LIVELONG ACCUMULATED RADIATION EXPOSURE DOSE FROM MEDICAL RADIOGRAPHY AND NUCLEAR MEDICINE IN A POPULATION REPRESENTATIVE SAMPLE

Heiner von Boetticher[1,2] *, Merle Meiboom[1], Wolfgang Hoffmann[3]

[1] Klinikum Links der Weser, Institute for Radiology, Bremen, Germany
[2] Klinikum Links der Weser, Academy of Radiation Protection, Bremen, Germany
[3] Ernst-Moritz-Arndt University Greifswald, Institute for Community Medicine, Greifswald, Germany

Abstract. Diagnostic radiography is a leading cause of man-made radiation exposure. Individual and population based radiation risk assessment require retrospective assessment of lifelong exposure from medical sources. The prevalence of radiologic examinations and the resulting cumulative red bone marrow dose are presented in a population based retrospective epidemiologic study.

KEYWORDS: Diagnostic radiology; dose assessment; red bone marrow dose; dose assessment modeling

1. Introduction

Diagnostic radiography is the most important single source of exposure to ionizing radiation in the general population (Berrington and Darby 2004; Ron 2003). Presently, radiography contributes some 40% to the overall radiation exposure. However, presently both the population based lifelong prevalence of radiologic examinations and the resulting cumulative radiation doses are unknown. The red bone marrow dose is the place of origin of leukemia – a group of diseases that can be caused by radiation. Compared to other diseases caused by radiation exposure leukemia develops after lower doses and with shorter latency following exposure. Thus the cumulative red bone marrow dose is an important factor when dealing with risk estimations and causes of leukemia.

2. Data base

The lifetime dose of the red bone marrow from different kinds of radiologic examinations was estimated for a population based representative cohort (2811 subjects) of the Northern Germany Leukemia and Lymphoma Study (NLL) – who served as controls in a large population-based

* Presenting author
Address: Senator-Wessling-Str. 1, D-28277 Bremen, Germany
Email: heiner.boetticher@klinikum-bremen-ldw.de

Table 1. Correction factors for x-ray examinations on the basis of the development of the film-screen imaging system.

Time period	Required dose for film-screen imaging system (μGy)	Relative dose factor (reference period 1976-1985)
1946 – 1955	40 - 80	8
1956 – 1965	20 - 40	4
1966 – 1975	10 - 20	2
1976 – 1985	5.0 - 10	1
1986 – 1995	2.5 - 5.0	0.5

Table 2. Correction factors for real life radiologic practice with respect to patient dose.

Category	Standard of radiologic practice	Factor
A	Ideal standard	1
B	Lower realistic standard	2
C	Medium realistic standard	4
D	Upper realistic standard	8

Table 3. Matrix of combined correction factors for advancement of radiologic technology and standard of radiologic practice for X-ray examination (excluding chest x-ray screening).

	Standard of radiologic practice			
Time period	**A**	**B**	**C**	**D**
until 1945	16	32	64	128
1946-1955	8	16	32	64
1956-1965	4	8	16	32
1966-1975	2	4	8	16
1976-1985	1	2	4	8
since 1986	0.5	1	2	4

epidemiologic case control study conducted in Northern Germany (Hoffmann et al 2008). In the study were included conventional radiography including chest x-ray screening examinations, fluoroscopies with contrast medium, catheter examinations, and interventions; examinations with computer tomography, and nuclear medicine examinations. The personal interviews were administered in a standardized, computerized way considering number, calendar year and kind of each examination as well as gender and age of the subjects.

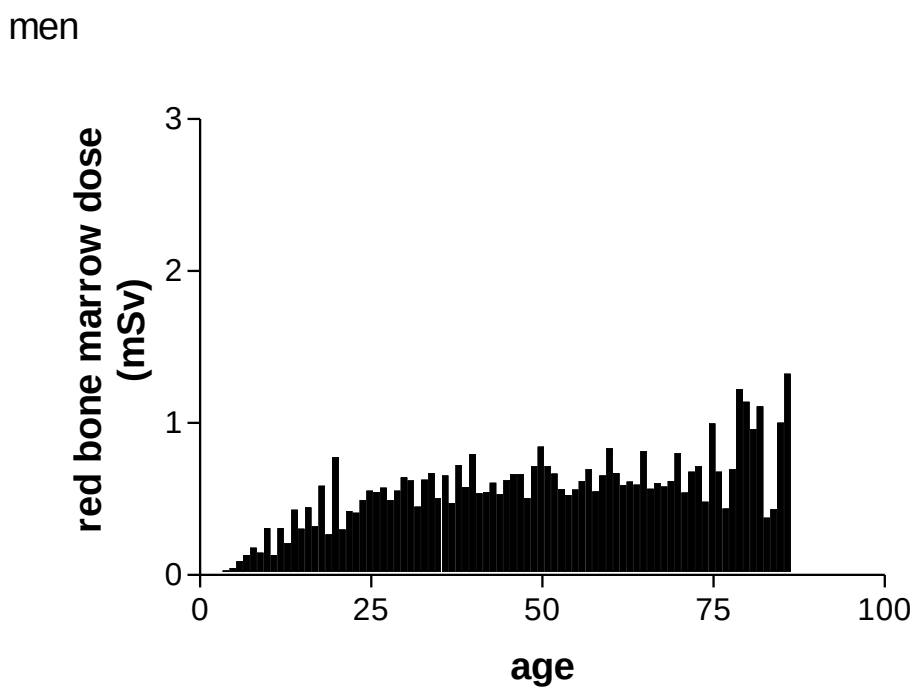
3. Algorithm

The calculations are based on the comprehensive quantification model suggested by von Boetticher and Hoffmann (2007) which include calendar year, age and kind of examination, gender of the subjects, technical development and real life conditions of radiological practice. As an example the Tables 1-3 describe the method used for conventional diagnostic radiography without chest x-ray population screening (von Boetticher and Hoffmann 2007).

4. Results

The number of radiologic examinations for diagnostic purposes increases continuously over lifetime in all cohorts. The rise appears to be less steep in childhood and young adults and becomes steeper in later life. Likewise, the number of examinations rises over consecutive cohorts and is highest in the

Figure 1: Mean values of red bone marrow dose per age considering all male subjects of the study.



most recent cohort. The red bone marrow dose decreases with later birth year. Nevertheless it depends slightly on age (Figure 1) but more so on calendar year. Until 1970 traditional examinations like conventional and mass screening examinations caused the main dose. They were replaced by technically advanced examinations mainly computer tomography and cardiac catheter. Remarkably, the distribution of the red bone marrow dose over lifetime seems to depend more on availability of the technique of examination than on age. Diagnostic radiography practice is significantly influenced by development of technique.

4. References

Berrington de GA, Darby S. Risk of cancer from diagnostic X-rays: estimates for the UK and 14 other countries. Lancet 2004; 363: 345-351.

Hoffmann W, Terschüren C, Heimpel H, Feller A, Butte W, Hostrup O, Richardson D, Greiser E. Population-based research on occupational and environmental factors for leukemia and non-Hodgkin's lymphoma: the Northern Germany Leukemia and Lymphoma Study (NLL). Am J Ind Med 2008; 51: 246-257.

Ron E. Cancer risks from medical radiation. Health Phys 2003; 85: 47-59.

von Boetticher H, Hoffmann W. A model and reference data for retrospective dose assessment of organ doses (red bone marrow, lymphatic system) in diagnostic radiography and nuclear medicine, 1946-1995. Health Phys 2007; 92: 315-331.