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

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ABSTRACT

Most of the patients in the intensive care unit for children are newborns and infants having an infection of the central nervous system, with systemic septic and respiratory infections. Therefore, mobile X-ray equipment including mobile shields is routinely used for diagnosis of the respiratory tract, heart and endovascular cateterisation. The aim of this work was to determine the radiation exposure to the children in the vicinity of the exposed patient in the same or next room. Three measurement runs were carried out with thermoluminescence dosimetry system. The results show that the homogeneity of the irradiation field is adequate, the exposure of children to radiation in the vicinity of the exposed patient in the same or next room is very low, practically in the range of the lowest detectable dose. The entrance dose on the breast of the patient was found to be 0.07 mSv. Therefore, there is no basis for the risk estimation of genetic, leukemogenic and cancerogenic detriment.

Introduction

Today's knowledge about biological effects of radiation, as well as the radiobiological principle that young organisms are more sensitive to ionising 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

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radiographs. The latter represent some 90% of all children radiodiagnostics.

The WHO Ionising 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 unoptimised 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 unnecessarily 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 ionising radiation.

One of the new techniques – mostly used for respiratory tract diagnosis, heart and endovascular cateterisation – 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 bedrooms and 1 single bedroom. 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 equipment and mobile shields behind the bed is shown.

The mobile X-ray unit was a Phillips Practix 100 equipment. Mobile shields of firm Weimer Strahlenschutz were used together with the equipment. The lead content of the shields is 1 mm, the dimension is 140 156 5 cm. One of the shields

Fig. 1. Location of the mobile X-ray and shields in the intensive care unit for children.

Fig. 2. Microprocessor controlled Toledo 654 reader.

has a window with lead glass for a better control of the patients during the exposure.

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 followed by 120 min at 100 °C in an automatic microprocessor 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].

Results

Three measurement runs were carried out. The aim of the first measurement run was to determine the homogeneity of the radiation field independently from the absolute dose values. Random irradiation conditions frequently used for lung radiography were chosen: the voltage of the X-ray tube was 51 kV, the quantity of charge 6.3 mAs, the distance of the X-ray tube from the detectors was 104 cm. The number of exposures in this measurement run was 5. The dosimeters were placed on the bed without the patient or scattering medium, 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.

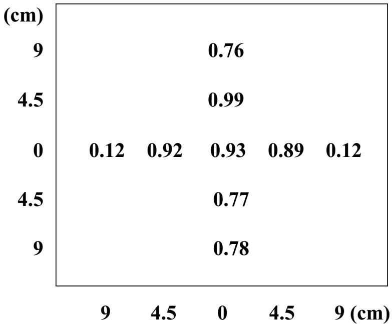

Fig. 3. The results of the dose (mSv) measurements in the center and at 4 and 9.5 cm.

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 (90 and 150 cm) and distances from the X-ray tube are shown in Figure 4.

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 has to be mentioned that both measurement run were carried out without scattering medium. 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[12], the lowest detectable dose, defined as 3 times the standard deviation of the reading of unirradiated dosimeters, is 5 Sv 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 detect-

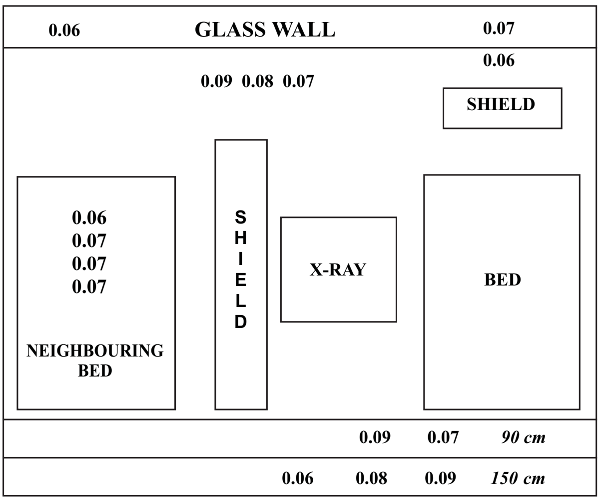

Fig. 4. The doses (mSv) measured on the neighbouring bed behind the shield and on the glass wall of the room.

Fig. 5. Position of dosimeters on the patient.

(0.10 mSv). On the eye and the gonad no dose was measured from the X-ray diagnostic exposure of the chest. It should be mentioned that measurements made for a single X-ray examination cannot be assumed to be representative for all such examinations. However, these results are in good agreement with our earlier study[12] where radiation doses have been determined on various parts of the body on 78 patients of different age groups during thorax examinations.

TABLE 1
THE DISTRIBUTION OF THE SURFACE DOSE ON THE PATIENT

Organ	Dose (mSv)
Breast	0.07
Back	0.02
Thyroid	0.05
Right eye	0.00
Right gonad	0.00

able 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.

The doses in the Table 1 are the difference of the measured actual dose value and the dose of the control dosimeters

Conclusions

In the Department of Intensive Care a mobile X-ray unit is routinely used. The doses in the surrounding of the equipment are very low, practically in the range of the lowest detectable dose (D_{LDL} = 5Sv) 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 for these children.

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DOZE U BLIZINI POKRETNE RENDGENSKE OPREME U JEDINICI ZA INTENZIVNU NJEGU DJECE

S A Ž E T A K

Većina pacijenata u jedinici za intenzivnu njegu djece su novoronđenčad i dojenčad koja boluju od infekcije središnjeg živčanog sustava, sepse i respiratornih infekcija. Stoga se pokretna rendgenska oprema sa zaštitnim zaslonima rutinski koristi u dijagnostici respiratornih bolesti kao i kod srčanih i endovaskularnnih kateterizacija. Cilj je ovog istraživanja odrediti stupanj izlaganja radijaciji djece u blizini ozračenog pacijenta u istoj ili susjednoj sobi. Izvršena su tri mjerenja pomoću termoluminiscentnog dozimetrijskog uređaja. Rezultati ukazuju na primjerenu homogenost radijacijskog polja te da je stupanj izlaganja radijaciji djece u blizini ozračenog pacijenta u istoj ili susjednoj sobi vrlo nizak, tj. da je u rasponu najnižih mjerljivih doza. Kako je doza radijacije na razini prsiju bolesnika iznosila 0,07 MSv, smatramo da ne postoje osnove za procjenu rizika leukemogenog ili genskog cancerogenog oštećenja.