INTRODUCTION
The major x-ray procedures that expose the medical staff at hospitals are angiography and heart catheterization. Most of those procedures take place while the medical staff is standing to the right side of the patient (the patient is lying on his back). It is possible to change some of those examinations and make those invasive procedures on the left side of the patient instead of the right side of his body.

The position of the medical staff influences the staff’s x-ray effective dose. The choice of the x-ray projection, as AP, PA, left lateral, or right lateral projections, causes effective dose differences. These differences arise from the asymmetrical positioning of tissues and organs inside the body, x-ray shielding of organs by other organs, and different radiation sensitivity of each organ.

The physicians usually stand close to the patient pelvis, keeping some distance from the x-ray source. Thus, standing on the right side of the patient in angiography and heart catheterization usually exposes the left side of their body (in most of the cases, their standing position is not frontal towards the patient’s irradiated volume).

Based on anatomical indicators, the traditional concept of building x-ray equipment was to fix the x-ray accessory items at the left side of the patient bed so the medical staff is standing to the right of the patient. Modern x-ray equipment in fluoroscopy rooms for angiography and heart catheterization is built to allow easy and comfortable working from both sides of the patient.

This work shows the differences in the effective dose of the medical staff working in fluoroscopy procedures and standing to the right side of the patient compared to working at his left side. The work is based on Monte Carlo simulation under PCXMC 2.0 software. The effective dose calculations were performed for a reference adult (73.2 kg, 178.6 cm), 100 kV, focus to skin distance (FSD) of 100 cm, and entrance surface air kerma of 1 mGy. The number of photons in the simulation was 250,000 (the simulation error was ±0.3%).

The radiation spectrum was formed by filtration of a 2.5 mm Al and tungsten target.

The imaging volume of the patient is the source of scattered radiation towards the medical staff. The simulation radiation angle was taken as -20° in the cranial-caudal direction (z-axis) and +45° and -45° in the lateral direction (xy plane). These directions were chosen as the typical exposure angles of the staff.

The effective dose calculation considers the x-ray penetration through the apron. The calculations were performed for direct x-ray spectrum, using IPEM spectrum processor. The calculation results produced entrance surface air kerma after full apron protection (0.5 mm lead equivalent). Calculation of the staff effective dose was obtained by using the effective dose of the full body irradiation at the above specific angle and considering the shielding influence.

RESULTS
The standard lead apron thickness for angiography and heart catherization is 0.5 mm lead equivalent. This protection layer transmits only 3.02% of the x-ray spectrum, formed by tungsten target, 100 kV, and 2.5 mm Al spectrum.

PCXMC 2.0 effective dose simulation results and the shielding of the protective apron combined to assess the medical staff’s effective dose while the staff member stand to the right or left sides of the patient bed.
Table 1: Staff effective dose per 1 mGy Air kerma outside the lead apron and staff irradiation angles of -20º in the cranial-caudal direction (z-axis) and +45º and -45º in the lateral direction (xy plane).

<table>
<thead>
<tr>
<th>Projection</th>
<th>mSv</th>
<th>45º to left/45º to right projection effective dose ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>45º to left</td>
<td>0.0122</td>
<td></td>
</tr>
<tr>
<td>45º to right</td>
<td>0.0106</td>
<td>114.8</td>
</tr>
</tbody>
</table>

The results in Table 1 show that standing at the right side of the patient (i.e., exposing the left side of the medical staff member at 45º) causes a larger effective dose than standing at the left side of the patient in the same conditions.

CONCLUSIONS
This work simulate the differences in the effective dose of the medical staff working in angiography and heart catheterization procedures and standing to the right side of the patient compared to working at his left side. This Monte Carlo exposure simulation of the medical staff, while they are standing to the right side of the patient, shows effective dose excess of 114.8% compared to standing in the same conditions at the left side of the patient.

REFERENCES