FOETAL DOSE OPTIMISATION ALGORITHM IN DIAGNOSTIC RADIOLOGY AND NUCLEAR MEDICINE IMAGING PROCEDURES

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1. INTRODUCTION

- The number of Diagnostic Radiology and Nuclear Medicine imaging procedures carried out globally is substantial, with a trend of annual increase.
- Such procedures are occasionally necessary to be performed on women known to be pregnant. In such cases the concern is greater, due to the in utero radiation exposure of the developing foetus and its potential biological effects.
- The present study focuses on highlighting the key factors affecting foetal radiation burden, as well as the presence of a foetal dose optimisation algorithm, based on internationally accepted standards.
- A tolerance foetal dose level is specified, in comparison to typical estimated foetal dose values for common imaging procedures.

2. MATERIALS & METHODS

- Published guidelines of renowned international organisations (IAEA, ICRP, ACR, SPR), as well as contemporary literature were selected for further analysis.
- Selection criteria specifically focused on key factors affecting foetal radiation burden with respect to:
  - the type of examination
  - gestational age
  - important clinical information
- All the above were exploited, in the framework of a foetal dose optimisation algorithm.

3. FOETAL RADIATION BURDEN INCREASE: IMPACT OF THE TYPE OF IMAGING PROCEDURE

- **Diagnostic Radiology**
  - when the primary beam crosses the foetal region
  - high technique factors – extended FOV
- **Nuclear Medicine**
  - increased administered activity and/or half-life
  - radiopharmaceuticals crossing the placenta

4. FOETAL RADIATION BURDEN INCREASE: IMPACT OF THE GESTATIONAL AGE

- Foetal radiosensitivity is maximised during periods of rapid cellular proliferation, specifically during organogenesis and CNS development.

GESTATIONAL STAGE	START (weeks p.c.)	END (weeks p.c.)
Organogenesis	**~3-5**	**~12**
CNS development	**~6**	**~25**

- Max foetal radiosensitivity: **~8-15 weeks p.c.**

5. FOETAL DOSE OPTIMISATION ALGORITHM: CORE DATA – RULES & TESTS EXPLOITED

- **core data**
  - reproductive age: typically 12-50 y.o., no hysterectomy or tubal ligation
  - first 10 days of menstrual cycle: decreased conception probability
  - missed period or irregular menstrual cycle: potential pregnancy

- **rules & tests**
  - (28-day rule) vs. (10-day rule)
  - postpone exam till the beginning of the next menstrual cycle
  - pregnancy testing

6. FOETAL DOSE OPTIMISATION ALGORITHM (1/2)

- **Low foetal dose exam**
  - Take medical history - apply **28-day rule** (starting from the beginning of the last menstrual cycle)
    - <28 days: carry out exam (no further measures)
    - >28 days: discuss with the doctor the possibility of postponing the exam until the start of the next menstrual cycle
      - ✓ exam can not be postponed: carry out exam applying ALARA

6. FOETAL DOSE OPTIMISATION ALGORITHM (2/2)

- **Possibly high foetal dose exam**
  - **Regular menstrual cycle**: Take medical history - apply **10-day rule** (starting from the beginning of the last menstrual cycle)
    - ≤10 days: carry out exam (no further measures)
    - >10 days: discuss with the doctor the possibility of postponing the exam until the start of the next menstrual cycle
      - ✓ exam can not be postponed: carry out exam applying ALARA
  - **Irregular menstrual cycle**: perform **pregnancy test**
    - (-): carry out exam (no further measures)
    - (+): discuss with the doctor – consider justification and foetal radiosensitivity factors
      - ✓ exam can not be postponed: carry out exam applying ALARA

7. FOETAL TOLERANCE DOSE VALUES

SCENARIO	TOLERANCE DOSE (mGy)
Diagnostic Radiology / Nuclear Medicine procedures	100
Pregnant recently treated with RNT	1
Occupationally exposed pregnant	1
Pregnant who is a caregiver to people recently treated with RNT	1

- 1 mGy: annual dose limit for the public
- Pregnancy termination is not discussed for foetal dose values up to 100 mGy
- Foetal dose value 100-500 mGy: decision on a case-by-case basis

8. TYPICAL FOETAL DOSE VALUES IN DR / NM - CONCLUSION

DR / NM PROCEDURE	TYPICAL FOETAL DOSE (mGy)
Chest radiography	<0.01
Lumbar/Pelvis radiography	1.1 (max. 4.0)
CT abdomen	8.0 (max. 49)
Tc-99m MAA lung perfusion	0.5/early pregnancy 0.8/9 mo.
Tc-99m MDP bone scan	4.6/early pregnancy 1.8/9 mo.
PET/CT (FDG)	max.: ~22 typical: <10

- Foetal radiation burden is significantly lower than the tolerance dose of 100 mGy, provided that the imaging procedures are justified and in accordance with the foetal dose optimisation algorithm.
- Under these circumstances, concerns are not justified and a recommendation for pregnancy termination is highly unlikely.