MEASUREMENT OF THE GONAD DOSE OF INFANTS DURING X-RAY EXAMINATION OF THE HIP

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1. INTRODUCTION

As the consequence that in most parts of Europe, at least 1% of dysplasia of the hip without severe dislocation do not show any clinical symptoms in early infancy even in repeated careful examination (1), the number of X-ray screening to detect these cases for early prophylactic treatment increases in the last years. During these radiological examinations of the hip joints a special lead shield of 1.5 mm Pb with a fenestration can be used to protect the gonads (2). This window allows the determination of all parts of skeleton to make a correct diagnosis while all other parts, especially the gonads, are safely shielded. To improve protection against scattered radiation an additional lead shield is used beneath the tests while examining boys. To check the effectiveness of this gonad protection direct dosimetric studies on the patient during X-ray examinations were performed.

2. METHODS AND MEASUREMENTS

The measurements of radiation dose were done with LiF (TLD-100) extruded chips and CaF_2:Dy (TLD-200) crystals with dimensions $6.35 \times 6.35 \times 0.9$ mm^3. The read out of the thermoluminescence dosimeters was performed with a modified E G & G system using a special selected program for the heating cycle (3) the dosimeters were calibrated in the radiation field of a Co-60 source under the consideration that the requirements for electron equilibrium in a tissue equivalent material (polyethylene) are satisfied. The exposure TL-response of the LiF-dosimeters was measured between 1 mR and 100 mR and of the CaF_2:Dy dosimeters in the region of 50 µR to 70 mR (4). In the Co-60 radiation field the standard deviation of the measurements was in the exposure range of about 10 mR, 5% for the LiF-dosimeters and 4.5% for the CaF_2-dosimeters. Because of the large fluctuation of the non radiation induced thermoluminescence in the exposure region below 1 mR the standard deviation increases to 25% for the LiF- and to 10% for the CaF_2-dosimeters.

Since our examinations were not performed in a Co-60 radiation field, but with diagnostic X-rays, the measured exposures had to be corrected for the relativ sensitivities of the thermoluminescence dosimeters. At energies below 100 keV the sensitivities of TLD-100 and TLD-200 increases compared to Co-60 radiation. The energy dependence of both the dosimeters was measured with a monochromator and the filtered bremsstrahlung from a gold target excited by electrons from a Van de Graaff accelerator (4) the final sensitivity correction factors for the dosimeters were estimated

with so called tandem measurements. During all examinations one TLD-100 and one TLD-200 dosimeter wrapped in a black plastic foil (polyethylene 5.35 mg/cm^{-2}) were attached to the skin in front of the X-ray diagnostic machine as well as on the rear side. Therefore both dosimeters are exposed simultaneously in the same diagnostic X-ray energy region and indicate the identical exposure. From the ratio the different energy response of both dosimeters - the thermoluminescence light emitted from the LiF and the CaF_2 is different in its intensity - the effective energy of the X-ray spectrum at the site of the dosimeter can be infered. The measured energy response of the dosimeters allows the estimation of the correction factor for the both dosimeters. The correction factor of TLD-100 was estimated about 1.3, the correction factor of TLD-200 varies from 8.5 to 10. Due to the uncertainty in the correction factor the standard deviation of the measurements with CaF_2 as well as with LiF increased to 10% in the 10 mR region and up to 20% in the exposure region below 1 mR. Finally, a factor of 0.91 rad per R was used for the conversion from exposure to tissue dose.

3. GONAD DOSE

3.1. Testicle dose

The examinations of the hip were performed with diagnostic X-rays generated at 50 kV and 65 kV. In the consequence of the different thickness of the several patients the parameters of the X-ray generator had to be varied in general. The focus-film distance was 100 cm. For measuring the testicle dose the dosimeters wrapped in a black plastic foil were attached behind the scrotum. During the X-ray examinations the scrotum was shielded with an additional 1 mm lead protection at the flanks and the rear to reduce scattered radiation.

Generator parameters		Dose	Range
kV	m As	mrad	mrad
65	2.5	0.15±0,08	< 0.02-0.35
50	6.3-8	0.23±0.2	< 0.02-0.65

TABLE 1 Dose behind the scrotum, testicle dose

The maximum exposure measured with displaced scrotum protection was 0.65 mrad.

3.2. Estimation of the ovary dose

TLD-200 dosimeters wrapped in black plastic foil were attached at the end of a rubber tube and put into the rectum of the patient up to about 7 cm above the anus. 2 cm from the dosimeter a lead mark was fixed which was generally shielded by the 1 mm lead gonad protection during the X-ray examination. The correction factor of the dosimeters could be calculated from the effective energy determined from tandem measurements on the skin in front of the X-ray machine as well as on the rear side. Depending on the position of the dosimeters and the variations of the X-ray adjustments the absorbed dose in the rectum varies between 0.4 and 1 mrad. The mean absorbed dose was determined to be 0.6 ± 0.3 mrad.

Generator parameter		Dose	Range
kV	m As	mrad	mrad
65	2	0.55 0.3	0.4 - 1
65	2.5	0.7 0.11	
50	6.3 - 8	0.6 0.3	0.3 - 1

TABLE 2 Measured dose in the rectum, ovary dose.

3.3. Dose using high intensifying screen-film combinations

During a lot of examinations high intensifying screen-film combinations (Trimax alpha 4 screen together with Trimax XM-film) was performed. Using this combination the detail visibility was not influenced and after adjustment to 60 kV and 1 mAs the same grade of blackening was obtained as in the former examinations. The mean dose measured in the rectum was 0.12 ± 0.04 mrad and the dose at the scrotum varied from values of an elevated background to 30 µR - 70 µR.

4. CONCLUSION

These measurements of the testicles and ovaries doses of young infants during X-ray examination of the hip show that the used simple fenestration method is an effective gonad protection. Additional one can reduce most effectively the gonad dose by using high intensifying rare earth screen-film combinations. The gonad dose obtained for one X-ray photograph of the hip with high intensifying screens for girls is equivalent to the natural radiation dose of 1/2 day and for boys of 1/10 - 1/5 day.

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