ON CLINICAL USE OF FLUOROD DOSIMETRY FOR DEEP SEATED TUMOR IN RADIOTHERAPY OF MALIGNANCY

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悪性腫瘍の放射線治療における硝子線量計の臨床的応用

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小管状形の硝子線量計（直径1㎜，長さ6㎜）は小さいので，身体の深部に発生した腫瘍等の際に，体腔内あるいは腫瘍組織に挿入して，その位置の吸収線量を測定するのに便利なものである．これは放射線照射前に挿入し，照射後に取り出して，その硝子から発生する蛍光の強さを特定の蛍光測定装置によつて測定することにより，直ちにその線量を随時に読みとることができる．

日本で製品化されたリチウム硝子の線量計は，これを適当な厚さの金属カプセル（0.2㎜の白金当量）に封入して使用することによつて，治療に用いられる通常X線および Co−60あるいは Radiun のγ線エネルギーの範囲の放射線を，波長依存性を考慮せずに可成の精度で測定することができる．

こゝに報告するリチウム硝子線量計の臨床応用例は，これ迄に放医研および千葉大学において，食道癌，胃癌，子宮癌，膀胱癌，舌癌等について実験的に荒居が行なつた線量測定の結果を，1962年の第10回国際放射線学会において，塚本が口頭発表したものである．

I. Introduction

Radiation dosimetry, using a tiny glass rod containing silver-activated phosphate, was originated and developed in the United States of America by Schulman and others (1950), and in recent years it has been used in several clinics in Japan for the dosimetry in radiotherapy and also discs of the same fluoglass has been used for the purpose of radiation protection instead of filmbadge in several laboratories in our country.

Here, I will refer only to its clinical use. This method of radiation dosimetry is very useful particularly in the case of a deep seated tumor because of the small size of the rods (1 mm $\phi\times$6 mm). A number of these rods can be implanted in the tumor or inserted in the body space before irradiation, and the dose can be measured by a fluorometer after treatment. A schematic diagram of the fluorometer is shown in Fig. 1.

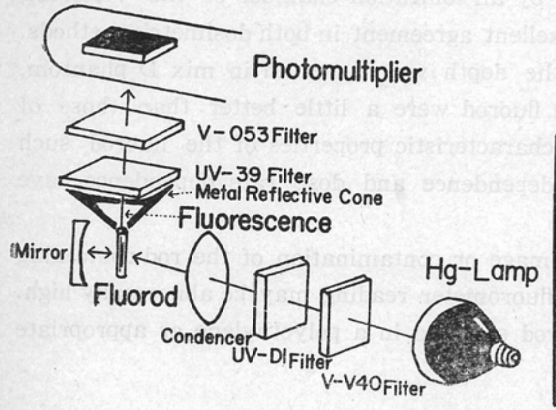


Fig. 1. Schematic diagram of fluorometer developed in Japan.

	Ba-Fluorod (Schulman's original)		Li-Fluorod (Home made)	
Basic component	KPO_3	25%	$LiPO_3$	50%
	$Ba(PO_3)_2$	25%	$Al(PO_3)_3$	50%
	$Al(PO_3)_3$	50%		
Additional component	$AgPO_3$	8%	$AgPO_3$	7%
			B_2O_3	3%

Table. 1. Comparison of fluorods components of 2 types.

II. Physical Characteristics

The basic component of the fluorod glass which was used in our study was somewhat different to that of schulman's original, being composed of some ingredients of lower atomic numbers. Comparison of these components is made in Table 1.

As a result, energy dependence of sensitivity of an uncovered rod in the lower energy range (X-ray, 65 KeV), was reduced to almost six times that of Co-60 γ-ray. The energy dependence sensitivity of a covered fluorod, using various metal sheathes, was also examined in air (Fig. 2). It was found that a sheathe of platinum of 0.2 mm thickness seems to be sufficient for dosimetry of conventional X-ray (energy range of

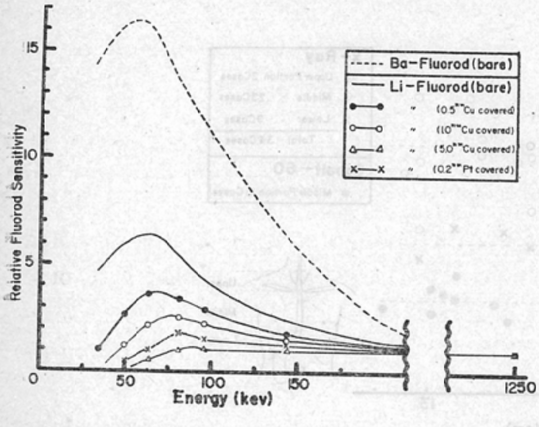


Fig. 2. Comparison of energy dependence of two fluorods and their variations in energy dependence caused by different metal sheathes of different thicknesses.

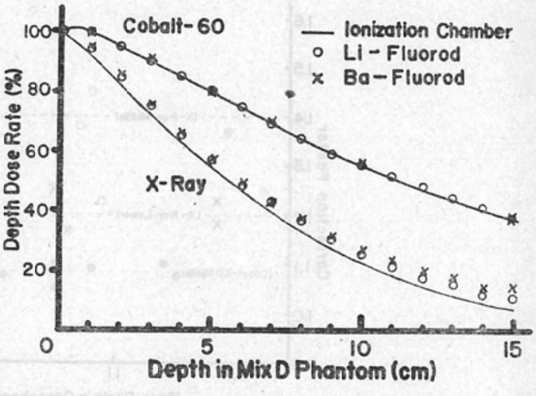


Fig. 3. Comparison of depth dose curve of 2 types of fluorod and ionization chamber, for Co-60 γ-ray and X-ray (200 KVp). Field size: 10×10 cm

250 KVP).

When the depth dose curve was plotted in Mix D phantom using uncovered rods and comparison was made to the curve obtained by an ionization chamber of the Victoreen type (Fig. 3). For Co-60 γ-ray there was exellent agreement in both dosimetric methods. However, for X-rays with 200 KVP, as the depth was increased in mix D phantom, higher values were obtained but the lithium fluorod were a little better than those of Schulman's original barium fluorod. Other characteristic properties of the fluorod such as directionality dependence, temperature dependence and dose rate dependence have proved satisfactory for our clinical use.

Precautions should be taken to avoid damage or contamination of the rod containing body fluid during clinical procedure, or the fluorometer reading may be abnormally high. It is therefore recommended to use the fluorod enclosed in a polyethylene or appropriate metal sheath of correct thickness.

III. Clinical Experiments

1) In oesophagus cancer the fluorods enclosed in thin polyethylene tube, with and without metal sheath were inserted in the oesophageal space in the center of the tumor during the treatment. The actual dose measured by this method was compared to the calculated dose. It was found that there was great variation in individual cases, especially, in the middle portion of oesophagus when pendulum therapy with 330 deg. was made by conventional X-ray. Tissue correction factor in this case was 1.4, while in full rotation treatment with Co-60 this factor was lower than 1.1 and its variation is also smaller than that of conventional X-ray (Fig. 4).

2) In some cases of stomach cancer the polyethylene enclosed fluorods were sewn into the stomach wall in several places with examinational laparatomy. Attached to the rods were small metal markers. Preoperative-irradiation with Co-60 unit was perfor-

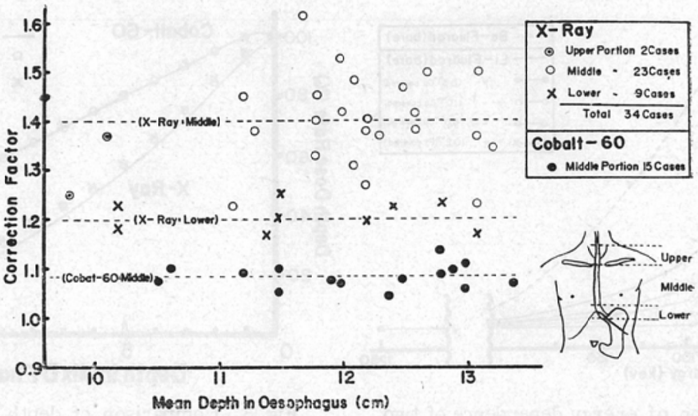
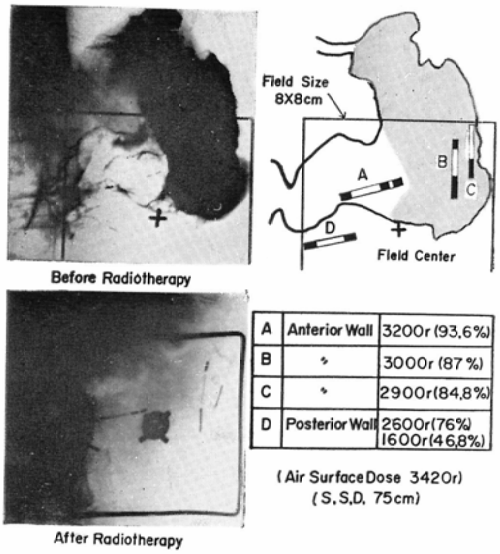


Fig. 4. Tissue correction factors in chest regions irradiated with moving beams of X-ray (200 KVp) and Co-60 γ-ray. X-ray (330 deg. Pendulum), Co-60 (Full Rotation).

med. It was followed by resection of the stomach and the dose of each rod was measured. It was found that a part of the stomach which was in the irradiation field at the beginning of the treatment had slipped out of the field, due to dislocation by shrinkage of the stomach during treatment period (Fig. 5).



A	Anterior Wall	3200r (93.6%)
B	〃	3000r (87%)
C	〃	2900r (84.8%)
D	Posterior Wall	2600r (76%) 1600r (46.8%)

Fig. 5. Photograph with schematic illustration of fluorods sewn to stomachs wall. Reduction in dose D is due to fluorod having slipped out from irradiation field during treatment period.

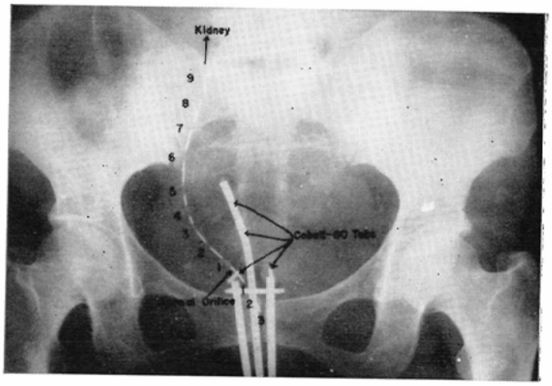


Fig. 6. X-ray photograph of inserted fluorods enclosed in ureteral catheter with metal markers which gave positive shadows. Intracavitary irradiation with Co^{60} tubes.

3) In carcinoma of the cervix uteri, dose measurement was made both by external beam radiation therapy with Co-60 and by internal irradiation, using Co-60 tubes. 12 polyethylene enclosed fluorods were inserted through urethra into the bladder and the ureter, as shown in Fig. 6. The highest dose was obtained by internal irradiation at a position 1 cm higher than the ureteral orifice as shown in Fig. 7.

For the treatment of pelvic infiltration of the carcinoma uteri, Co-60 moving beam therapy from two portals seated anterior and posterior with 70 deg. pendulum was used on point B in pelvis. Maximum dose area was off course broader and higher in position along ureter than that of internal irradiation (Fig. 8).

4) For carcinoma of the bladder a rubber balloon with fluorods attached to the inside surface was inserted into the bladder through the urethra and blown up with air. Dosimetry of front and back wall was made separately (Fig. 9).

As some variation between the calculated and the measured dose was found, further investigation is needed to determine the difference in exact dose of the tumor which lies on different part of wall of the bladder.

5) For carcinoma of the tongue, often treated by interstitial irradiation with radium needles, fluorod dosimetry is especially useful, but fluorods are better sheathed in metal

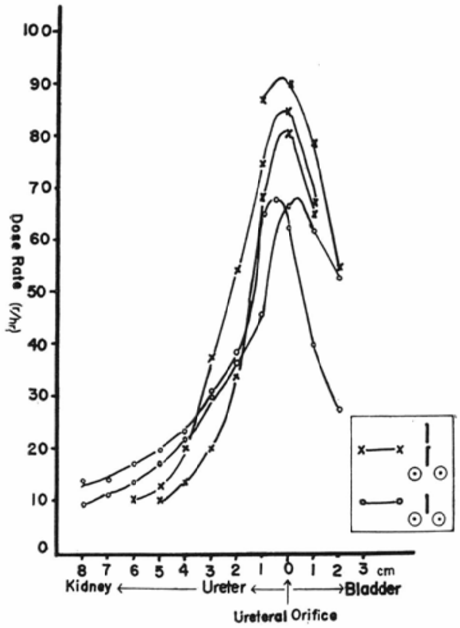


Fig. 7. Dose distribution curve by intracavital irradiation of carcinoma of cervix uteri.

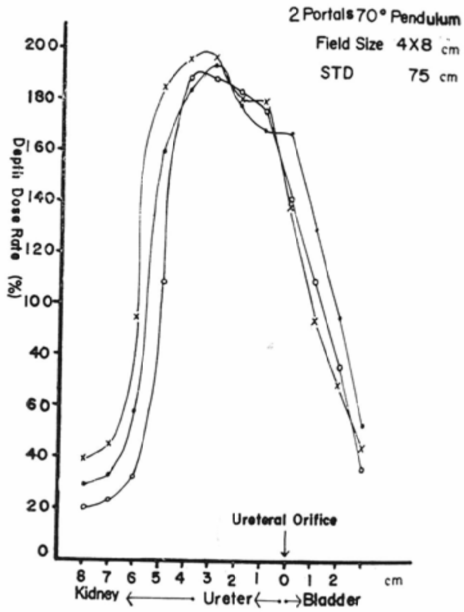


Fig. 8. Dose distribution curve by external irradiation of carcinoma of cervix uteri, using Co^{60} in front and back portals of 70 deg. pendulum.

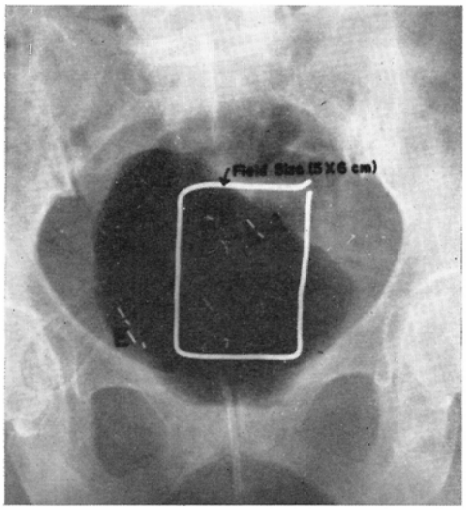


Fig. 9. Fluorods with markers attached to inner surface of blown-up rubber balloon in bladder.

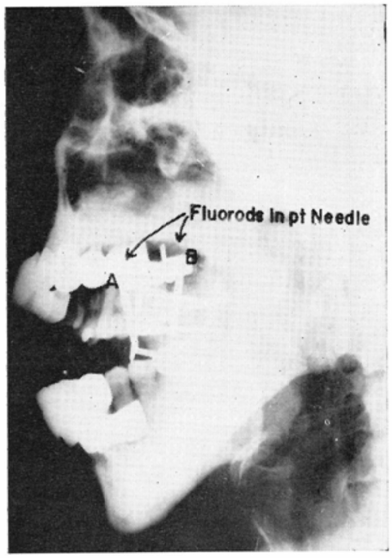


Fig. 10. Single-plane interstitial treatment of tongue with radium needles. Fluorods A and B are in platinum sheathes.

for puncture in tumor. As shown in Fig. 10, doses at A and B were 24 r/hr and 106 r/hr respectively. The dose of the polyethylene enclosed rod put at the center of surface of the tumor was 37 r/hr. The latter value is in good agreement with tumor dose of Paterson-Parker's table which is 38 r/hr.

From the results of 6 cases of tongue cancer the dose values of the fluorods enclosed in polyethylene tube which were put at the surface center of the tumor were in fair agreement with the dose calculated when single plane irradiation with needles was performed. (This applies to single plane irradiation only and not to multiplane.)

IV. Conclusion

Fluorod dosimetry is an exellent, practicable and reliable method for routine clinical use, because of the small size and other characteristics of the rod. It has been employed successfully for the treatment of cancer in almost all tissue and space of the body.

It can be used for patients receiving ionizing radiation within the energy range of 250 KV to 2000 KV, including radium, radon, Co-60, Cs-137 and high-energy X-ray generators, regardless of portal size and depth of tumor in the body. It can also be used for conventional X-ray treatment of lower energy by using appropriate metal sheath.

It is feasible for the measurement of an accumulated dose on Co-60 treatment up to 10000 r within a certain treatment period. A much wider use of it is desirable from many points of view, and is highly recommended.

Remark: This paper was presented on August 31, 1962 at Xth International Congress of Radiology in Montreal, Canada.