Patient doses and examination frequency for diagnostic radiology in Iceland 1993 - 1998

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Abstract: Presented are data on the frequency of x-ray examinations that have been gathered in two surveys with a five year interval. There is a 17% increase in the number of x-ray examinations from 1993 to 1998. During the same time computed tomography examinations have nearly doubled. Patient dose data for the different types of examinations are also presented and an assessment is made of the contribution of these examinations to the Collective Effective Dose (CED). The number of CT examinations has increased from 8,3% of all x-ray examinations in 1993 to 13,6% in 1998 and contributes more the 50% of the CED in 1998.

Introduction

The Icelandic Radiation Protection Institute (IRPI) performed two surveys on the frequency of diagnostic x-ray examinations in Iceland in 1993 and 1998. Earlier information is limited. Measurement of patient doses for over 4500 conventional x-ray examinations have been performed at 14 x-ray departments all over the country, in more than 28 x-ray rooms. These measurements were made with Dose Area Product meters (DAP). Dose evaluations for CT examinations have been made for all the CT units in the country. Patient doses for breast examinations have also been evaluated. This paper will present results of these efforts, revealing trends in the frequency of radiological examinations and patient doses and an assessment of the collective effective dose (CED) [1] contributed by diagnostic radiology examinations. Of particular interest are trends in patient doses and examination frequency in computed tomography and its contribution to the CED.

Material and Methods

Examination frequency

Data on examination frequency was collected by IRPI on two separate occasions, in 1994 (for examinations made in 1993) and again in 1999 (for examinations made in 1998). Earlier data collections have been made in Iceland, but not in the detail necessary for comparison with the this data. Data were collected from all x-ray departments in the country, covering more than 95% of the medical diagnostic imaging examinations done in Iceland in these years. About 80% of the data were detailed with information on examination types, age and sex of the patient.

Patient doses

In 1994 IRPI started a program to evaluate patient doses by using dose measurement systems consisting of DAP meters connected to PC-computers. A software was developed, that made it easy for the radiographers to collect data on all x-ray examinations made with the x-ray equipment. This includes information such as examination type, age, weight and sex of the patient, the high tension (kV) used, number of films used and the film-screen combination used. The software collected data from the DAP meters during the x-ray procedure and could separate DAP for fluoroscopy and radiographs. It could also calculate the fluoroscopy time. From this

data the effective dose [1] for the different x-ray examinations could be calculated using appropriate conversion coefficients from the literature [2].
All Mammography examinations are performed at the Icelandic Cancer Societies Breast Screening Center in Reykjavik and with mobile equipment around the country. Patient doses for breast imaging is based on data collected by a computer program on PC-computers. They are connected to the x-ray equipment that is used in the screening program. This program collects information about exposure factors for each image made, such as kV, mA, exposure time, thickness of the compressed breast and other information. The mean glandular tissue dose is calculated and stored for each exposure. The effective dose was calculated using the ICRP weight factor for breast[1], multiplied by the mean glandular dose and the mean numer of projections used.

For CT examinations, patient doses were assessed by dose measurements in 4 of the 5 CT units used in Iceland. Free in air and phantom doses were measured with a pencil shaped ionization chamber connected to an electrometer (Radcal Corp. USA). The CTDIw [3] for each unit was calculated and with information from examination protocols at each location, the DLP [3] for the most common examinations was calculated. The effective dose for CT examinations was calculated by using normalized values of effective dose per DLP for different body regions [3].

Table 1. Frequency of x-ray examinations 1993 and 1998

	1993	1998	Change %
Number of all x-ray examination (incl. CT and Mammography)	160.711	188.739	+17,4
Computed Tomography	13.368	25.841	+93,3
CT ex. as a fraction of all x-ray examinations	8,3%	13,6%	
Mammography	13.155	14.872	+13,1
Number of x-ray examinations per 1000 inhabitants	609	685	+12,5

Results

Examination frequency

The national survey in 1993 shows that 160.710 x-ray examinations were made that year and this number has increased to 188.740 in 1998 (+ 17,4%). The most striking increase is in CT examinations, which went from 13.370 to 25.760, which is an increase of 93%. The results are shown in table I.

There are good data available about the number of CT examinations since they began in 1981. Today there are 5 CT-units in use in the country and the majority of the examinations are made with 4 of these units (1 is an old unit that only contributes less than 1% of the examinations). In figure 1, the examination frequency

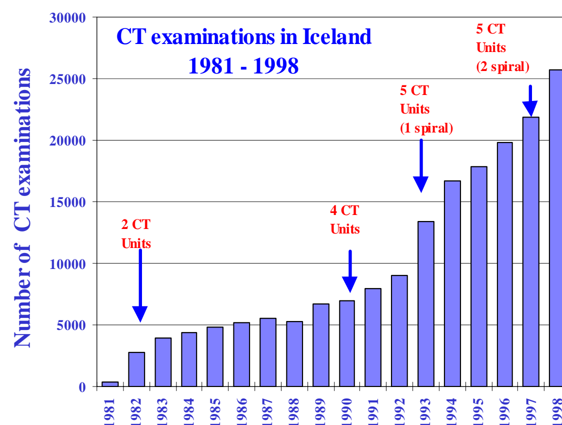

Figure 1. Frequency of CT examinations in Iceland 1981 - 1998

for CT examinations are shown, from 1981 and on the figure are indicators for the number of CT units that are in use at each time. In 1993 the first spiral CT unit was introduced and today there are 2 spiral units and one multi-slice unit.

The increase in Mammography examination is mainly due to different coverage of the country in the screening program for these years. The average number of Mammography examinations per year from 1989 - 1998 is 14.100.

Patient doses

Patient mean effective dose for the most common conventional x-ray examinations, based on DAP measurements are shown in table II. The table also shows information on mean high tension (kV) used, the mean number of films, and mean DAP values (in Gy cm^2) and measurement range. There is a very wide range in DAP measurements for most of these examinations.

Table II. Mean effective doses for some common conventional x-ray examinations, with information about used kVp, number of films used, mean measured DAP and measurement range.

Examination type	Mean kVp	Mean number of films	Mean DAP $Gycm^2$	Range $Gycm^2$		Mean effective dose mSv
				Min	Max	
Barium Enema	99	15,4	56,6	1,5	204,7	***11,9***
MUCG	74	11,0	34,5	2,3	51,9	***10,7***
ERCP	80	7,5	22,1	0,1	100,6	***4,4***
Urography	72	11,2	18,2	0,8	64,8	***3,5***
Lumbal Spine	73	4,6	12,9	0,2	97,6	***2,0***
Abdomen	76	3,2	6,1	0,2	40,1	***1,4***
Pelvis	74	1,4	3,4	0,1	24,6	***0,7***
Thoracal Spine	71	2,9	5,2	0,3	18,5	***0,7***
Cervical Spine	69	5,8	1,0	0,05	3,6	***0,2***
Lung	122	2,2	0,6	0,01	5,4	***0,1***
Skull	72	3,8	2,0	0,02	4,3	***0,05***

The mean effective dose for Mammography is 0,36 mSv and contributes 5,4 manSv to the CED. The method of data collection and dose measurements in CT, only gives average doses for the different examinations, with no indication of range. The mean effective dose for the most common CT examinations are shown in table III with assessment of their contribution to the CED. The contribution of the different x-ray examinations to the Collective Effective Dose are shown in figure II.

Table III. Number of CT examinations in 1998, mean effective dose and contribution to CED

Examination Type	***Number of examin. 1998***	***Mean Effective Dose mSv***	***Collective Effective Dose manSv***
Head	10.888	1,3	14,6
Lung/Chest	4.186	8,5	35,5
Neck	437	4,0	1,7
Spine	3.309	3,3	10,8
Kidneys	435	5,3	2,3
Abdomen	3.154	13,2	41,6
Liver/Spleen	2.046	5,8	11,9
Pelvis	775	6,1	4,7
Other	532	4,5	6,8
Total:	**25.762**		**129,9**

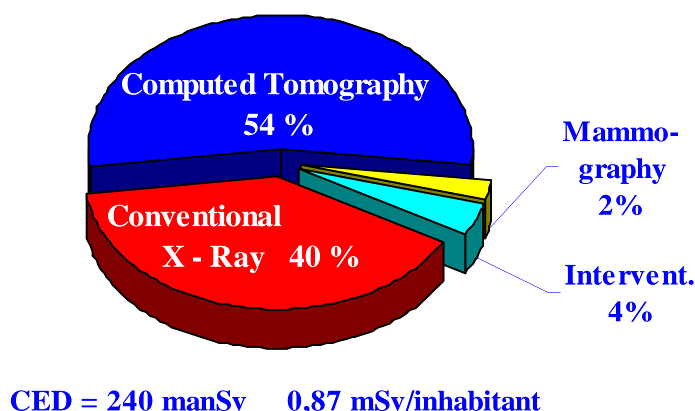

Figure 2. Collective effective dose for x -ray examinations in Iceland

Discussion and Conclusions

Examination frequency is increasing in Iceland but the number of examinations per thousand inhabitants is very similar in Iceland (689) as in the neighbouring countries, such as Norway (708), Sweden (568) and Finland (704)[4], but lower than the average number for Level I countries, 940, according to the latest UNSCEAR report[4]. The most pronounced trend in examination frequency is the increase in CT examinations which has nearly doubled.

CT examinations now contributes more than 50% of the total CED from all x-ray examinations, similar to trends in other countires[5]. The highest doses arise from CT examination of the abdomen, chest and pelvis. On average CT examinations are high dose examinations which have a great effect on CED. Patient dose measurements for conventional examinations show a wide range, which indicates a potential for optimization in performance. Advances in CT technology are opening new diagnostic possibilities for the benefit of the patient and CT examinations are becoming the examination of chocie for more and more indications. Even though new CT equipment can achieve examinations with lower patient doses compared to older CT units, changes in examination protocolls can include larger parts of the patient being irradiated and higher doses. The CED is increasing rapidly due to both higher number of CT examinations performed and increasing doses per examination. Efforts to reduce doses should inlude optimisation of both how CT examinations are performed and the criteria for requesting them.

References

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