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SURVEY OF DIAGNOSTIC PAEDIATRIC RADIOLOGY AND THE RESULTED COLLECTIVE EFFECTIVE DOSE (2000 y)

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Abstract. The purpose of our study was to update the annual frequency of X-ray examinations and the pattern of paediatric radiology in 2000 year. Also, to assess in terms of effective dose the magnitude of pediatric patient exposure during conventional X-ray examinations, selected by their high frequencies or their relatively high doses delivered to patient. The annual effective doses from all medical examinations for the average pediatric patients are as follows: 0.85 mSv for 0 year old, 0.53 mSv for 1 year old, 0.56 mSv for 5 year old, 0.72 mSv for 10 year old and 0.74 mSv for 15 year old. The resulting annual collective effective dose was evaluated at 872 manSv, with the largest contribution of pelvis and hip examinations. However, this value could be much larger because the CT annual use increased in 2000 y up to 3.1% of total examinations from a negligible one of 0.1% in previous survey.
Key words: paediatric radiology, X-ray examinations, effective dose, collective effective dose

Rezumat. Lucrarea estimează consumul radiologic anual şi frecvenţele relative ale diverselor proceduri utilizate în radiologia pediatrică în anul 2000. Pulmonul rămâne organul cu cea mai frecventă examinare (radioscopică şi radiofotografică). Mărimea expunerii pacientului din diverse examinări radiologice menţionate (doză efectivă) pe subgrupe de vârstă a fost evaluată la: 0,85 mSv-0,53 mSv (0-3 ani); 0,56 mSv (5 ani); 0,72 mSv (10 ani); 0,74 mSv (15 ani). Doza efectivă colectivă rezultată din examinările radiologice convenţionale în anul 2000 a atins valoarea de 872 omSv. Tomografia computerizată a ajuns în anul 2000 la o frecvenţă medie de utilizare de 3,1% comparativ cu 0,1% găsită în studiul anterior (1995), ceea ce modifică evident dimensiunea actualei doze colective anuale.
Cuvinte cheie: radiologia pediatrică, examene radiodiagnostice, doză efectivă, doză colectivă

INTRODUCTION

Because of their longer life expectancy, the risk of late manifestations of detrimental radiation effects is greater in children than in adults and, consequently, paediatric radiology gives ground for more concern regarding radiation protection than radiology of adults (1,2).

The purpose of our study was to reassess, the frequency and pattern of paediatric X-ray examinations and the magnitude of paediatric patient exposure during conventional X-ray examinations, in terms of effective dose. The estimates of effective dose specific to pediatric radiology are needed both as there is a wide range of patient size and different radiographic techniques in comparison with adults.

The anatomical features and body proportion vary due to the developmental process in infancy, childhood and adolescence. They are different in respective age groups and distinct from those of a mature patient.

MATERIAL AND METHODS

We have continued the practice of our last national survey (3,4) using hospitals and clinics as the basic units for the annual frequency of X-ray examinations.

25 out of 44 districts of Romania participated with 56 sanitary units of different size (table 1).

Table 1. Distribution of districts on the number of paediatric beds

Number of paediatric beds per hospital	Number of districts	Percentage
100 – 299	9	36
300 – 499	11	44
500 – 899	4	16
≥ 900	1	4

Data on a sample of 22870 patients were collected on a special form detailed by age, sex and type of examination.

In order to assess how representative geographic distribution of data is, we have compared the radiology workload of each district with radiology workload statistics for Romania for financial year 2000, as provided by the Ministry of Health (5).

Effective doses (ED) have been derived from measurements of dose-area product (DAP) carried out on over 1100 patients undergoing X-ray examinations in pediatric units, between 1999 and 2000. The DAP measurements have been performed by a Diamentor (PTW Freiburg) transmission ionization chamber attached to the diaphragm housing of the X-ray set and accurately calibrated (6,7).

The conversion coefficients for estimating effective doses are those calculated by the NRPB using Monte-Carlo techniques on a series of 5 mathematical phantoms representing 0, 1, 5, 10 and 15 year old children (8).

RESULTS AND DISCUSSION

Table 2 shows the annual frequency of X-ray examinations within each age subgroup and whole group compared to those of 1995 survey (3,4).

It can be seen from table 2 that chest radiography still remained the most frequent examination in the whole age group 0-15 years followed by the limb and joints examinations.

The others chest examinations such as fluoroscopy and photofluorography decreased as percentage contribution in 2000 year to 10.4 and 5.3, respectively.

CT examinations soared to 3.1% of all medical examinations in 2000 year recording a very spectacular rise in comparison with 1995 year.

A detailed analysis of percentage contribution of different X-ray examinations by age group reveals some particularities.

So, in the first two age groups (0-1 year and 1-3) the most frequently used

examinations are those of chest (radiography), pelvis, limbs and joints. After the age of four the limbs and joints examinations have the highest contribution to annual totals.

In the last groups (8-11 year and 12-15 year) chest fluoroscopy shows about the same annual use as chest radiography but with different contribution to collective dose. The use of CT rises constantly up to 4.3% of all medical X-ray examinations in the preschool children whereas after the age of eight, this procedure contribution declines to 2.4-2.6%.

The average DAP values for twelve pediatric examinations are presented in table 3.

Table 2. Percentage frequencies of paediatric examinations (2000 y comparatively with 1995 y)

Examination	2000 y					2000 y	1995 y
	Age group (years)					whole group	
	0 - 1	1 – 3	4 - 7	8 - 11	12 - 15	0 – 15 y	
Chest - radiography	61.2	49.2	24.0	15.5	13.2	25.9	33.7
- photofluorography	-	-	3.4	6.5	9.3	5.3	6.8
- fluoroscopy	-	5.1	12.9	13.0	12.8	10.4	14.3
Spine - lumbar	0.1	0.5	2.1	3.0	2.8	2.1	1.0
- thoracic	0.1	0.4	1.2	2.5	3.0	1.9	0.5
- cervical	0.1	0.4	1.0	1.2	1.5	1.0	0.7
Pelvis, hip	18.6	7.2	5.6	3.6	3.6	6.2	3.5
Head	4.3	9.0	12.2	12.7	10.3	10.3	8.5
Angiography	-	-	-	-	0.3	0.1	-
Abdomen	1.0	0.3	0.6	0.7	0.7	0.7	2.0
Cystourethrography	0.9	1.3	0.8	0.6	0.3	0.7	-
Urography	0.8	1.4	1.9	1.9	1.5	1.6	1.1
Upper gastrointestinal	1.9	1.6	4.1	4.2	6.3	4.3	3.0
Lower gastrointestinal	1.1	1.0	1.9	1.9	1.8	1.7	0.7
Limbs, joints	6.4	18.7	24.0	30.0	30.2	24.7	24.2
CT - head	1.8	2.3	3.1	1.9	1.7	2.1	0.1
- body	1.7	1.6	1.2	0.8	0.7	1.0	0.01

Table 3. Average dose-area product values (Gy cm^2) for paediatric patient

Examination	Age group (years)				
	0 - 1	1 - 3	4 - 7	8 - 11	12 - 15
Chest - radiography - photofluorography - fluoroscopy	0.11 ± 0.05 - -	0.17 ± 0.09 - 0.80 ± 0.45	0.31 ± 0.12 0.67 ± 0.37 0.76 ± 0.42	0.57 ± 0.20 1.1 ± 0.4 1.2 ± 0.80	0.73 ± 0.21 2.9 ± 0.6 1.8 ± 1.1
Spine - lumbar - cervical	2.2 ± 1.3	4.6 ± 3.9	7.2 ± 4.4	13.5 ± 5.3	18.8 ± 7.1 2.4 ± 1.3
Pelvis, hip	1.7 ± 1.4	3.8 ± 1.4	5.1 ± 2.5	22.0 ± 7.0	23.5 ± 10.3
Head	0.80 ± 0.10	2.0 ± 0.9	5.3 ± 2.8	6.8 ± 2.2	6.1 ± 2.7
Angiography	-	-	-	-	9.6 ± 5.3
Abdomen	1.2 ± 0.8	1.6 ± 1.1	1.3 ± 0.7	3.9 ± 2.2	3.8 ± 1.2
Cystography	2.4 ± 1.0	1.8 ± 0.8	4.6 ± 1.4	14.5 ± 5.3	20.4 ± 6.4
Urography	5.4 ± 2.8	10.8 ± 4.7	6.2 ± 3.3	14.1 ± 9.0	21.4 ± 11.5
Upper gastrointestinal	-	0.9 ± 0.3	1.6 ± 0.8	3.8 ± 1.9	8.4 ± 5.1
Lower gastrointestinal	-	0.5 ± 0.3	1.4 ± 0.9	2.2 ± 1.4	5.6 ± 3.1

The average effective dose per examination (table 4) indicates that urography and cystography as the top contributions to newborn babies total dose (0.85 mSv) the highest value of all age group values.

As children's age risk, ED tends to decrease and in the top place of X-ray procedures is lumbar spine examination.

Table 4. Average effective doses (mSv) for paediatric patient

Examination	Age group (years)				
	0 - 1	1 - 3	4 -7	8 - 11	12- 15
Chest - radiography - photofluorography - fluoroscopy	0.18 ± 0.08 -	0.11 ± 0.07 - 0.53 ± 0.30	0.10 ± 0.04 0.20 ± 0.10 0.38 ± 0.21	0.12 ± 0.04 0.26 ± 0.13 0.38 ± 0.25	0.13 ± 0.04 0.40 ± 0.18 0.33 ± 0.25
Spine - lumbar - cervical	3.5 ± 2.4	3.2 ± 2.7	4.0 ± 2.1	5.3 ± 1.8	4.5 ± 1.9 0.57 ± 0.32
Pelvis, hip	3.1 ± 0.8	3.5 ± 1.3	3.0 ± 1.6	3.6 ± 1.2	3.4 ± 1.5
Head	0.32 ± 0.07	0.28 ± 0.11	0.30 ± 0.16	0.34 ± 0.12	0.21 ± 0.11
Angiography	-	-	-	-	0.32 ± 0.19
Abdomen	2.0 ± 1.3	1.2 ± 0.8	0.8 ± 0.3	1.2 ± 0.7	0.85 ± 0.27
Cystography	5.6 ± 2.2	2.9 ± 1.1	2.4 ± 0.7	2.5 ± 0.9	2.2 ± 0.7
Urography	8.6 ± 4.5	6.1 ± 2.7	3.8 ± 1.6	4.2 ± 2.7	4.8 ± 2.6
Upper gastrointestinal	-	0.7 ± 0.3	1.0 ± 0.5	1.6 ± 1.0	2.1 ± 1.1
Lower gastrointestinal	-	0.35 ± 0.13	0.50 ± 0.28	0.47 ± 0.27	0.88 ± 0.43
All medical examinations	0.85	0.53	0.56	0.72	0.74

The resulted collective effective doses of pediatric patients from conventional radiology examinations are presented in table 5.

Table 5. Annual collective effective dose from paediatric examinations (manSv)

Examination	Age group (years)					
	0 - 1	1 – 3	4 - 7	8 - 11	12 - 15	0 - 15
Chest - radiography	16.7	8.5	5.3	5.7	7.3	43.5
- photofluorography	-	-	1.5	5.1	15.9	22.5
- fluoroscopy	-	4.2	10.7	15.0	18.0	47.9
Spine - lumbar - cervical	1.1	4.9	29.0	88.2	111.6 3.7	234.8 3.7
Pelvis, hip	88.1	39.6	36.6	39.7	52.1	256.1
Head	2.1	4.1	8.0	13.1	9.2	36.5
Angiography	-	-	-	-	0.3	0.3
Abdomen	3.0	0.6	1.0	2.4	2.5	9.5
Cystourethrography	7.3	5.9	4.2	4.4	2.7	24.5
Urography	10.2	13.8	15.4	24.7	30.0	94.1
Upper gastrointestinal	-	1.7	9.1	20.4	55.9	87.1
Lower gastrointestinal	-	0.4	2.1	2.7	6.6	11.8
TOTAL (rounded)	129	84	123	221	315	872

The estimated value of 872 manSv has a distinct upward trend with child's age (except the group 1-3 years).

The percentage contribution to collective dose and their annual frequencies of eleven conventional radiological examinations, arranged in descending order of their contribution to collective dose, is shown in figure 1.

As can see, the highest contributors to annual collective dose are pelvis, hip and spine examinations.

Although the X-ray examinations of chest accumulate frequencies over 40 per cent, their contribution to collective dose summarizes only 13.1%.

It must be point out that the lack of significant increase or decrease in the annual frequency of X-ray examinations in paediatric radiology (11% in 1995 *vs* 12% in 2000 of all medical X-ray examinations) doesn't means that collective dose followed the same tendency (9).

The current contribution of computed tomography of 3.1% of total annual X-ray procedures in 2000 indicates that collective dose could be substantially higher than that currently estimated.

With the much increase of CT contribution there is a clear need to measure and develop optimization activities for this high dose procedure, as well as periodical survey of radiological pattern, because the benefit of some high dose examinations should be carefully weighted against the increased risk.

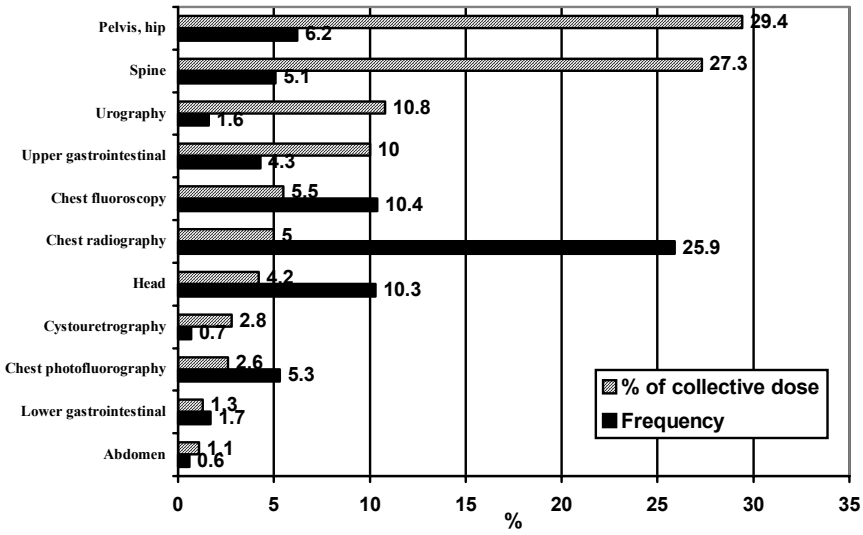

Fig. 1 Contribution to collective dose and frequency from 11 paediatric conventional X-ray examinations

CONCLUSIONS

- Paediatric X-ray examinations represented 12% of all medical procedures performed in 2000 y in Romania.
- Current pattern of paediatric radiology shows a mean increase of CT frequency of 3.1% of total annual X-ray procedures.
- The annual effective doses from conventional X-ray procedures ranged from 0.53 mSv (age subgroup 5 y) to 0.85 mSv (new born babies).
- The resulted annual collective dose of paediatric patients from conventional X-ray procedures was 872 manSv with the highest contribution of pelvis, hip and spine examinations.

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