Purpose or Objective: Radiotherapy treatment of pregnant women is a relevant problem in terms of fetus radioprotection. A preliminary dosimetric evaluation of fetal dose could influence clinical decision of patient irradiation and, once the treatment has been approved, an accurate dose evaluation is important to estimate fetal radiation exposure risks. Fetal dose irradiation risks are described in AAPM report n.50 [1] and ICRP 84 [2] where is proposed a fetal dose limit of 10 cGy. In this work we describe dosimetric measurements related to a brain treatment for a pregnant woman in term of: preliminary measurements for optimal plan parameters assessment, pre-treatment in phantom dose measurements of approved plan and in vivo dosimetry to confirm pre-treatment evaluation.

Material and Methods: Treatment has been performed with 3DCRT on a Clinac 21 EX with dose of 60Gy in 30 sessions. At the time of dose evaluation patient was in 22° week of pregnancy. Distance from umbilicus to lower field edge is 53cm. Preliminary and pre-treatment measurements have been performed with both farmer ionization chamber in Rando phantom modified adding a water phantom and with TLD 100 in Rando phantom with bolus. Use of bolus over Rando phantom reproduces in a better way patient shape and dimensions. During all treatment we perform daily in vivo TLD dosimetry. In preliminary measurement session we evaluate relation between fetal dose and: field dimension, collimator rotation, presence of MLC, use of enhanced dynamic wedge (EDW) and thickness of lead shielding. We also study change of dose with distance from radiation field edge and with measurement depth.

Results: About treatment parameters we observed an important dose reduction using 90° collimator rotation and using MLC [4]. Fetal dose increase with EDW is acceptable only for small angles. The more relevant parameters related to dose increase are distance from field edge and field dimension. These are anatomy related parameters and cannot be optimized. Considering measured value of fetal unshielded dose (in the range of 1-2 cGy) we decide to use 8mm thickness lead shielding [3]. In preliminary phase we observed a little increase in dose with depth as reported in [5]. Result of pre-treatment and in vivo measurement is reported in table 1.

Conclusion: Treatment parameters like collimator rotation, MLC or EDW strongly influence fetal dose. This aspect must be considered in patient plan preparation. Pre treatment dosimetry is important to estimate fetal clinical irradiation risk and to evaluate the need and thickness of lead shielding. In vivo dosimetry is always important to confirm pre treatment dose evaluation. Differences between pre treatment and in vivo dosimetry should be attributed to differences in patient and phantom shape, dimension and internal structure. In our case we can give a precautionary estimation of fetal dose of 1.6 cGy, a value below 10cGy limit proposed by [1,2].

Purpose or Objective: to calculate organ doses for several protocols of a radiotherapy cone beam equipment using the PCXMC software, validated comparing doses with TLDs. Furthermore the set of coefficients to provide an estimation of organ doses was assessed for patients of different genders and sizes.

Material and Methods: The system in use was an Elekta CBCT (XVI) and the protocols analysed were four: head, pelvis, chest and chest-4D with different parameters. The first part of the study investigated the opportunity to use PCXMC, a software based on Montecarlo simulation generally employed for projective radiology, to calculating organ doses. This commercial software allows the user to specify patient age and size, radiation beam geometrical setup, beam energy, filtration; a dosimetric indicator (entrance skin dose or DAP) is required to calculate final organ and effective doses. A new version of the software introduces the possibility to simulate rotational beams, subdividing the exposure in single contributions at different angles and performing the total doses calculation in a batch way. The software was adapted to better simulate the modulated filtration of this particular CBCT considering different filtered beam contributions. A set of 50 TLDs (Harshaw - TLD 100) was selected, irradiated and analysed, for each protocol, to compare measurements with PCXMC results. The influence of patient size on organ dose was evaluated varying heights, weights and genders. Three levels of height and weight corresponding respectively to the 5th, 50th and 95th percentile of US males and females adult population were considered. The organ doses were normalized to the PCXMC standard adult phantom doses and the calculated ratios were plotted versus the equivalent diameter of each patient size.

Results: The differences between PCXMC and TLDs doses are shown in table 1 for different protocols;

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Organ</th>
<th>PCXMC</th>
<th>TLD</th>
<th>% of TLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head and neck N/C</td>
<td>1.86</td>
<td>0.90</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Respiratory-airways</td>
<td>0.04</td>
<td>0.01</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Lungs</td>
<td>0.9</td>
<td>0.96</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Simmetry 210 P</td>
<td>Head</td>
<td>10.1</td>
<td>10.18</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Breasts</td>
<td>15.6</td>
<td>15.94</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Lungs</td>
<td>0.9</td>
<td>0.96</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Chest M20 F0</td>
<td>Head</td>
<td>20.4</td>
<td>20.2</td>
</tr>
<tr>
<td></td>
<td>Breasts</td>
<td>21.3</td>
<td>19.2</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>Ovaries</td>
<td>19.7</td>
<td>22.3</td>
<td>102</td>
</tr>
<tr>
<td>PIVIT TNC</td>
<td>C-0.5</td>
<td>18.4</td>
<td>16.21</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>Prostate</td>
<td>16.0</td>
<td>12.32</td>
<td>20</td>
</tr>
</tbody>
</table>

The respiratory airways and the prostate show a difference over 15%, probably as a consequence of their position at the boundaries of the beam, with a critical match of exposure geometry for actual and virtual anthropomorphic phantoms. Regarding simulations with patients of different heights, weights and genders a variability in a range ±40% for pelvic region and ±30% for chest was observed; specifically, for the same acquisition protocol, organ doses for a slim patient could be much higher than the organ dose of an overweight patient. Fig 1 shows, as an example, dose correction factors versus equivalent diameters for breast with different protocols and relative fits.

Fig 1 correction factor vs patient equivalent diameter
Conclusion: Our results confirm the validity of PCXMC with rotational module also for particular geometrical conditions; patient dose can be evaluated based on patient equivalent diameter.

EP-1619

Ovaries and uterus Equivalent dose to in patients treated for Hodgkin Lymphoma with mediastinal RT

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Purpose or Objective: Hodgkin's lymphoma (HL) is one of the most curable types of cancer. Most HL patients are young (average age of 32 years); long-term side effects of the treatment are becoming increasingly important. Infertility after treatment could have a high psychosocial burden for young patients. Therefore, one of the most common malignancies diagnosed during pregnancy. The aim of the present study is to measure dose to ovaries and uterus, during supra-diaphragmatic radiotherapy performed with different techniques (3DRT, IMRT, VMAT and helical IMRT-Tomotherapy®).

Material and Methods: Dose measurements were performed using the plans of four different female patients, in reproductive age. The patients have been treated with chemotherapy and mediastinum irradiation (isocenter dose 30 Gy). An adult anthropomorphic Alderson Rando phantom (Rando phantom) was utilized for woman simulation. For each patient the Rando phantom TC-scan was matched with the PET/CT. Doing it, an approximate patient specific isocenter position on the Rando phantom and a relative position of ovaries and uterus in terms of phantom slices were identified. Treatment planning images and diagnostic whole body PET/CT were fused by means of Velocity Al 3.0®. Calcium fluoride thermoluminescent dosimeters, TLD-100, were used for dose measurements, 5 TLDs were used for every measurement. Patient’s treatment was simulated in 4 different techniques: 3DRT, IMRT, VMAT and helical IMRT-Tomotherapy®. To compare the results paired T student test was used.

Results: The equivalent doses to left ovary, right ovary and uterus, were respectively 16 mSV (range 5-19), 10 mSV (range 8-14) and 9 mSV (range 7-12) with 3DRT techniques; 15 mSV (range 7-23), 11.5 mSV (range 6-17) and 13 mSV (range 6-18) with VMAT; 14 mSV (range 6-23), 14 mSV (range 6-23) and 13 mSV (range 9-20) with IMRT and 54,5 mSV (range 44-70), 50mSV (range 40-72) and 56 mSV (range 33-67) with helical Tomotherapy®. Helical Tomotherapy® doses were significantly higher than the other three (p<10-8 for all three techniques; 3DRT, IMRT, VMAT and 3D (p=0.023 and 0.004 respectively). VMAT and 3D results are not statistically different one from each other (p=0.42).

Conclusion: All the techniques give a dose to ovary and uterus well below 20 mSV. This is the dose considered safe in terms of deterministic effects on embryo or foetus and with a relatively low risk of stochastic effect. Helical Tomotherapy® and IMRT give higher gonads dose as compared to other techniques. The implications of these data may be relevant also for patients in the very early stages of their pregnancy.

EP-1620

Accuracy of cone beam computed tomography while decreasing dose to patient

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Purpose or Objective: To construct a data warehouse of radiotherapy imaging performance data by automatically extracting CT and CBCT acquisition and dose information from the hospital PACS and ARIA oncology management system.

Results: We found that CBCT system is rather insensitive to the size (max 20 mm) and direction of the deliberate shift of the phantom. Precision of the correction shifts were within 0.5 mm that is in the limit of estimated uncertainty. It was observed that the MTF was insensitive to physical scanning parameters and much more dependant on image reconstruction protocol parameters. Uniformity improved and low contrast visibility decreased while lowering dose of scanning protocol. The CBCT system under investigation showed excellent precision for positioning the phantom even while dose of scanning protocol was reduced ~90%. On the other hand - low contrast visibility decreased and would most likely limit the amount of dose reduction to acceptable level that is still to be determined.

Conclusion: This work showed that CBCT is a very accurate localization method even in conditions where scanning dose was decreased to ~10% of initial dose. It is necessary to further assess the suitability of new low dose protocols qualitatively to develop acceptable clinical scanning protocols as well as to investigate possibility to improve reconstruction protocols.

EP-1621

Automated extraction and management of radiotherapy imaging dose data

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Purpose or Objective: To construct a data warehouse of radiotherapy imaging performance data by automatically extracting CT and CBCT acquisition and dose information from the hospital PACS and ARIA oncology management system.