Experience feedback of a radiation protection incident in radiotherapy: Irradiation of a pregnant patient

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Introduction:
A woman, treated by radiotherapy in the Centre François Baclesse in Caen for a head and neck cancer was proving pregnant (3rd month of pregnancy during the treatment). The pregnancy was revealed after the completion of the treatment (30 fractions – 2 Gy / fraction). In order to know the dose received by the fetus, measurements have been achieved with identical conditions as for the treatment.

Materials and methods:
Irradiation technique: VMAT on a Clinac iX (Varian) linac. 2 arcs of 307 UM and 278 UM with 6 MV photons
Phantom: Compact polystyrene to simulate the body and head and neck cylindrical phantom to simulate the irradiated volume
The ionization chamber was positioned at 45 cm of the field edge. This distance was measured by the medical doctor on the patient.
The measurements were achieved with the same parameters recorded on the "record and verify" software (Mosaiq – Elekta)
The measurement cumulated 5 repetitions to improve the accuracy

Results:
For 1 fraction: 0.83 mGy
For the whole treatment (30 fractions): 24.9 mGy

Discussion:
1/ The dose far from the irradiation field has 3 components [1]:

- Photons scattered by the irradiated volume of the patient (internal)
- Photons scattered by the irradiated materials (couch) and the walls of the treatment vault
- Leakage radiation from the linac

2/ The 1st component of the dose (scattered photons inside the patient) is very low because of the large distance between the field edge and the measuring point. In the ICRP report #84 (Pregnancy and medical radiation) [2] off axis values of dose are given for cobalt 60: approximately 0.25% at 45 cm but for linacs this off axis dose is lower 2 to 5 times (depending on beam energy). Our measurements (0.04%) are so, in good agreement with the ICRP #84 data. In the literature, several authors reported equivalent fetal doses for head and neck irradiations [3] [4] [7]. For irradiated volumes closer to the uterus (Hodgkin desease), the doses are obviously much greater [5] [6].

Conclusion:
The value of the effective dose measured (≈ 25 mSv) is superior to the upper legal limit for the fetus (1 mSv). In consequence, this case was declared as an incident to the French Nuclear Safety Authority (ASN) but it is assumed not to be critical for the children:

- *Malformations have a **threshold of 100-200 mGy or higher** and are typically associated with central nervous system problems* [1]
- *A fetal dose of 100 mGy has a small individual risk of radiation-induced cancer. There is over a 99% chance that the exposed fetus will **NOT** develop childhood cancer or leukaemia* [2]

[1] Fetal dose from radiotherapy with photons beams: Report AAPM TG n°36 MP vol.22-1 jan1995
[2] Pregnancy and medical radiation. ICRP 84
[3] Fetal radiation monitoring and dose minimization during intensity modulated radiation therapy for glioblastoma in pregnancy. Horowitz DP J Neurooncol. 2014
[4] A study of the shielding used to reduce leakage and scattered radiation to the fetus in a pregnant patient treated with a 6-MV external X-ray beam - Han, Health Phys. 2009
[5] In utero exposure to therapeutic radiation for Hodgkin lymphoma. Klieger-Grossmann - Can Fam Physician. 2009
[6] High fetal irradiation: about one pregnant woman receiving infradiaphragmatic radiotherapy for Hodgkin lymphoma - Moreau - Cancer Radiother. 2007
[7] Determination of possible doses to the gonads or fetus in pregnant patients during radiation therapy.Lin FJ, 1989