A study of bone marrow in X-ray dosimetry as to a consideration of dose distrubution according to its structural phase

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骨髄線量測定の観点からみた骨髄構造について*

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骨梁に接する骨髄の部分に起きるイオン化は，骨梁から離れた骨髄部に起きるイオン化より高いので，特に医療用の軟放射線については，(1)骨梁に接した巾10ミクロンの骨髄容積と，(2)骨梁から10ミクロン以上へだたつた部分にある骨髄容積とを分けて考えておく必要がある.

正常人体の肋骨，胸骨，椎骨及び大腿骨頭の顕微鏡写真について，三種の方法で上記容積を測定し，平均値と標準偏差とを計算した.

骨梁に接した巾10ミクロンの部分に，電離が2倍生じたと仮定すると，均一に電離が生じたと考へる時より単位容積には，乳児では6%，11才以上では 2.4%多い事になる.

Introduction

In measuring an absorbed dose of irradiated bone marrows an importance should be placed on the volume of marrow substace surrounding trabeculae of the bone. Highest ionization is produced in this area within the bone marrow, because bony substance of higher atomic number contributes more ionizations than the less dense substance located a distance from the trabeculae (1). For practical purposes of dosimetry of the marrow irradiated with soft medical X-rays (about 50 kev or less), it is believed to be sufficient in considering the volume of a zone surrounding bony trabeculae by thickness of 10 microns.

Material and Method

Histological sections of ribs, sternal bones, lumbal vertebrae and femoral bones, in normal men, were photographed and printed enlarged 24 time in diameter. The picture were divided into many sub-section of equal area. Five to ten sub-sections were selected at random for each photograph and they were measured with following ways:

Mothod I. Circumference in microns in each sub-sections of all the bony trabeculae was measured bya curvimeter. Measured values were multiplied by 10 microns. The total of these gives a fraction of approximate volume of the marrow substance surroun-

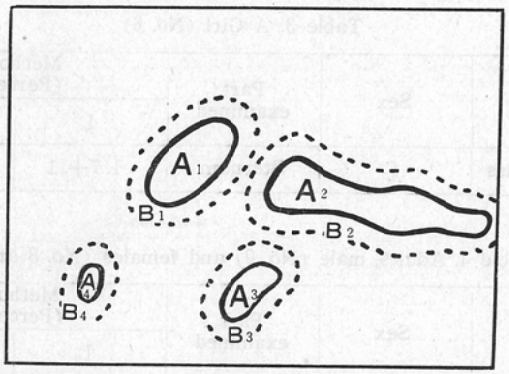
(1) Spiers, F.W., Brit. J. Radiol., **22**, 521, (1949).

ding trabeculae by 10 microns.

Method II. Areas immediately surrounding trabeculae by 2.4 mm on the photograph were cut off (these areas are corresponding to the thickness of 100 microns on the actual substance) and weighted by a torsion balance. Measured values indicate approximate ten-fold-figure of portion of a marrow volume mentioned.

Method III. Areas of bony trabeculae were cut off from photographs. Total of these areas gives a fractional volume of the trabecular substance in the bone marrow.

Fig. 1. Schematic representation of the section of the bone.



A: Area of trabeculae in a unit sub-section of bone preparation.
B: Area of the marrow substance surrounding (and within ten microns from) bony trabeculae.
C: Area of the marrow substance more than 10 microns distant from the bony trabeculae.
Hence area of unit section: $S = \Sigma A + \Sigma B + C$

Results

Measured values are shown in underlisted tables : 1-5. Each figure represents a mean fraction of a cross section of the bone with a standard deviation.

Under the supposition that ionizations eleborated in the area surrounding the trabeculae by 10 microns are twice as much as those in other area, the ionizations in infants' bone marrow would be increased 6%, and 2.4% in the age group of above 11, when compared to a suppositional occasion on which the ionizations are elaborated evenly within the bone marrow.

Table 1. An Infant (No. 1)

No.	Age	Sex	Part examined	Method of measurement (Percent of an unit area)		
				I	II	III
1	6 Days	f	Femur	4.0±.1	3.0±.1	20±1

Table 2. Sucklings (No. 2 and 3)

No.	Age	Sex	Part examined	Method of measurement (Percent of an unit area)		
				I	II	III
2	5 Months	f	Sternum	2.0±.2		
			Femur	2.9±.2		
3	6 Months	m	Vertebra	3.8±.2	4.1±.2	32±4
			Femur	2.7±.1		
			Femur	2.3±.2		

Table 3. A Girl (No. 6)

No.	Age	Sex	Part examined	Method of measurement (Percent of a unit area)		
				I	II	III
6	14Years	f	Sternum	1.7+.1	2.0+.1	12+1

Table 4. Adults, male (No. 9) and females (No. 8 and 10)

No.	Age	Sex	Part examined	Method of measurement (Percent of a unit area)		
				I	II	III
8	28Years	f	Sternum	1.9±.1	2.1±.1	12±2
9	31Years	m	Vertebra	1.5±.1		
10	39Years	f	Rib	1.2±.1		
			Sternum	1.8±.1	2.4+.2	10±1
			Vertebra	1.7±.2	2.2±.2	10±2

Table 5. An old man (No. 13) and a woman (No. 16)

No.	Age	Sex	Part examined	Method of measurement (Percent of a unit area)		
				I	II	III
13	51Years	m	Rib	0.6±.1		
			Sternum	1.5±.2		
			Vertebra	1.4±.1		
16	64Years	f	Sternum	0.8±.1		
			Vertebra	1.2±.1		

Acknowledgement

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Fig. 2.

Fig. 3.

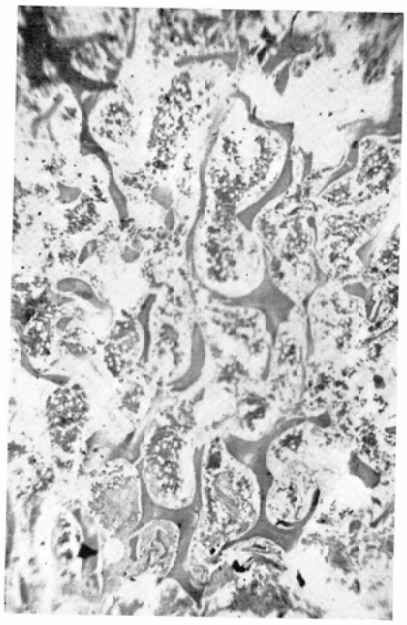

Fig. 4.

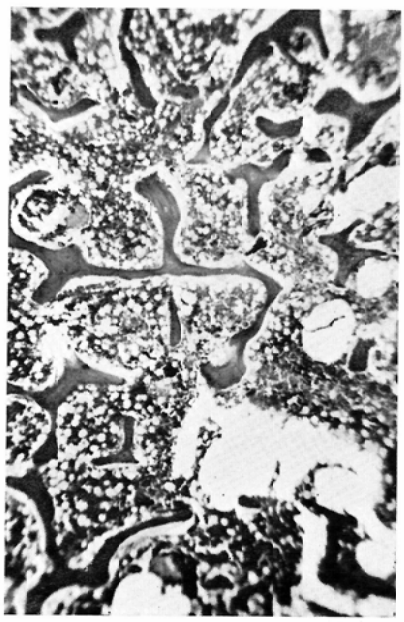

Fig. 5.

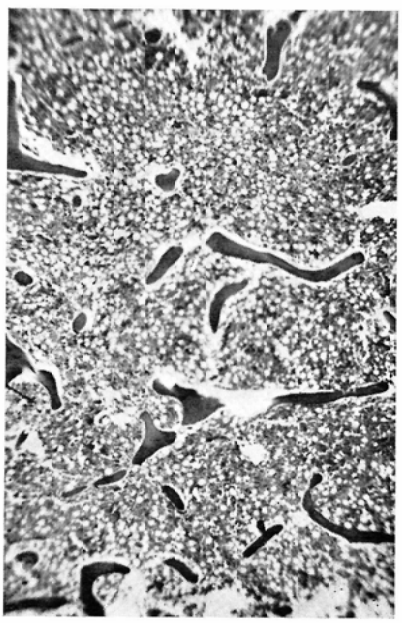

Fig. 2 to 5 are microphotographs enlarged 17 diameter. Fig. 2: Femur of an infant. Fig. 3: Sternum of a girl. Fig. 4: Vertebra of an adult. Fig. 5: Vertebra of an old woman.