RADIOLOGICAL DOSE TO THE CHILD DURING CARDIAC CATHETERIZATION (AXIAL RADIOLOGICAL PROJECTIONS)

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The use of axial angiography techniques for hemodynamic diagnosis considerably affects the levels of radiation dose to the pediatric patient under examination. Recently, several assessment procedures of radiation dose were carried in the literature, nevertheless many doubts still remain concerning the techniques proposed and the dose values obtained for the different examined organs. Particularly the results obtained by using thermoluminescent dosimeters applied to the patient's body are not convincing, because in these procedures the detectors may easily move away, without possibility of control, from the radiation beam area, thus supplying incomplete and fragmentary results. The aim of this study is to ascertain the dosage levels for the child undergoing cardiac catheterization with the use of axial radiological techniques, in order to define the relationship between fluoroscopic and angiographic dosages and to critically evaluate the possibility and the levels of irradiation of critical organs, as a function of radiological beam positioning.

MATERIALS, METHODS AND RESULTS

The research was carried out in the Hemodynamics Laboratory of the Cardiology Institute of the University of Bologna with a total of 50 cardiac catheterization performed by using axial techniques on patients whose age ranged from 1 day to 11 years, mean value 4 years.

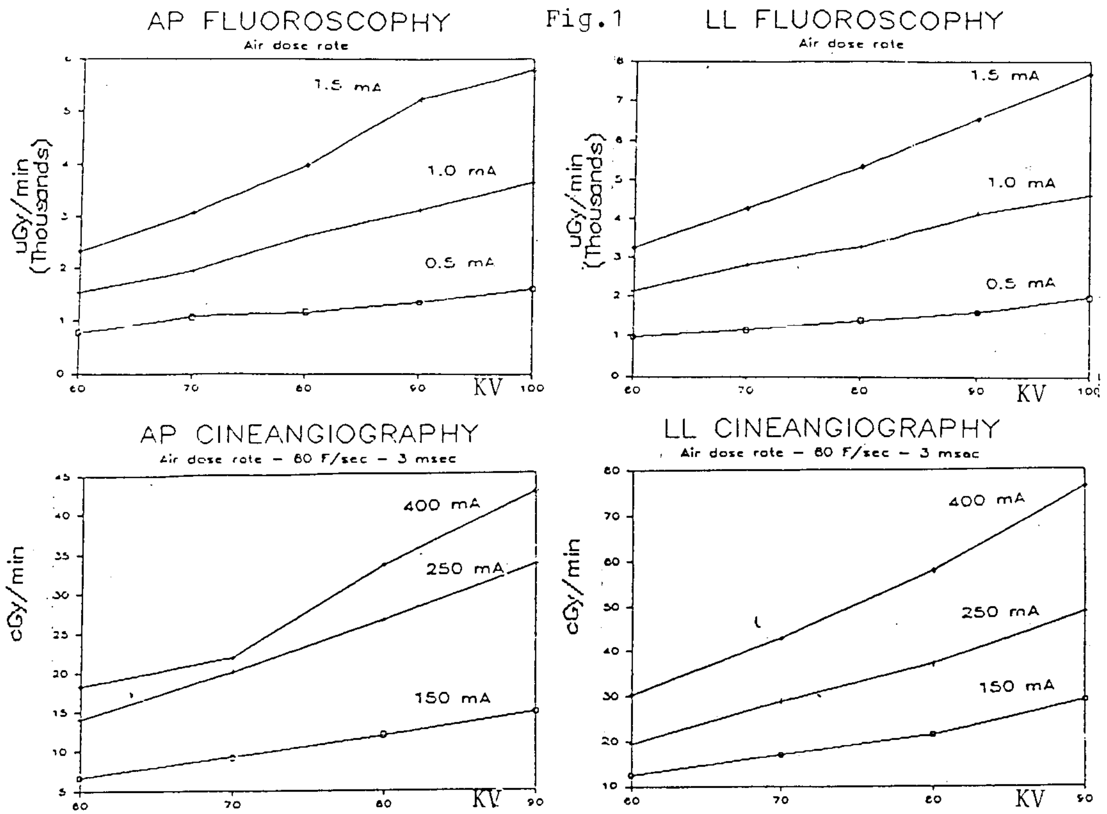
The laboratory, where examinations were performed, is equipped with biplane CGR Radiological System. When in PA projection, the image intensifier is in the upper position. Each radiation tube is provided with a screening system which allows to confine the radiation field to the minimum useful surface. Rx-I.I. distance amounts to 105 cm, both for PA and LL projections. The radiological system is equipped with an automatic control device which acts by changing the voltage applied to Rx tubes. Current and graphic emission time are manually set.

The research protocol was divided in two phases:

1) characterization of the radiological system from the patient's radioprotection standpoint;
2) recording of radiological data and emission times during examination to calculate the dosages for the individual patients.

The characterization of the radiological system was performed by using IONEX-type dosimeter with 0.6 cm^3 ionization chamber to record the dose in air, 15 cm from I.I. entrance screen, in correlation with the voltage and the current supplied to the radiological tube, both in fluoroscopic and angiographic conditions. The results are illustrated in Fig.1. For each diagnostic examination taken into consideration, recordings were made of radiological data and time in fluoroscopy of various projections with the relevant radiological data and time in angiography, of

Fig.1



age, weight, and height of the patient. Thus, by using Fig.1 curves,it was possible to assess the fluoroscopic and angiographic dose to the skin of the patient for each single projection. Fluoroscopic emission time ranges from 0,7 to 58,8 minutes (M=22,1 min) and fluoroscopic air dose for PA ranges from 0,4 to 7 cGy (M=3,7 cGy). Angiographic emission time, for PA and LL projections respectively ranges from 14 to 107 sec (M=36,5 sec) and from 5 to 87 sec (M=30,8 sec).Angiographic air dose ranges from 3,5 to 107 cGy (M=55,3 cGy) for PA and from 2,6 to 165 cGY (M=83,8 cGy) for LL projections. The results of the fluoroscopic tests for LL projection are not recorded, as they are negligible if compared to PA results. Fig. 2 illustrates the dose distributions for the individual patients.

DISCUSSION

The curves of Fig.1 confirm the good performance of the radiological equipment. Fluoroscopic information (time and radiological data) may be compared with those recently published in the literature. The angiographic time (number of frames/examination), although considerably changing case by case, is on average similar to that reported in the literature, whereas resulting air dose values (23 cGy (PA), 29 cGy (LL)) are particularly high and, anyhow, at lest 10 times higher than those recently presented. Our results point out that there is at least a 1/10 ratio between fluoroscopic and angiographic air dose and, hence, they suggest that the cineangiographic phase is the most dangerous for the

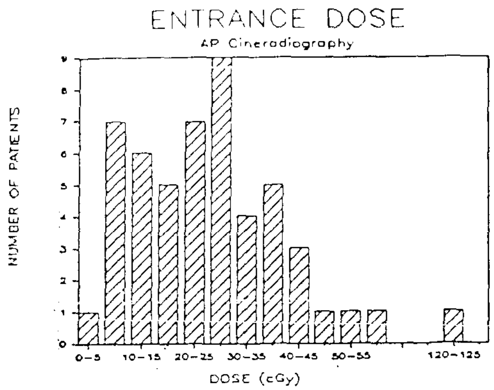
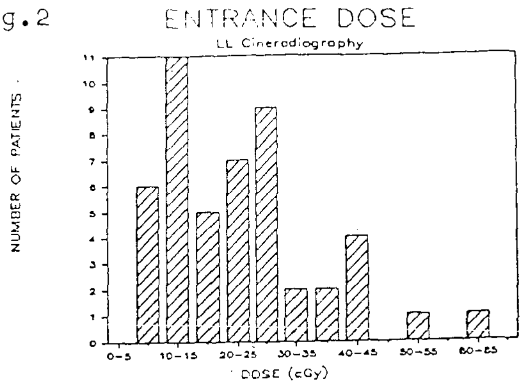


Fig.2



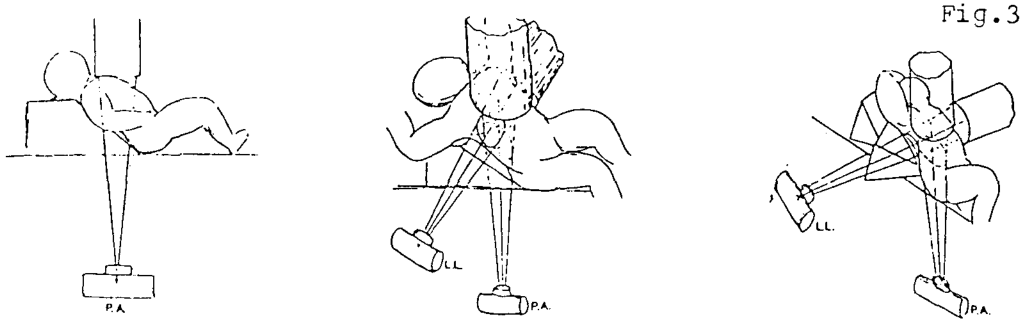
patient from the protection standpoint. In our opinion, the low graphic air dose values quoted in the literature are due to the difficulties met in keeping the thermoluminescent dosimeters within the radiation beams when the patient is moved around or variously positioned for the different projections. This problem arises only during the angiographic phase, as in the fluoroscopic one the patient remains in PA position and the dosimeters are certainly within the radiologic beam. This explains why the fluoroscopic values are in agreement.

Considering our results, we decided rather to give separate air dose figures for PA and LL than to add them up, as is usually done, because a careful analysis of the examination procedures and the different projections (Fig.3) very seldom reports cutaneous overlapping of the irradiation fields of the two tubes. Therefore, we prefer to consider a larger area exposed to a smaller dose than to overestimate the exposure at any possible point. Nevertheless, it is extremely important to take account of the very different results, on the other hand expected in this kind of diagnosis, to pinpoint and discuss the cases of abnormal irradiation of the patient. This analysis is possible thanks to the method we adopted, based on the recording of radiological data and emission time. Furthermore, with reference to the cases under examination, for all air doses over 43,5 cGy, the analysis highlighted the technical causes (misadjustment or breakdown of the radiological system) and the operational causes (projection repetition) which brought about the abnormal value.

Observing the diagnostic medical procedure, the recorded data point out a systematic use (49 out of 51 cases) of the biplane radiological recording. A greater attention in estimating the real usefulness of a biplane observation in each projection could possibly lead to a decrease in the use of LL projection and a remarkable dose reduction.

The use of "axial" cineangiography modifies the risk of irradiation of important organs, both for the different positioning of the beams, which are at times closer to them, and for the greater energies employed to penetrate thicker layers of tissue. The evaluations reported in the literature cannot be compared whatsoever, both because of the different technical performances of the system and because of the different medical procedurte management (seriography, cineangiography, etc.). By observing the images in Fig.3, it is clear that, when the patient is tilt up, the radiation beam gets closer to the thyroid gland and to the gonads but, for the thyroid, it cannot be higher than

Fig.3



the I.I. entrance air dose (i.e. 0,26 uGy/frame). In a standard examination, including about 2000 frames for each projection, the thyroid air dose should therefore be less than 104 uGy. Considerably higher values indicate bad operation of the system, wrong placing of the tubes and inadequate screening.

CONCLUSIONS

For the pediatric patient undergoing cardiac catheterization, the radiological dose is one of the parameters which have to be carefully considered as a risk, expecially with reference to the possibility of repetition of the examination or integration with less dangerous techniques (ultrasound). Comparing fluoroscopic and angiographic dose values, the latter show greater irradiation for the patient. This leads to a critical evaluation of the methods of examination and, expecially, to consider the advisability of systematic biplane radiological recordings. The proposed methods, in the framework of which parameters strictly connected to the technical performances of the system and to the operational examination procedure are regularly collected, permits a critical analysis of the results and highlights the causes of abnormal irradiation of the patient. The radiation of important organs (thyroid, gland, gonads) may be evaluated both by analysing the beam angle and by using the data obtained as input parameters of mathematical models which take into consideration the patient's soma and the beam bearing. In any case, the results show a smaller irradiation than that expounded in the literature.

REFERENCES

- BARGERON L.M.Jr., ELLIOTT L.P., SOTO B., BREAM P.R., CURRY G.C.: "Axial cineangiography in congenital heart disease". Circulation 1977, 56, n.6, 1075-1083.

- ELLIOTT L.P., BARGERON L.M.Jr., BREAM P.R., SOTO B., CURRY G.C.: "Axial cinenagiography in congenital heart disease". Circulation 1977, 56 (6), 1084-1093.

- MARTIN E.C., OLSON A.P., STEEG C.N., CASARELLA W.J.: "Radiation exposure to the pediatric patient during cardiac catheterization and angiocardiography". Circulation 1981, 64 (1), 153-157.

- REUTER F.G.: "Physician and patient exposurte during cardiac catheterization". Circulation 1978, 58, 134.

- WALDMAN J.D., RUMMERFIELD P.S., GILPIN E.A., KIRKPATRICK S.E.: "Radiation exposure to the child during cardiac catheterization". Circulation 1981, 64, 158.

- ADAMS F.H., NORMAN A., BASS D., OKU G.: "Chromosome damage in infants and children after cardiac catheterization and angiography". Pediatrics 1978, 62, 312.

- AMIEL M., CLERMONT A., JOCTEUR-MONROZIER D., MORONI JP., BRUN P. "Etude dosimétrique au cours de l'angiographie cardiaque chez le jeune enfant". Ann. Radiol. 1976, 19, 623-628.

- ARDAN G.M., HAMILL J., EMRYS-ROBERTS E., OLIVER E.: "Radiation dose do the patient in cardiac radiology". Br.J.Radiol.1970, 43, 391-394.

- BEACH S.A., DOLPHIN G.W.: "A study of the relationship between x-ray dose delivered to the thyroid of children and the subsequent development of malignant tumors". Phys.Med.Biol.1961, 6, 583.

- CALLISEN H.H., NORMAN A., ADAMS F.H.: "Absorbed dose in the presence of contrast agents during pediatric cardiac catheterization". Med.Phys. 1979, 6(6), 504-509.

- DORPH S., MYGIND T., NORTHEVED A., OKHOLM B., PETERSEN K.O.,OIGAARD A.: "A dose-reducing fluoroscopy system: dose measurements and clinical evaluation". Radiol.1970, 97, 399-403.

- MARTIN E.C.: "Radiation exposure to the the pediatric patient during cardiac catheterization and angiography". Circul.1981, 64.

- GOUGH G.H., DAVIS R., STACEY A.J.,: "Radiation doses delivered to the skin, bone marrow and gonads of patients during cardiac catheterization and angiocardiography". Br.J.Radiol.1968, 41, 508.

- GROLLMAN J.H., KLOSTERMAN H., HERMAN M.W., MOLER C.L., EBER L.M. MAC ALPIN R.N.: "Dose reduction low pulse-rate fluoroscopy". Radiology 1972, 105, 293-298.

- GROLLMAN J.H.: "Radiation reduction by means of low pulse-rate fluoroscopy during cardiac catheterization and coronary arteriography". Am.J.Roentgen.Rad.Ther.Nucl.Med. 1974, 121, 636.

- GUSTAFSSON M., MORTENSSON W.: "Irradiation to the thyroid gland at cardiac catheterization and angiocardiography in children". Br.J.Radiol. 1976, 49, 686-689.

- HEMPELMANN L.: "Risk of thyroid neoplasm after irradiation in children". Science 1968, 169, 159.

- KAUDE J., SVAHN G.: "Absorbed gonad and integral doses to the patient and personnel from angiographic procedures". Acta Radiol. 1974, 15, 454-464.

- LANGMEAD W.A., WALL B.F.: "An assessment of lithium borte thermoluminescent dosimeters for the measurement of doses to patients in diagnostic radiology". Br.J.Radiol. 1976,49,956-962.