# A Study on Dose Distribution around Fletcher-Suit Colpostat Containing $^{137}Cs$ Source*

Wee-Saing Kang, Ph D

*Department of Therapeutic Radiology, College of Medicine, Seoul National University, Seoul, Korea*

This paper presents dose distributions in water around Fletcher-Suit colpostat containing $^{137}$Cs tube, and shielding effect of internal lead shield. Using ready packed film, author measured dose distribution in water around the colpostat containing cesium source.

Nine sheets of films on one side of the colpostat are packed with acryl frames cut out so as to fill water, and irradiated in water by cesium source in the colpostat. Dose distributions on transverse plane and upper plane 0.5 cm from upper surface of the colpostat were measured. Shielding effect was greater in upper medial direction than in lower medial direction. And that was the greatest around 30° from the axis of the colpostat on upper side and around 50° on lower side.

In the region 7 cm from the center of the colpostat, shielding efficiency was 0.23 to 0.35 on the lower 50° and 0.26 to 0.42 on the upper 30°, and decreased with increase of distance.

Key Words: Dose distribution, Fletcher-Suit colpostat, $^{137}Cs$ source

## INTRODUCTION

Fletcher-Suit colpostat is an ovoid designed to reduce dose to bladder and rectum[1~4]. It containes lead shields as internal structure for reduction of doses to bladder and rectum. For evaluation of doses to those organs, three dimensional dosimetry around the applicator is first required.

Several authors reported dosimetric results around the colpostat[5~10]. In gegeral, however, the effect of dose reduction of internal shielding in colpostat is not still considered in computation of dose to baldder and rectum, or only guessed. Its main reason is that there do not exist accurate and sufficient data on three dimensional dose distribution.

There are several reasons to make it difficult to measure dose distribution around colpostat for gynecologic brachytherapy. Spacial variation of doses is severe, especially in region near from the radioactive source and in interface of shielded region. When large volume of detector is used to measure dose, it is not easy to decide point for which its value stands. Also, accurate localization of detectors is difficult. Because of low dose rate from $^{137}Cs$ tube, noise from small size of detector could make a significant error. Using ready packed films, author made measurements of dose distribution in water around the Fletcher-Suit colpostat containing $^{137}Cs$ tube.

Nine sheets of films on one side of the colpostat are packed with acryl frames cut out so as to fill water, and irradiated in water by cesium source in the colpostat with internal shield. Dose distributions on transverse plane and upper plane 0.5 cm from upper surface of the colpostat were obtained. Those results and shielding effect of small lead shield are reported.

## MATERIAL AND METHOD

Fletcher-Suit standard colpostat was used (3M Co, Minnesota USA). It containes an internal structure like as Fig 1 that was made of a brass frame and a pair of lead shields. The lead shields were of a part of a circle and of 5.0 mm thickness, and located at upper and lower corner of medial side. The thickness of the brass frame was 0.8 mm except for the lower part on handle side.

Ready packed film (X-Omat V, Kodak Co, USA) as a means for dosimetry was used. Film was adopted for several reasons. Film makes it possible to measure dose distribution through just one exposure. Also, film makes it possible to save time, and to reduce error in consecutive positioning of detector like as ion chamber and personal exposure to radiation. Film makes it possible to measure broad range of dose from a few cGy to several hundred cGy so that it is ideal for measurement of dose in area with great spacial variation of dose. Because dose rate at position several cm far from

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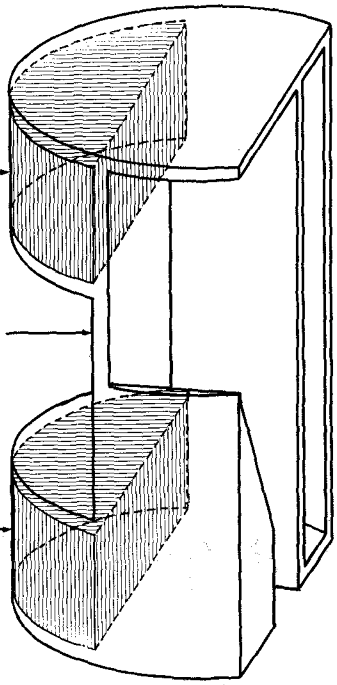


**Fig. 1.** Internal structure of Fletcher-Suit colpostat. Lead blocks for shielding bladder and rectum are imbedded in brass structure. The thickness of the lead blocks is 5 mm and the thickness of the brass wall 0.8 mm except for lower part on handle side.

the center of source is low like as a few cGy/h, several hour could be required for reasonable exposure. It could be exposed for a long time like as 1 or 2 hour to get sufficiently proper optical density. Because physical density of film is similar to that of water, it was expected that it does not almost disturb dose distribution.

For measurement of dose distribution in water film should be set up in water, but could not be independently set up parallel with the fixed interval. So any support to achieve such purpose was required. As support, acryl frames were made. Those were cut out into shape like as Fig 2(c) and had 2 pathways, on upper and lower sides, that allow air and water to pass. Thickness of one acryl plate was 0.5 or 1.0 cm nominal but actual thickness was different from the value and not uniform. Films were inserted between acryl frames. To line up film, cross reference lines were drawn on the surface of film envelope at a fixed distance on each direction. Films and acryl frames were packed one by one. When films and acryl frames were piled up, they were lined up using thick polystyrene phantoms stood up into L shape. Nine films were used for dosimetry on one side of Fletcher-Suit colpostat. Seperation between outermost two films was 6 cm or so.

Fletcher-Suit colpostat was put on film. The handle of the colpostat was set up parllel to film plane (Fig 2(a)) or parllel to a plane perpendicular to the film (Fig 2(b)). After the colpostat was fixed on the envelope of film with plastic tape, some marks to indicate margin of of the colpostat and direction of its axis were made using a set square. To exposure films on both medial and lateral sides at the same time, all films on both sides were clamped on. At the time, 4 spacers with same thickness as the diameter of the colpostat were put on the corner of acryl frame, and to maintain equal separation of films abutting to the colpostat from handle and to prevent motion of the colpostat two small blocks of styrofoam with equal size were put one by one between film and the handle on each side. In the case of Fig 2(b), some plates of acryl pressed with lead block as a device to maintain contact of film and colpostat were attached to the handle of the colpostat. To minimize the influence of the device to dose distribution, the lead block and acryl plates except for a plate to hold the handle were put as far as possible from the handle.

Clamped films and acryl frames attaching Fletcher-Suit colpostat were immersed into water. Next, by tilting the system, air between films was replaced with water. $^{137}Cs$ tube (6504, 3M, Minnesota USA) was input into the colpostat. The position of the source was at the lowest position of the source holder in the colpostat, and the colpostat was set 6 cm or so deep in water. Exposure time was equivalent to 50 mg. Ra. eq-h. After drying the envelopes of films, some functures to identify film and indicate reference lines to line up films were made.

Reading of optical density of the processed film was made by means of film densitometer (TD-504, Macbeth, USA). To convert optical density to dose to water, characteristic curve made by using $^{60}Co$ was used.

## RESULT

Dose distribution on the transverse plane which is medial-lateral plane involving the symmetric axis of the Fletcher-Suit colpostat is presented on Fig 3. Dose rate is represented in a unit cGy/mg Ra eq/h. The dose distribution on medial side is not

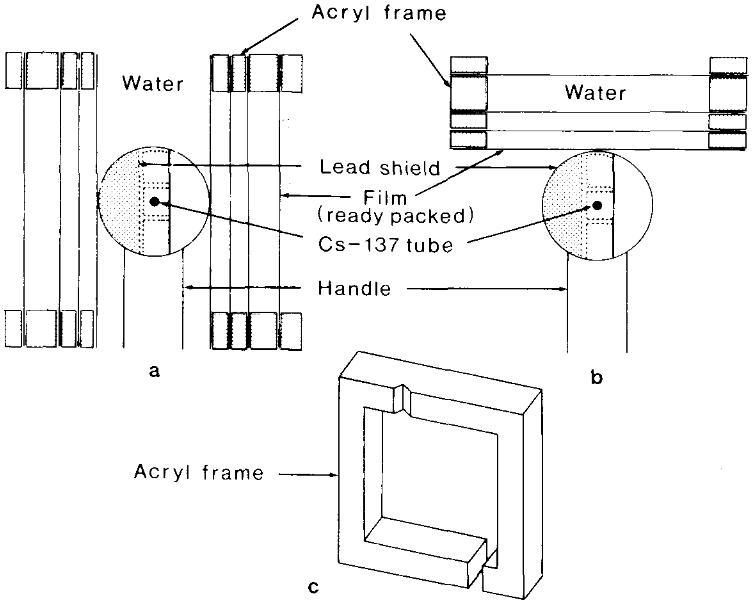


**Fig. 2.** Schematic disgram of setup for exposure to film in water. Nine films on on side are packed with acryl frames (a) Medial and lateral side. (b) Front side. (c) Acryl fra,e.

symmetric so that on lateral side about the longitudinal axis of the colpostat, and dose rate on medial side in some area is lower than that at the symmetric point on lateral side. The dose distribution on the upper half on medial side with internal shields is not symmetric to that on the lower half about the equator of the Fletcher-Suit colpostat. Shielding effect is more effective on the upper half than on the lower half. That result means that active source of $^{137}Cs$ was not centralized in the colpostat on the longitudinal axis.

Dose distribution on the plane which is 0.5 cm above from the upper surface of the Fletcher-Scuit colpostat and parallel to the equator of the colpostat is presented on Fig 4. Dose rate is same as in Fig 3. The dose distribtuion is not symmetric in circle of 3 cm radius about sagittal plane, which bisectes the colpostat and handle, but roughly symmetric out of the circle. That result means that while internal shield contributes to reduction of dose rate in the circle of 3 cm radius on the yet described plane, that does not nearly affect the change of dose rate out of the circle.

Dose rates at some points on two lines on the medial side which are at 30° from the upper part of the longitudinal axis of the Fletcher-Suit colpostat and at 50° from the lower part of the axis are

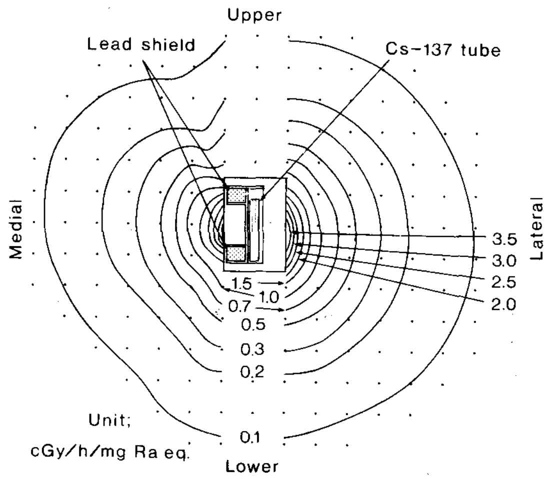


**Fig. 3.** Dose distribtuion on the transverse plane of Fletcher-Suit colpostat. Unit of dose rate is cGy/hr per unit mg Ra eq of 137Cs. The distance between the nearest dots is 1 cm.

presented on Fig 5. They are compared with unshielded dose rates at points on lateral side symmetric to the longitudinal axis. Those two lines were selected because internal lead blocks shield most effectively on the lines or the close as if expected

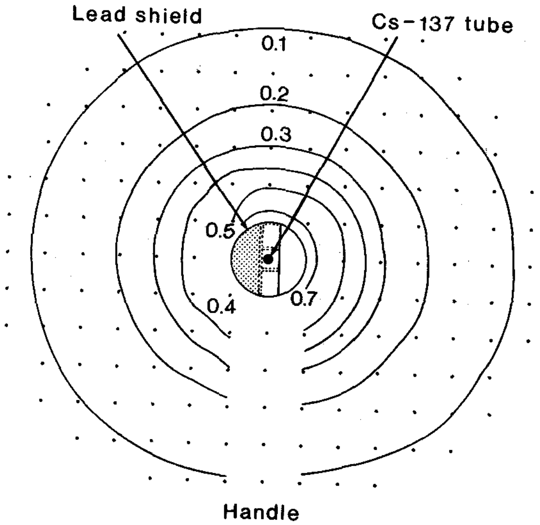


**Fig. 4.** Dose distribtuion on the plane 0.5 cm above the upper surface of Fletcher-Suit colpostat. Unit of dose rate is cGy/hr per unit mg Ra eq of 137Cs. The distance between the nearest dots is 1 cm.

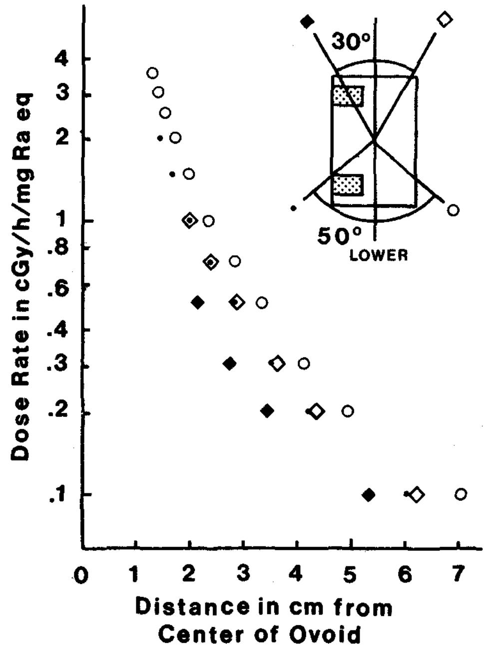


**Fig. 5.** Dose rates on some points on lines most dffectively shielded and symmetric about longitudinal axis of Fetcher-Suit colpostat. Circles and dots indicate upper side, and open and unopen rhombs do lower side. Dots and unopen rho,bs meah shielded dose rates, and circles and open thombs do unshielede dose rates on lateral side.

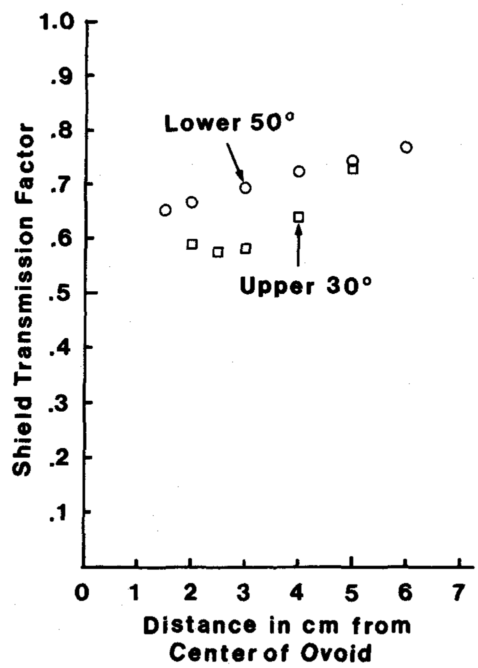


**Fig. 6.** Transmission factors on some points on special lines. The lines are selected like as in Fig. 5.

from Fig 3. Shielding effect is found from the figure.

Shield transmission factors at some points on the lines defined on Fig 5 are presented on Fig 6. The shield transmission factor (STF) is defined as following:

$$STF(r, \theta)=\frac{DR_S\ (r, \theta)}{DR_{US}\ (r, \theta)} \quad (1)$$

where $DR_S$ (R, θ) and $DR_{US}$ (r, θ) are respectively shielded and unshielded dose rate at distance from the center of Fletcher-Suit colpostat and at angle θ from the longitudinal axis on medial side. Because unshielded dose rate on shielded area of medial side could not be measured without destruction of the colpostat, dose rate at symmetric point on lateral side was substituted for $DR_{US}$ (r, θ) in this paper. As shielding efficiency (SF) means the ratio of dose reduction due to internal shield to the unshielded dose at same location, it could be defined as following:

$$SF\ (r, \theta)=1-STF\ (r, \theta) \quad (2)$$

With the above relation, Fig 6 presents that shielding efficiency depends on the location. Shielding efficiency decreases with increase of distance from the center of the colpostat. In the region 7 cm from the center of the colpostat, shielding efficiency was 0.23 to 0.35 on the lower 50° and 0.26 to 0.42 on the upper 30°.

## DISCUSSION

Delclos, et al[3] reported transmission factors through the tungsten shield on the planes 1.2 cm from the upper surface of Fletcher-Suit clopostat and 1.0 cm from its lower surface. Hass, et al[4] reported transmission factors through the tungsten or lead shield and dose rates for 30 mg Ra eq of 137 Cs on the planes at same position as Delcles, et al. Even though their results were obtained on the planes different from ours, transmission factors are of range of values relatively close to our results.

Even though they compared distribution of transmission factors on two planes separated by different distance from the upper or lower surface, we could find that transmission factors are lower on upper side than on lower side. Those mean that the upper part of the internal shields could reduce dose rate more effectively than their lower part.

Dose distibution of the transverse plane was not reported on the papers of Delclos, et al[3] or Hass, et al[4]. Our result on the dose distribution on the transverse plane presents that dose distribution is not symmetric about equatorial axis. From our result and the others, we could attain to such a conclusion as cesium source is not centralized in the Fletcher-Suit clopostat, but shifted a little bit to one side along the longitudinal axis.

Sharma, et al[11] showed a internal view of the medial side of the Fletcher-Suit colpostat. In their figure, holder of cesium tube was located below the center of the Fletcher-Suit colpostat. Our result of dose distribution on lateral side (Fig 3) shows that cesium source was located at position shifted downward from the center of the colpostat. Such result is clearly proved by the results of Sharma, et al[11].

Because the results of this study contains only a part of dose distribtuion around Fletcher-Suit colpostat, they are insufficient for calculation of dose in intracavitary treatment planning but helpful for prediction of doses to bladder and rectum.

## CONCLUSION

Dose distribution in water around the Fletcher-Suit colpostat containing $^{137}Cs$ tube was measured with ready packed films packed with acryl frames. The planes on which dose distribution was measured are transverse plane and a plane 0.5 cm above the upper surface of the colpostat. Following conclusions were obtained from the results.

1. Shielding efficiency by internal lead blocks is not symmetric.
2. Shielding efficiency is more effective on upper side than on lower side, and 0.23 to 0.35 on the lower 50° and 0.26 to 0.42 on the upper 30°.
3. Cesium source is located at position shifted downward from the the center of the colpostat.
4. On the plane 0.5 cm above the upper surface of the colpostat, dose rate reduced in the circle of 3 cm radius but did not nearly change out of the circle.

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＝국문초록＝

# $^{137}Cs$ 선원을 내포한 Fletcher-Suit Colpostat 주위의 선량분포에 관한 연구

서울대학교 의과대학 치료방사선과학교실

**강 위 생**

$^{137}Cs$ 선원을 내포한 Fletcher-Suit Colpostat 주위의 물에서 선량 분포와 내부의 납차폐물에 의한 차폐 효과가 본 논문에 기술된다. 미리 포장된 필름을 이용하여 세슘선원을 내포한 콜포스타트 주위의 선량 분포를 측정하였다.

콜포스타트의 한 방향에 9매의 필름을 아크릴 틀을 이용하여 평행하게 고정시키고 세슘튜브를 이용하여 조사하였다. 콜포스타트의 내측과 외측은 동시에 조사하였으며, 전방은 따로 조사하였다. 콜포스타트의 종축이 포함된 내외 횡단면과 윗쪽 표면 밖 0.5 cm 떨어진 단면에서 선량분포를 얻었다.

차폐효율은 콜포스타트의 상부측이 하부측보다 컸으며, 상부측에서는 종축에서 내측으로 30° 정도의 선과 하부측에서는 50° 정도의 선에서 차폐효율이 각각 가장 큰 것으로 나타났다. 콜포스타트의 중심에서 반경 7 cm 범위내에서 차폐효율은 상부 30°에서는 0.26－0.42, 하부 50°에서는 0.23－0.35였으며 거리가 멀어짐에 따라 감소하였다. 콜포스타트 상부표면에서 0.5 cm 떨어진 단면에서 대략 3 cm 반경의 원내에서는 차폐효과가 있었지만 그 밖에서는 거의 없었다.