Optimization of Dose Distribution in Intracavitary Treatment of Cervical Cancer with Buchler’s Afterloading System

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Abstract: We evaluated dose optimization for the treatment of cervical cancer using Buchler’s high-dose-rate (HDR) remote-control-afterloading-system (RALS). When Buchler’s system is used for intracavitary treatment, the irradiation times for the tandem and ovoid sources should be selected separately. The effects of variation of the tandem-to-ovoid dose ratio on the dose distribution are described.

Key words: Buchler’s HDR-RALS, dose optimization

INTRODUCTION

In the treatment of carcinoma of the uterine cervix, it is not uncommon to encounter patients who have never borne children or with carcinoma which has deeply invaded the vaginal wall. The vaginal vaults in such patients do not readily expand when it is attempted to place ovoid applicators as close to the uterine orifice as possible. We have often found it necessary to irradiate patients with unsatisfactory position of ovoid applicators. As the distance of the ovoid sources from the vaginal vaults increases, the irradiation time required for the dose from these sources is increased. The patient’s rectal dose is increased as well (Fig. 1). This article describes an investigation of a method of minimizing the increment of the rectal dose in such a case in order to optimize the dose distribution in intracavitary treatment in individual patients.

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Method

Buchler's afterloading system includes an Ir-192 sources with a tandem applicator and two Cs-137 sources with ovoid applicators (Fig. 2). We usually draw a 6 Gy-line through the A-point (A-line) at every treatment.

In order to determine the extent of variations, we reviewed reference X-ray films and measured the ovoid-to-A-point distance (O-A distance) in 40 treatments. Most of the patients underwent intracavitary irradiation 4 times in 4 weeks (6 Gy/fraction). The interpatient variation and the treatment to treatment intrapatient variation of O-A distance was then evaluated.

When Buchler's afterloading system is used for the intracavitary treatment of cervix cancer, the time necessary to obtain a certain irradiation dose at the A-point must be selected separately for the tandem source and for the ovoid sources. Isodose patterns can be modified by changing the relative contribution of the tandem source and to ovoid sources. Therefore, in the examination of variations in dose patterns, A-lines were drawn at various ratio of tandem dose to ovoid dose at target delivery to the A-point of 6 Gy. A-lines with unsatisfactory ovoid applicator position were also drawn to examine the limit of O-A distance that could be corrected with the simple procedure of varying the ratio of tandem dose to ovoid dose.

Result

Considerable intertreatment variation of the isodose pattern was seen in consecutive 40 treatments. Isodose curves in treatments with short and long O-A distance are illustrated in Fig. 3. The ovoid size was 2 cm diameter, and the distance from the Cs-sources to the top surface of the ovoid was 1 cm. Therefore, when the ovoids were placed deep in both sides of the vaginal portion of the uterus, the O-A distance was very short. When the carcinoma was so large or the patient's vagina was so poorly expandable that the ovoid applicator

Fig. 2. Diagrammatic representation of tandem and ovoid applicators. A) anterior view B) lateral view

Fig. 3. Isodose curves in a treatment with short O-A distance of 2.1 cm (left) and with a rather long O-A distance of 4.0 cm (center). On the right, the two sets of curves are superimposed to show the effect on the rectal dose.
Fig. 4. The O-A distance measured on 40 reference X-ray films varied from 2.0 to 4.3 cm. The average distance was 2.8 cm. In 40 percent of the treatments the distance was more than 3 cm.

could not be fixed deep enough, the O-A distance was very long. The review of the 40 reference X-ray films revealed that the O-A distance varied from 2.0 to 4.3 cm (Fig. 4), and the average distance was 2.8 cm. In 40 percent of the treatments, the distance was more than 3 cm. Interpatient variation in the mean O-A distance was ranged from 2.3 to 3.7. Intrapatient variation is indicated by the vertical line on each column. One patient (left column) showed only 0.2 cm treatment variation, while another (6th column from the left) showed 2.0 cm variation. The average intrapatient variation was 0.8 cm.

(A)

O-A DISTANCE 3cm
TANDEM/OVOID RATIO
3Gy/3Gy
4Gy/2Gy
5Gy/1Gy

(B)

O-A DISTANCE
3cm
3.5cm
4cm

TANDEM/OVOID RATIO 4/2Gy

Fig. 6. A) A-lines for 3 different tandem-ovoid dose combinations at fixed O-A distance (3 cm) are shown. They are 3 Gy/3Gy (-----), 4Gy/2Gy (-----), and 5Gy/1Gy (-----).
B) A-lines for 3 different O-A distances at fixed tandem-ovoid dose combination (4 Gy/2 Gy). They are 4 cm (-----), 3.5 cm (-----), and 3 cm (-----).
distance was evaluated in 10 consecutive patients (Fig. 5), in whom the distance ranged from 2.3 to 3.7 cm. Intertreatment variation of the O-A distance in individual patients was also studied; in one patient, the variation was 2.0 cm, while in another it was only 0.2 cm. The average variation was 0.8 cm. Variations of the A-line for 3 different tandem-ovoid dose combinations at fixed O-A distance are shown in Figure 6-A. They show variation in width above and below the A-point. Variations of the A-line for 3 different ovoid positions at fixed tandem-ovoid dose are shown in Figure 6-B. They swell out in the lower region below the A-point as the O-A distance increases.

**Discussion**

In conventional RALS systems, Co-60 are used for tandem and ovoid sources, while Buchler’s system in our department is equipped with two types of sources, which are Ir-192 and Cs-137. The activities of these sources are quite different, and the irradiation time should be selected accordingly. Furthermore, as the Ir-192 source is rather recently developed source, dose optimization for this system is still under development.

We used irradiation of 3 Gy from the tandem source and 3 Gy from the ovoid sources for a total A-point dose of 6 Gy. If the ovoid sources were placed apart from the uterine orifice, the time necessary to irradiate 3 Gy from ovoid sources had to be increased, resulting in an increase of the rectal dose. Even under this condition, by varying the tandem-ovoid dose ratio, we can reduce the rectal dose and keep the A-point line at almost the same target zone. This procedure is effective when the ovoid sources are placed not more than 1 cm from the uterine orifice. In one patient, the intertreatment variation of the O-A distance was 2 cm. In such a case, it may be necessary to apply another tandem-ovoid assembly pattern or to rearrange the applicators. However the average intra-patient variation in the O-A distance variation was rather small. Therefore, in most patients, the dose distribution in individual treatments could be well corrected by selecting the appropriate tandem-ovoid dose ratio.

We are not certain whether the specific isodose pattern of 3 Gy/3 Gy we used is the best pattern for basic treatment. Some authors have suggested the use of isodose patterns similar to those in low dose-rate irradiation as Manchester’s method, which we formerly routinely applied. The A-lines of these patterns roughly correspond to 4 Gy/2 Gy pattern. However we are certain that the basic method of selecting the optimal dose distribution for each patient and for each pattern of carcinoma invasion is a superior treatment method. Buchler’s afterloading system offers versatility in terms of producing many dose distribution patterns using program disks which oscillate the tandem source in the applicator. Furthermore, when we used various dose combinations from the tandem and ovoid sources, we were able not only to reduce the rectal dose in the event of less than ideal placement of the ovoid applicator, but also to select more suitable dose distributions for each treatment (Fig. 7).

All of these patients showed complete remission after the treatment. However the follow-up period has not been long enough to evaluate the late side effects, because late side effect of rectal injuries needs several years to come out. We believe that decreasing the rectal dose by modifying the dose distribution is an important procedure in avoiding rectal in-

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**Fig. 7.** Examples of selection of dose distribution pattern according to tumor extension.
Dose Optimization with Buchler’s RALS

juries in the intracavitary irradiation of cervical cancer.

The dose distribution in each treatment can be optimized by use of a computer system in which target configuration is input on an anatomical image displayed on a CRT, such as that for MRI. After the applicators are fixed and the reference X-ray data input, the computer generates optimized information and the final parameters necessary for irradiation, such as the irradiation time for each applicator, or generates instructions regarding rearrangement of the applicators.

CONCLUSION

The use of various tandem-ovoid dose ratios in the intracavitary treatment of cervical carcinoma using Buchler’s afterloading system was examined. By this way, we were able to obtain the optimal dose distribution for individual treatments. Using this technique, we could modify the isodose curves to minimize increase of the rectal dose produced by increase of the distance of the ovoid applicators from the vaginal vaults.

REFERENCES