# Doses in the Vicinity of Mobile X-ray Equipment in a Children's Intensive Care Unit

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## INTRODUCTION

Today's knowledge about biological effects of radiation, as well as the radiobiological principle that young organisms are more sensitive to ionizing radiation, show that even low doses do induce effects in organisms. The radiation organ and tissue sensitivities are different, therefore it is necessary to observe them in respect to their specific function and related dose. That is why we should draw attention to the large number of X-ray examinations on children, especially thorax photographs. The latter represent some 90% of all children radiodiagnostics.

The WHO Ionizing Radiation Protection Expert Committee (1) has drawn special attention, within its recommendations, to the restriction of radiodiagnostic procedures on children and stressed the obligatory use of special gonads protection and good technique, if the examinations must be done at all. The recommended special care and protection during examinations on children is justified with the fact that it is exactly the children irradiation which increases the entire population genetic risk.

The inconsistent and often unoptimized examination technique leads to large absorbed dose variations in children. This was proved in a nation-wide children irradiation exposure survey (2). A significant standard deviation was found, due to obvious reasons such as age, height and weight of patients, dosimeter placing, shooting projections and different X-ray equipment. This is why it is important to intensify efforts on technique optimisation in paediatric radiology, to eliminate unnecessaryly by high absorbed doses. A standardised method would, before all, require an exact knowledge of irradiation doses on patients. Our earlier measurements (3-7) have been performed with the aim of establishing an evaluation model for the total population exposure, as well as for the risk estimation in Croatia. The lower radiation doses of our patients, as compared to some results in the literature (8-9) can be due to the special children adjustment technique and measurement conditions. Although new techniques and new examination methods led to an increased number of radiological examinations, improvements of X-ray equipment and radiation protection measures can actually decrease the exposure of patients to ionizing radiation.

One of the new techniques - mostly used for respiratory tract diagnosis, heart and endovascular cateterization - uses mobile X-ray equipment. Since 1997 a mobile X-ray equipment has been routinely used on children in the Intensive Care Unit of the Clinic for Infectious Diseases "Dr. Fran Mihaljević" in Zagreb. Most patients in the Intensive Care Unit are the new-borns and infants with an infection of central nervous system, with systemic septic and respiratory infections. Therefore mobile X-ray equipment is used for the radiological diagnosis of children who can not be transported to the X-ray Department of the Hospital because of the nature of their illness (monitoring of vital functions, artificial respiration, heavily endangered vital condition).

Research has been done as a prospective study with the goal to measure doses during the standard use of mobile X-ray unit in its surroundings. The aim of this work was to determine the exposure of children to radiation in the vicinity of the exposed patient in the same or the adjacent room.

## MATERIAL AND METHODS

Department for Intensive Care in the Clinic for Infectious Diseases "Dr. Fran Mihaljević" has 7 beds in 3 double-bed rooms and 1 single-bed room.The boxes are separated from each other with a glass wall. Every bed has a room of about 6-8 $m^2$. The distances between beds are at least 160 cm, the maximum distance being 300 cm. The dimensions of the doors and rooms enable easy handling and shifting of the X-ray unit and shields to the optimum position. In Figure 1 a room with mobile X-ray equipement and mobile shields behind the bed is shown.

Figure 1. Location of mobile X-ray and shields in the Intensive Care Unit for Children

For dose measurements thermoluminescent dosimetric system was used. Individually calibrated TLD-700 detectors (by Harshaw) were placed in pairs of two in light-tight black plastic and rubber holders 3 mm thick during patient and calibration irradiation. The TLD`s were annealed for 60 min at 400°C folowed by 120 min at 100°C in an automatic microprosessor controlled TLD oven (manufacturer PTW). All readings were made with a microprocessor-controlled TOLEDO 654 (Pitman/Vinten) reader in the Ruđer Bošković Institute. The reader is shown in Figure 2. Before readout, external (100°C for 20 min) and internal (100°C for 6 s) pre-heat treatments were applied. The readout temperature was 270°C. The laboratory calibration was performed using TLDs irradiated by a $^{137}$Cs source. The dose shown by the control detectors was subtracted from the values measured accrued during the exposure. Control detectors were unirradiated detectors showing the dose of natural background radiation during the transport and storage of dosimeters. The energy dependence, linearity and reproducibility of the TLD system have been determined earlier (10-11).

Figure 2. Microprocessor controlled Toledo 654 reader

# RESULTS

3 measurement runs were carried out. In the first one, the dosimeters were placed on the bed without the patient, in the centre of the primary beam and at the lateral distances of 4, 6.5, 9.5, 13.5 cm. In Figure 3 the results of dose measurements in the center and at 4 and 9.5 cm, respectively are shown. The number of exposures in this measurement run was 5, the voltage of the X-ray tube 51 kV, the quantity of charge 6.3 mAs. The distance of the X-ray tube from the detectors was 104 cm.

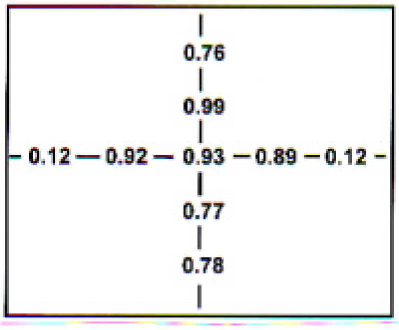


Figure 3. The results of the dose measurements in the center and at 4 and 9.5 cm

The results in Figure 3. show adequate homogeneity of the irradiation field within 10 cm in vertical direction. It is obvious that in horizontal direction the dosimeter at the distance of 9.5 cm was not in the primary beam, because the dose at this distance was 0.12 mSv. The doses measured in the second measurement run on the neighbouring bed behind the shield, as well as the doses on the glass wall of the room at various heights and distances from the X-ray tube are shown in Figure 4.

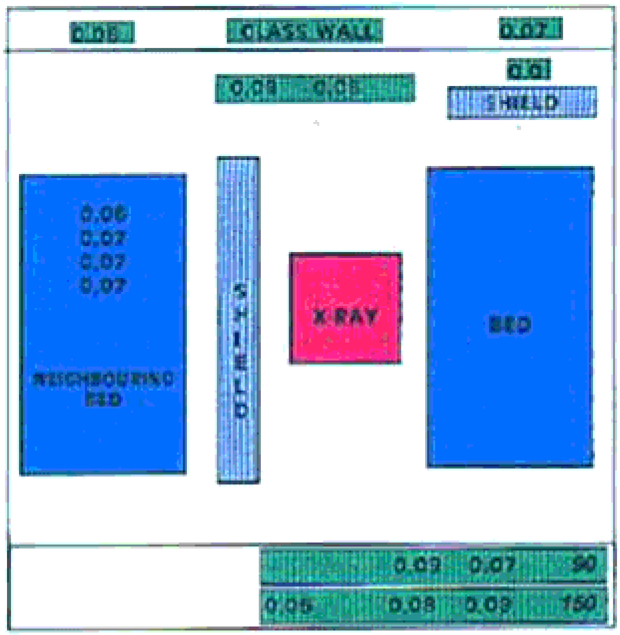


Figure 4. The doses measured on the neighbouring bed behind the shield and on the glass wall of the room

The conditions of the irradiation were: voltage 42 kV, quantity of charge 3.2 mAs, the tube-bed distance 115 cm. The doses are in the range of 0.06-0.09 mSv. In the first measurement run even after 5 exposures similar values to these were obtained. It is evident that the doses in the surrounding of the equipment are very low, practically they are in the range of the lowest detectable dose. According to our earlier study, the lowest detectable dose, defined as 3 times the standard deviation of the reading of unirradiated dosimeters, is 5 µSv for the used TL dosimetric system. Taking into account that the dose of the control detectors was 0.08 and 0.07 mSv for the 1st and the 2nd measurement runs, respectively and that the doses in both measurement runs were similar, though in the first run 5 exposures were given, it can be concluded that there are no detectable doses in the surrounding of the equipment.

In the 3rd measurement run, the configuration of dosimeters in the surrounding was the same, but the irradiation was carried out with a patient. It was a small girl, age 2 years, weight 11.5 kg. Position of dosimeters on the patient are shown in Figure 5. The irradiation conditions were the same as in the 2nd measurement run. The distribution of the surface dose is shown in Table 1.

Figure 5. Position of dosimeters on patient

Table 1. The distribution of the surface dose on the patient

| Organ | **Dose (mSv)** |
|---|---|
| Breast | 0.17 |
| Back | 0.12 |
| Thyroid | 0.15 |
| Right eye | 0.10 |
| Right gonad | 0.10 |

The dose of the control dosimeters was 0.10 mSv. That means that on the eye and the gonad no dose was measured from the X-ray diagnostic exposure of the chest.

## CONCLUSIONS

In the Department of Intensive Care a mobile X-ray unit is routinely used. The doses in the surrounding of the equipement are very low, practically in the range of the lowest detectable dose ($D_{LDL}$=5μSv) According to our study, it can be concluded that the exposure of other children in the vicinity of the exposed patient in the same or next room is not measurable. Therefore there is no need for the risk estimation of genetic, leukemogenic and cancerogenic detriment.

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