Radiation exposure of pregnant patients and pregnant employees in imaging departments: An overview of regulations and recommendations

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II

(Non-legislative acts)

DIRECTIVES

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laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/41/EEC, 90/278/Euratom, 97/43/Euratom and 2003/122/Euratom

Article 62

Special protection during pregnancy and breastfeeding

1. Member States shall ensure that the referrer or the practitioner, as appropriate, inquire, as specified by Member States, whether the individual subject to medical exposure is pregnant or breastfeeding, unless it can be ruled out for obvious reasons or is not relevant for the radiological procedure.

2. If pregnancy cannot be ruled out and depending on the medical radiological procedure, in particular if abdominal and pelvic regions are involved, special attention shall be given to the justification, particularly the urgency, and to the optimisation, taking into account both the expectant individual and the unborn child.

3. In the case of a breastfeeding individual, in nuclear medicine, depending on the medical radiological procedure, special attention shall be given to the justification, particularly the urgency, and to the optimisation, taking into account both the individual and the child.

4. Without prejudice to paragraphs 1, 2 and 3, Member States shall take measures to increase the awareness of individuals to whom this Article applies, through measures such as public notices in appropriate places.
A number of physicians recommend termination of pregnancy for women exposed to diagnostic X-rays.

40% of family physicians and 70% of obstetricians recommended abortion for women exposed to diagnostic x-rays in early pregnancy.

Fink D, Glick S. Harefuah 124:717-719, 1993
Radiation awareness among radiology residents, technologists, fellows and staff: where do we stand?

Subramaniyan Ramanathan - John Ryan

Abstract

Objectives To investigate and compare the knowledge of radiation dose and risk incurred in common radiology examinations among radiology residents, fellows, staff radiologists and technologists.

Methods A questionnaire containing 17 multiple choice questions was administered to all residents, technologists, fellows and staff radiologists of the department of medical imaging through the hospital group mailing list.

Results A total of 792 responses were received. Mean score was 8.5 out of 17. Only 48 % of all participants scored more than 50 % correct answers. Only 23 % were aware of dose from both single-view and two-view chest X-ray; 50-70 % underestimated dose from common studies; 50-75 % underestimated the risk of fatal cancer. Awareness about radiation exposure in pregnancy is variable and particularly poor among technologists. A statistically significant comparative knowledge gap was found among technologists.

Conclusions Our results show a variable level of knowledge about radiation dose and risk among radiology residents, fellows, staff radiologists and technologists, but overall knowledge is inadequate in all groups. There is significant underestimation of dosage and cancer risk from common examinations, which could potentially lead to suboptimal risk assessment and excessive or unwarranted studies posing significant radiation hazard to the patient and radiology workers.

Main Messages

- Knowledge of radiation dose and risk is poor among all radiology workers.
- Significant knowledge gap among residents, fellows and staff radiologists.
- Significant underestimation of risk from common examinations.
- Significant knowledge gap among residents, fellows and staff radiologists.
- Significant knowledge gap among residents, fellows and staff radiologists.

Keywords Radiation dose - Radiology Technologists - Cancer risk - Quality of care - Radiology education

Introduction

Radiology plays a prominent role in the diagnostic and interventional procedures involving exposure to ionising radiation. There is increasing concern over the overuse of radiation on living organs. Council on Radiation Protection and dosimetry, "Limiting Radiation Exposure United States", reported a severe underestimation of the population of the U.S. radiation since the early 1980s [1]. In particular, the cancer risk, is underestimated, as it has no minimal adverse outcomes take at least 1-2 years. One of the published scientific knowledge of radiation dose and examinations is very limited. Not all performed predominantly among patients, medical students and nurses [5-13]. Surprisingly, there are very few studies of these methods with professionals about radiation risks incurred to patients during common imaging tests, and an inability to accurately answer the common questions raised by patients [8-12, 14-16]. It is important for the referring physicians to understand the radiation risks. In our study, though very limited, knowledge of radiation risk in pregnancy was assessed based on a single question (Appendix, question no. 17). Importantly, only 13 % of technologists gave the correct answer, and a significant proportion of the participants suggested medical termination of pregnancy as an option. The knowledge was variable among other groups (residents, fellows and staff radiologists) in the range of 60-85 %. This is highly important, as the technologists come into close contact with the patients in the radiology department and they should have adequate knowledge on radiation exposure during pregnancy and should ideally be trained enough for answering patients' concerns and arranging a discussion with the radiologist.
A number of physicians **DO NOT** perform X-ray examinations on pregnant patients.

The radiation risk for childhood cancer is only 0.06% if the embryo dose is 10 mGy.

*Photo by L. Nilsson*

*Fetus at 13 weeks: Arm and leg bones begin to calcify.*
Conceptus dose from abdominal X-ray examinations

- Abdominal radiography
- IVU*
- Barium Enema**
- CT (Abdomen)


Photo by L. Nilsson
Fetus at 13 weeks:
Arm and leg bones begin to calcify.
<table>
<thead>
<tr>
<th>Examination</th>
<th>Conceptus dose (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone scan (phosphate)</td>
<td>~ 8</td>
</tr>
<tr>
<td>Liver colloid</td>
<td>~ 1</td>
</tr>
<tr>
<td>Renal DTPA</td>
<td>~ 4</td>
</tr>
</tbody>
</table>

Conceptus dose (1st trimester) from Tc-99m examinations

Photo by L. Nilsson

Fetus at 13 weeks:

Arm and leg bones begin to calcify.
Physician’s perception of risk associated with diagnostic x-rays

CONCLUSION. Our survey shows that physicians who care for pregnant women perceive the teratogenic risk associated with an abdominal radiograph and an abdominal CT scan to be unrealistically high during early pregnancy. This misperception could lead to increased anxiety among pregnant women seeking counseling and to unnecessary terminations of otherwise wanted pregnancies. This perception of high teratogenic risk associated with radiation could also lead to a delay in needed care of pregnant women.
Conclusion: This survey reveals that there is a lack of knowledge of fetal dosimetry in the imaging of pregnant women suspected of having pulmonary embolism.
How can we avoid accidental irradiation?
Determination of pregnancy before irradiation

- Investigation of the reproductive status of a female of childbearing age prior to x-ray imaging.

- It is prudent to consider as pregnant any woman of reproductive age presenting herself for an X-ray examination at a time when a menstrual period is overdue, or missed, unless there is information that precludes a pregnancy.

(ICRP Publication 84, 2000)
Determination of pregnancy before irradiation

Methods used for determination of pregnancy:

- Verbal questions
- Forms
- Urine and serum pregnancy tests

Define your department’s policy on how to screen pregnant patients!
Determination of pregnancy before irradiation

Screening for pregnancy

- healthcare personnel is not trained to question patients about their pregnancy status

- no policy with 100% guarantee of detection
'PLEASE INFORM THE STAFF
BEFORE YOUR X-RAY EXAMINATION
IF YOU THINK YOU MAY BE PREGNANT'
Do we know the frequency of these accidents?

Do we know the frequency of abortions?

Photo by L. Nilsson: 5-6 days, the clump has developed into a blastocyte, containing many more cells, and has entered the womb
Accidental irradiation of pregnant patients

‘1% of women of child-bearing age who underwent abdominal radiographs were unknowingly pregnant in their first trimester’


‘2.9% of trauma patients were pregnant and the unidentified pregnancy rate was 0.3%’

Bochicchio GV et al, J Am Coll Surg 2001;192:566-569
Acronym: CONCERT

CONCEptus Radiation Doses and Risks from Imaging with Ionizing Radiation

Duration: 36 months
Accidental irradiation of pregnant patients

Question to Obstetricians:

How many pregnant patients exposed accidentally to diagnostic X-rays visited you during the last 12 months to ask advise about the biological effects of radiation to the conceptus?

- 0: 31%
- 5-10: 4%
- 10-15: 2%
- 1-5: 63%
Physicians referring patients to X-rays

Question to interventional cardiologists:
What is the minimum and what the maximum age you use for questioning a patient about pregnancy?

43.4 % did not include minors in the age range

16 % did not include patients older than 40 y in the age range
Question to Radiologists:

How many pregnant patients are subjected to diagnostic X-ray examinations in your department every year?

0: 46%
1-5: 36%
6-10: 11%
11-15: 3%
16-20: 2%
>20: 2%
Physicians referring patients to X-rays

Question to radiologists:
What makes referring physicians reluctant to send pregnant patients to X-ray imaging departments even for extra abdominal exams? (you can choose more than 1 answers)

- Lack of knowledge about fetal dosimetry
- Possible legal consequences
- I don’t think that referring physicians are reluctant etc
- Other
Physicians referring patients to X-rays

Question to cardiologists:
What makes referring physicians reluctant to send pregnant patients to X-ray imaging departments even for extra abdominal exams?
(you can choose more than 1 answers)

- Lack of knowledge about fetal dosimetry
- Possible legal consequences
- I don’t think that referring physicians are reluctant etc
- Other
Physicians referring patients to X-rays

Question to obstetricians:
What makes referring physicians reluctant to send pregnant patients to X-ray imaging departments even for extra-abdominal exams?
(you can choose more than 1 answers)

- Lack of knowledge about fetal dosimetry
- Possible legal consequences
- I don’t think that referring physicians are reluctant etc
- Other
To justify an x-ray study
the risks to the unborn child should be known
Conceptus radiogenic risk

What is the conception age?

What is the estimated conceptus dose?
Is a detailed dose assessment always needed?

No if:

• age less than 2 weeks
• conceptus dose is low
Justification

Justification depends on the stage of pregnancy

- organogenesis: 3-15 weeks post conception
- size and position of uterus
PREGNANT ??

What is the dose received by my baby?
Conceptus doses below 100 mGy should not be considered a reason for terminating a pregnancy

ICRP Publ. 84

Although it is generally accepted that doses of 10 mGy or less are unlikely to be harmful, there are instances where doses may be higher due to specific circumstances or equipment. In such cases, it is important to consider the potential risks and the need for further investigation. The ICRP provides guidelines and recommendations to help decision-making in these situations.

ICRP Annals: Prenatal and Medical Radiation Protection
Reporting dose results

A description of the method used to estimate dose
A table presenting exposure data
A table presenting conceptus dose estimation
A brief paragraph on biological effects
THERE IS A CHANCE THAT A WOMAN WILL GIVE BIRTH TO CONGENITALLY MALFORMED CHILDREN, REGARDLESS OF ANY EXPOSURE TO RADIATION
Informed consents

J. Fielding and D. Washburn, *Journal of Women’s Imaging* 7:16-21, 2005
Dose optimization: Parameters that affect CT dose

Beam shaping filter
Filtration
Collimation

kV, mAs

Detection system efficiency

Scanning length, Reconstruction slice width, Scanner geometry
Pitch, Algorithms, Dose reduction tools
Practical actions to control dose to the patient

- Keep beam-on time to a minimum
- Keep the x-ray tube at maximal distance from the patient
- Keep the image receptor as close to the patient as possible
- Do not overuse geometric magnification
- Collimate as tightly as possible
- Use low dose rate pulsed fluoroscopy
Pregnant (or potentially pregnant) employees working in imaging departments
The working conditions of a pregnant worker, after the declaration of pregnancy, should be as such to make it unlikely that the additional dose to the conceptus will exceed about 1 mGy during the remainder of pregnancy.

Annals of the ICRP, Publication 84, 2000
A female worker should, in becoming aware that she is pregnant, notify the employer in order that her working conditions may be modified if necessary.
Dose monitoring

Conventional dosimeters  Real-time dose monitoring  Supplemental dosimetry
Conceptus Dose Estimation tool
Tools for medical dosimetry

http://ctdose-tumrad.med.uoc.gr/
Messages to take home

✓ Investigate the reproductive status of female patients of childbearing age prior to x-ray imaging

✓ Define your department’s policy on how to screen pregnant patients

✓ Estimate conceptus dose for abdominal X-ray studies and Nuclear Medicine examinations
Messages to take home

- Situations that may lead to radiation doses higher than 100 mGy are very rare in diagnostic radiology
- Abortion due to a diagnostic x-ray examination is not justified in the vast majority of cases

Thank you!