Occupational radiation exposure in chemoembolizations: Evaluation of doses in different body regions of professionals with different roles in the procedure

Poster No.: C-1530
Congress: ECR 2018
Type: Scientific Exhibit
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Keywords: Radioprotection / Radiation dose, Interventional vascular, Liver, Fluoroscopy, Chemoembolisation, Dosimetric comparison, Occupational / Environmental hazards, Workforce
DOI: 10.1594/ecr2018/C-1530

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Aims and objectives

Fluoroscopically guided interventional procedures are performed in great numbers in Europe and in the United States. The increasing use of ionizing radiation can be seen as simply the growing volume of work done or as the change of the procedures performed. [1-2]

Interventional radiology (IR) is an area that exposes medical staff to the highest doses of radiation. The scattered radiation to which medical professionals are regularly exposed comes mostly from the patient, therefore staff who remain close to the patient receive highest levels of radiation. Other factors can affect the levels of exposure for medical staff, including the professional's height, positioning in the room, the X-ray tube position in relation to the table and the patient, the use of radiological protection equipment, the total exposure time during the procedure and the condition of fluoroscopy and image acquisition. [1-5]

The main objective of the radiation monitoring is to ensure that the doses received by professionals do not exceed the values established by Portuguese Decree No. 222/2008. [6] The aim of this study is to investigate radiation exposure profiles in medical staff during an interventional radiologic procedure - hepatic chemoembolization.

Hepatocellular carcinoma is one of the most common cancers worldwide, the prognosis is poor because curative resection with partial hepatectomy or liver transplantation is only applicable to a small proportion of patients. [7-10]

For patients with unresectable disease, the goal of palliative treatment is to prolong survival and to control symptoms. Chemoembolization of the liver is a combination of chemotherapy delivered directly into the blood vessel feeding the tumor and a procedure called embolization in which an embolic agent is placed inside the blood vessels that supply blood to the tumor, in effect trapping the chemotherapy in the tumor. It is a nonsurgical and minimally invasive procedure performed by an interventional radiologist that takes a prolonged exposure to radiation. [8-9]
Methods and materials

This study was carried out at Centro Hospitalar do Porto, in the intervention room. We evaluated radiation dose in hepatic chemoembolizations based on four criteria: total exposure time (fluoroscopy time), procedure frequency, air kerma and dose area product (DAP), values that are the result of the selected protocol and are influenced by tube current (mA). This procedure was selected considering the potential high dose to medical staff due to prolonged exposure to radiation and the difficulty of the procedure. The disposition of the room is shown in figure 1.

![Fig. 1: Layout of the Intervention Room.](image)

References: - Porto/PT

This study reports to the radiation exposure values of professionals who attend hepatic chemoembolization procedures in a single institution during a six week period, and eleven procedures. The dosage of radiation absorbed was measured in six staff members, one primary interventionist and one assistant, a circulating nurse, a radiographer, an
anesthetist and an anesthetist nurse. The thermoluminescent dosimeters (TLD) were placed according to table 1.

<table>
<thead>
<tr>
<th>Professional</th>
<th>Dosimeter Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Interventionist and Assistant</td>
<td>Eye, thyroid, chest (one inside vest and one outside the vest), hand, inferior leg</td>
</tr>
<tr>
<td>Radiographer</td>
<td>Thyroid, chest (one inside vest and one outside the vest)</td>
</tr>
<tr>
<td>Nurse</td>
<td>Chest (one inside vest and one outside the vest)</td>
</tr>
<tr>
<td>Anesthetist</td>
<td>Chest (one inside vest and one outside the vest)</td>
</tr>
<tr>
<td>Anesthetist Nurse</td>
<td>Chest (one inside vest and one outside the vest)</td>
</tr>
</tbody>
</table>

All procedures were performed in an interventional room with an angiography equipment, that is in compliance with all standard radiation control tests made by the hospital external supporting physicist team. The equipment has two X-ray tubes, allowing images in two planes to be obtained with a single contrast volume injected. This equipment has a "Spectrabeam" filter, that delivers a better filtration of the soft radiation, and an additional anatomical filter to provide a high radiation protection regardless of the projection or the patient absorption. In the procedure of chemoembolizations, only the frontal X-Ray tube is used.

The equipment has detectors with a dimension of 40cm x 30cm, a pixel size of 154 m and can reach a maximum of 60 frames per second. The table is equipped with a ceiling-suspended transparent shield and a lead apron underneath the patient table. The procedures were performed with the optimized protocol for vascular abdominal.

**Dosimetry of professionals**

Several dosimeters (Li$_2$B$_4$O$_7$:Cu and CaSO$_4$:Tm) were used in all procedures. For each procedure, a set of control dosimeters (TLD) were used to discard any possible experimental reading errors. The TLDs were of the same type as the ones used for regular workers personal dosimetry, certified by and Approved Monitoring Service, being
calibrated for Hp(10) and Hp(0.07) quantities and traced to Portugal national standard irradiation laboratory.

In every procedure, dosimeters were placed on the primary interventionist (i.e., the physician who conducted the intervention) and on the assistant, who remained in the room throughout the entire procedure. Dosimeters were fixed at the following locations: on the lead glasses (on top of the surgical mask), lower leg and hand (bottom of the wrist), in the thyroid and chest two dosimeters were placed, one beneath the lead protector shield and another over it, in order to quantify the actual radiation dose values that the professionals are exposed to without and with the radiological protection.
**Fig. 1:** Layout of the Intervention Room.

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Results

Each procedure had an average time of fluoroscopy of eleven minutes and seven seconds, and thirty six acquisition frames totalizing a mean DAP of 951976 mGy.cm². The dosimetric results of the primary interventionist and of the assistant are markedly superior to the rest of the team due to their proximity to the patient (figure 2).

![Chest Dosimeter doses HP(10)](image)

**Fig. 2**: Chest Dosimeter, inside the vest, doses HP(10) during the 6 week monitorization of the primary interventionist, assistant and radiographer. The other members of the team have 0 mSV.

*References*: - Porto/PT

The anesthetic team and the circulating nurse do not have any dose registered in the dosimeters, since most of the time they stay out of the room and the radiology technician has low values due to the same reason. Extensive instrument manipulation during image acquisition causes high levels of hands exposure of the interventionist 1 (figure 3 and 4).
Fig. 3: Dosimeter doses during the 5 week monitorization of the primary interventionist: head, thyroid, hand, inferior leg.

References: - Porto/PT

The lower legs have a high dose due to the positioning of the X-ray tube under the table (figure 3), despite the lead skirt placed under the table. The results of figure 5, Relation between DAP and abdominal perimeter, shows that the increase in DAP is related to the abdominal perimeter of the patient, since the procedure time is similar through the various procedures.
Fig. 4: Mean dosimeter doses of the primary interventionist: head, thyroid, hand, inferior leg.

References: - Porto/PT

Fig. 5: Relation between DAP and Abdominal Perimeter through the 11 procedures.

References: - Porto/PT

From our results, we can conclude that work at the intervention room is safe from the point of view of radiation protection. Nevertheless, although staff radiation exposure is well within the established safety limits, high-dose-level procedures can be carried in
this room. It is necessary to maintain intensive radiation protection surveillance and implement radiation protection lectures on the interventional procedures.
Fig. 2: Chest Dosimeter, inside the vest, doses HP(10) during the 6 week monitorization of the primary interventionist, assistant and radiographer. The other members of the team have 0 mSV.

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Conclusion

In our study and despite our short sample, the dose levels measured indicate that professionals who are properly shielded do not exceed the annual dose limits. The interventionists perform around 70 chemoembolizations procedures per year, and the mean annual value for the crystalline in these specific procedures will be around 13mSv which does not exceed the 20mSv established by the recent European legislation. In this study, the interventionists always wear lead glasses, that attenuate the dose received. Our analysis demonstrates that individual dosimeters, positioned on the chest, under the vest, may underestimate the doses for other body regions, especially eye lens. Therefore, a strategy for additional stationary shielding for the eye lens is strongly recommended, especially for high dose procedures like chemoembolizations.
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