2. Reduction of Fetus' Dose in High Dose X-Ray Examinations

Fluoroscopy

- Collimation of the beam
- Limitation of fluoroscopic time
- Rare-earth screen-film combinations
- Removal of the grid
- Lead apron protectors

3. Reduction of Fetus' Dose in High Dose X-Ray Examinations

CT	Angiography
• Reduced number of slices	• Shielding of the pelvis
• Reduction of current	• Administration of contrast agent via brachial route instead of femoral

Gestational Sac Location, and Fetal Absorbed Dose

	Bladder Partially Filled	Bladder Full
"Gestational sac location:		
Distance from anterior surface (cm)	3.8	6.7
Distance from posterior surface (cm)	16.2	13.3
Normalized fetal absorbed dose (rad):		
AP projection	0.77	0.45
PA projection	0.048 ⇐	0.087
Ragozzino et al 1981		

"Fetal location at maximum and minimum bladder volume determined by sonography.

Irradiation of the Fetus in Nuclear Medicine Examinations

Placental transfer and distribution of radioactivity in the fetal tissues e.g. I-131 , Fe - 59

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Internal Irradiation

Distribution of radioactivity in mother's tissues and organs e.g. radiocolloids

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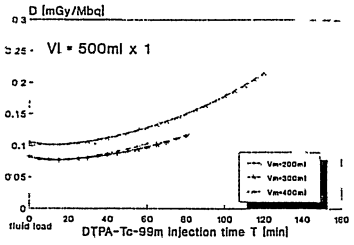
External Irradiation

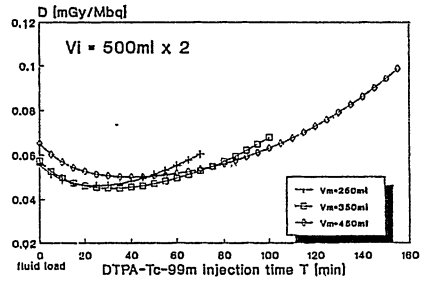
Reduction of Fetus' dose in Nuclear Medicine Examinations

- Smaller administered radioactivities and longer imaging times.
- Careful selection of the radioisotope and the radiopharmaceutical.
- Methods for reduction of organ doses.
- Protocols for radiopharmaceuticals rapidly eliminated by the kidney.

Variation to the dose to the bladder D with time T, elapsed from the water intake to the Tc-99m DTPA injection, for the 500ml x1 hydration scheme and for different micturition volumes.



Variation to the dose to the bladder D with time T, elapsed from the water intake to the Tc-99m DTPA injection, for the 500ml x2 hydration scheme and for different micturition volumes.



*Nuclear medicine examinations where pregnancy within the indicated period of time may result in doses to the unborn child from the time of implantation in excess of 1 mSv * (RP 100).*

Radiopharmaceuticals, investigations and administered activities	Avoid pregnancy (months)
59-Fe (iv): Iron metabolism 0,4 MBq	6
75-Se-Selenonorcholestorol: Adrenal imaging 8 MBq	12
131-I-MIBG: Tumor imaging 20 MBq	2
131-I-iodide: Thyroid metastases > 30MBq	4

** This value was chosen as a reasonable dose constraint for the unborn child.*

Council Directive 97/43 Euratom (MED)
Article 4 [2]

Member States shall promote the establishment and the use of diagnostic reference levels for radiodiagnostic examinations

Medical Reference Levels concerning the dose to the unborn child for the different types of radiodiagnostic examinations should be selected and established by appropriate bodies, using national and international experience from well managed operations, in order to be seen as rigid upper boundaries to the process of optimization.

Written protocols should be available for various x-ray examinations of the abdomen and nuclear medicine examinations, to ensure that the radiation dose to the unborn child is as low as reasonably achievable, whilst taking due attention to the outcome for the patient herself.

The role of the Medical Physicist

- Evaluation of doses from alternative studies for the justification process
- Establishment and application of protocols for the minimization of the fetal dose
- Measurment and estimation of the fetal dose

Conclusions

- Knowledge of the reproductive status of the patient, is nessecary to the personnel of the radiodiagnostic department, in order to conduct the examinations accordingly.
- Most radiodiagnostic procedures, when optimized, are associated with low doses and low radiation risks to the unborn child.