Quantitative Estimation of Radiation Cataract in Rabbits

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家兎の放射線白内障の定量的観察

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従来，放射線白内障を研究する場合，水晶体の溷濁を観察するには主として眼科的検査法に依らねばならないが，兎角，専門的な熟練を要し又，主観的になりがちな欠点がある．此の様な定性的な観察法に対して定量的に水晶体の溷濁を表わす方法を試みた．

照射された家兎の水晶体を一定の間隔で摘出し，フイルム用デンシト・メーターで水晶体の溷濁の濃度を測定したが，初期における軽度の溷濁は此の方法では対照との間に差を認める事が出来なかつた．而し乍ら後期に至り水晶体の溷濁が著明になると，測定された濃度も又増加して居り，今後更に測定法の改良などの研究の余地はあるが，放射線医学的見地から研究を行う場合，効果即ち溷濁の程度を定量的に考察する上に意義がある．

When radiation cataract was taken as the subject of studies, some ophthalmological examinations have been mainly used for observing the opacity of irradiated lens. However, these examinations as is widely practised in oculist seem to de subjective or qualitative methods.

Previously, we studied radiation cataract experimentally from a radiological standpoint rather than ophthalmological one[3]. At that time, mature cataract visible with naked eye was taken as criteria in order to estimate the radiation effect objectively.

However, to trace the degree of lens opacities we could not but use ophthalmoscopic method.

In present study, we attempt to measure the lens opacity somewhat objectively or quantitatively without using the ophthalmoscopic examination.

Materials and methods

Forty-three male rabbits (1.5–2.0 kg) were used for the study. X-rays were irradiated 2.000 r in a single dose (measured in orbit) with the following factors: 200 kVp, 18 mA, added filter 0.5 mm Cu+1.0 mmAl, H.V.L. 1.13 mmCu, T.S.D. 30 cm, area 3.0×3.5 cm, dose rate 175 r/min. in orbit.

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Each rabbit was fixed in a box. Only the left eye was irradiated 2.000 r with a narrow beam, the right eye being used as control. As described previously[3], the scattered dose in the right non-irradiated orbit was less than 5% of the irradiated one.

The animals were observed for one to six months after irradiation, and at a month's interval, about seven of them were killed after ophthalmoscopic examination. Both irradiated and non-irradiated eyeballs were enucleated and lenses were prepared with minute care. The density of these lenses (light transparency of the lens) was then measured with the photo-densitometer, which is used for measuring the density of X-ray films.

Results

All irradiated lenses, observed for relatively longer periods, developed opacities and showed its progressive tendencies. These observations were the same as described before[3], and also agreed with those of other investigators[1)4)].

No visible changes were observed ophthalmoscopically in the group killed a month after irradiation.

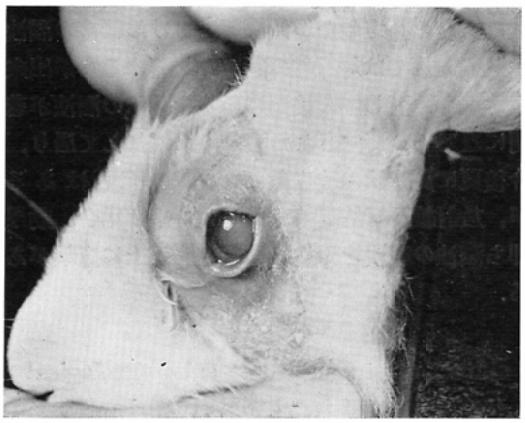


Fig. 1 (a) Immature cataract, four months after irradiation of 2.000 r

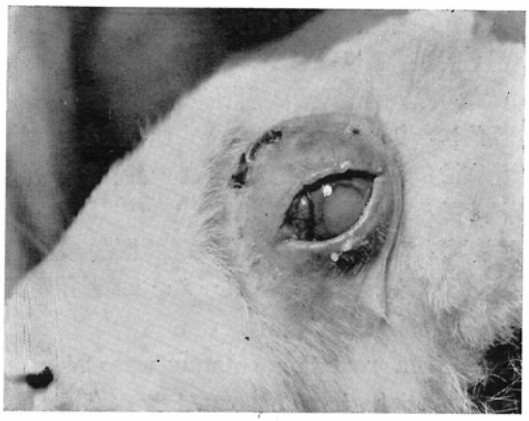


Fig. 1 (b) Mature cataract, five months after irradiation of 2.000 r

Table 1. Development of lens opacities after single dose of 2.000 r

Time after irradiation (Months)	1	2	3	4	5	6
No. of animals killed	6	6	6	9	9*	7**
Visible with ophthalmoscope, but not appreciable with naked eye	0/6	2/6	6/6	5/9	0/7	0/6
Visible with naked eye as so-called "immature cataract"	0/6	0/6	0/6	3/9	2/7	0/6
Mature cataract	0/6	0/6	0/6	1/9	5/7	6/6

* 2 animals were failed for perforation of cornea
** 1 animal was failed for perforation of cornea

In animals, observed for four or more months, lens opacities were marked (Fig. 1,a). Sooner or later, they resulted in complete opacities, or so-called mature cataract (Fig. 1,b). These results are shown in Table 1. Three animals failed in observation of the lens

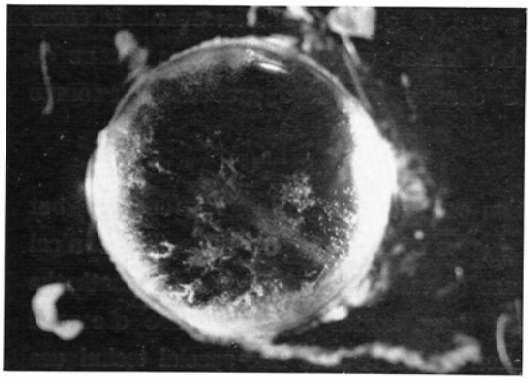
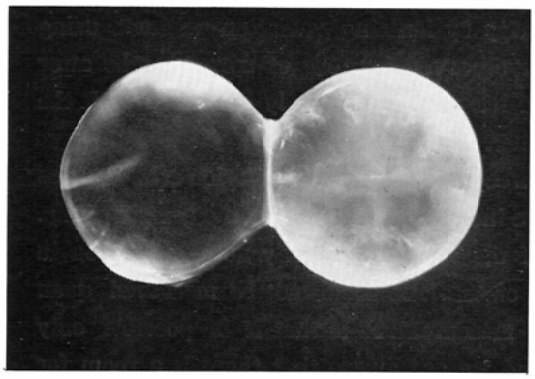
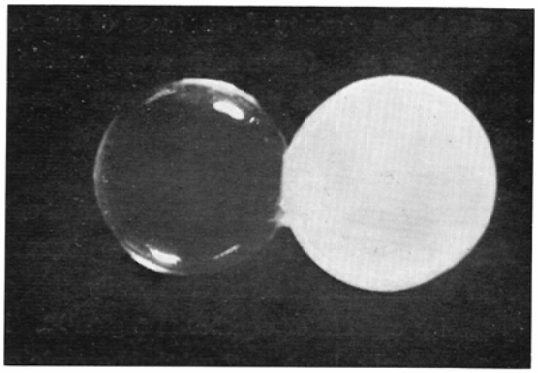


Fig. 2. Photographs of enucleated lenses after single dose of 2.000 r, "D" means density of the lens measured by photo-densitometer
(a) Four months after irradiation D=0.12



(b) Four months after irradiation, D = 0.22 (immature cataract) Opposite density (not irradiated) is 0.10



(c) Five months after irradiation, D = 0.52 (Mature cataract) Opposite density is 0.13

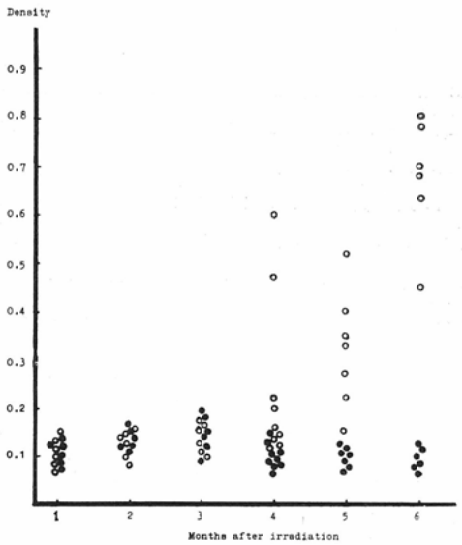


Fig. 3. Densities of the lens measured by photo-densitometer
○ irradiated single dose of 2.000 r
● not irradiated

because the cornea was severely ulcerated or perforated, suggesting some inflammatory changes.

The density of the lenses both irradiated and non-irradiated was measured by photo-densitometer just after the enucleation of the lens. These results are shown in Fig. 3. As shown in the illustration, within 3 months after irradiation, the measured density of the irradiated lenses ranged from 0.05 to 0.2, and as a result, no difference in density was appreciable between the irradiated and non-irradiated lenses in these period (Fig. 2,a). Four months after irradiation, however, when opacities of the lens became visible to the naked eye (Fig. 1,a), the measured density of the lenses increased, that is, the transmission of light through the lens decreased. At this period, the irradiated lenses were diffe-

rentiable in density from those of the control group (Fig. 2. b,c). However, in some animals of this four-month group whose irradiated lenses were then not as opaque as those of others in the same group, the measured density increased gradually in course of time.

Comment

Many investigators have reported about radiation cataract for the last few decades, but they have used different criteria to determine the degree of the cataract. The first clinical sign of radiation cataract is usually the appearance of vacuoles and opacities beneath the posterior capsule or equatorial region[1)4)]. However, these initial symptoms are observed with the slit lamp and ophthalmoscopic examination which require fine special techniques and long experience. As for the threshold dose level of radiation cataract, Cogan concluded that "lens changes resulting from irradiation do not have a critical level. The lower the dose the less apparent are the changes, with an endpoint depending chiefly on the method of examination"[2)]. From a radiological point of view, it is desirable that what is chosen as a criterion to measure the radiation effect should be apparent and recognizable to anybody. For this reason, visible complete opacity of the lens (the so-called "mature cataract") was chosen as the criterion in our previous study[3)]. Moreover, quantitative estimation of the effect is important in radiobiological studies. Thus, in our present study, we intended to qualify the degree of the lens opacity by ionizing radiation without using ophthalmological procedures. In rabbits which were observed for four or more months after irradiation, the measured density of the irradiated lenses was gradually increased with the lapse of time.

However, by this method, during the first three months after irradiation, the injuries of the irradiated lenses was so little that they were indistinguishable from the control group.

Ophthalmoscopically, however, the opacity of the lens was already noticeable even in this early period. Thus, the initial slight changes of the lens could not be measured quan titatively by this method. Another defect of this measurement is that it is possible only *in vitro*. This study is only a preliminary one, and we are aware that there is a room for improvement in the method. However, from a radiological point of view, this study appears to be of some significance in showing the possibility of measuring the effect of radiation quantitatively.

Summary

(1) This is a preliminary study of the method of quantitative estimation of lens opacities induced by radiation without using ophthalmoscopic examinations.

(2) The density of the irradiated lenses was measured *in vitro* with the photo-densitometer at a month's interval during the six months after irradiation.

(3) The early slight opacities of the lens could not be measured by this method (Fig. 2,a).

(4) Four months after irradiation, the density of the lens became higher than control and it increased gradually as the time went on. (Fig. 2,b,c).

(5) Although there remains a room for improvement in this method, the quantitative

estimation of the effect seems to be of advantage in radiobiology.

Reference

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