J Korean Soc Ther Radiol Vol. 4, No. 2, December, 1986

Treatment Planning Software for High Dose Rate Remote Afterloading Brachytherapy of Uterine Cervical Cancer

Seung Jae Huh, M.D., Wee Saing Kang, M.S.*

Department of Radiation Therapy, Soonchunhyang University Hospital
Department of Therapeutic Radiology, College of Medicine, Seoul National University*

In brachytherapy of uterine cervical cancer using the high dose rate remote afterloading system, it is of prime importance to determine the position of the radiation sources and to estimate the irradiation time. However, calculation with manual method is so time consuming and laborious, that authors designed a software as an aid to intracavitary radiotherapy planning using the personal computer to obtain the precision of treatment without being too complicated for routine use.

Optimal source arrangement in combination with dose rate at each specific points and irradiation time can be easily determined using this software in several minutes.

Key Words: Personal computer, Treatment planning software, Brachytherapy of cervical cancer of uterus.

INTRODUCTION

In recent years, the use of personal computers in radiation therapy has been increased in the primary application in the business related aspects[1]. Personal computers also can be used to assist in dose calculation of radiation therapy. A computer system for planning and reconstruction of high dose rate intracavitary treatment of uterine cervical cancer was devised using the 8-bit personal computer to obtain the precision of treatment without being too complicated for routine use. The purpose of this work is to describe a method for treatment planning in brachytherapy of uterine cervical cancer with high dose rate remote afterloading system. Optimal source arrangements in combination with dose rate at each points and exposure times can be easily determined by using this software within a short time.

MATERIALS AND METHODS

Treatment equipment and hardware: Remote control afterloading radiotherapy unit (Ralstron[R], Shimadzu) consists of high activity automatic over-riding ^{60}Co point sources (total 15 Ci). The software program was designed for the 8-bit personal computer (Apple II) with minimum of 48 KB word memory, one floppy disk drive, 9″ CRT monitor, and printer.

SOFTWARE STRUCTURE

Flow chart of the program is as the Fig. 1. Software was designed in order to be applicable to any magnification factor. Exposure or absorbed dose at any specific point for each source is proportional to weight of source exposure, product of source activity and exposure time. Authors use the Ci-min as a unit of activity-time because the activity of ^{60}Co source of Ralstron is indicated as Ci and exposure time as minutes.

In this system, point A[2-3] is considered to be 2 cm above along the uterine tandem from the external os and laterally 2 cm at right angle to the midline of applicator. Point B is 5 cm lateral from the center of the uterine canal and on a plane 2 cm above the external os. In case that uterus is deviated, then point A is carried to displaced uterus and is at a point 2 cm from the uterine canal in the perpendicular direction, whereas point B remains in its original position.

Specific point dose at each point and total doses are calculated and displayed on CRT monitor (Fig. 2). When the user wants to change dose

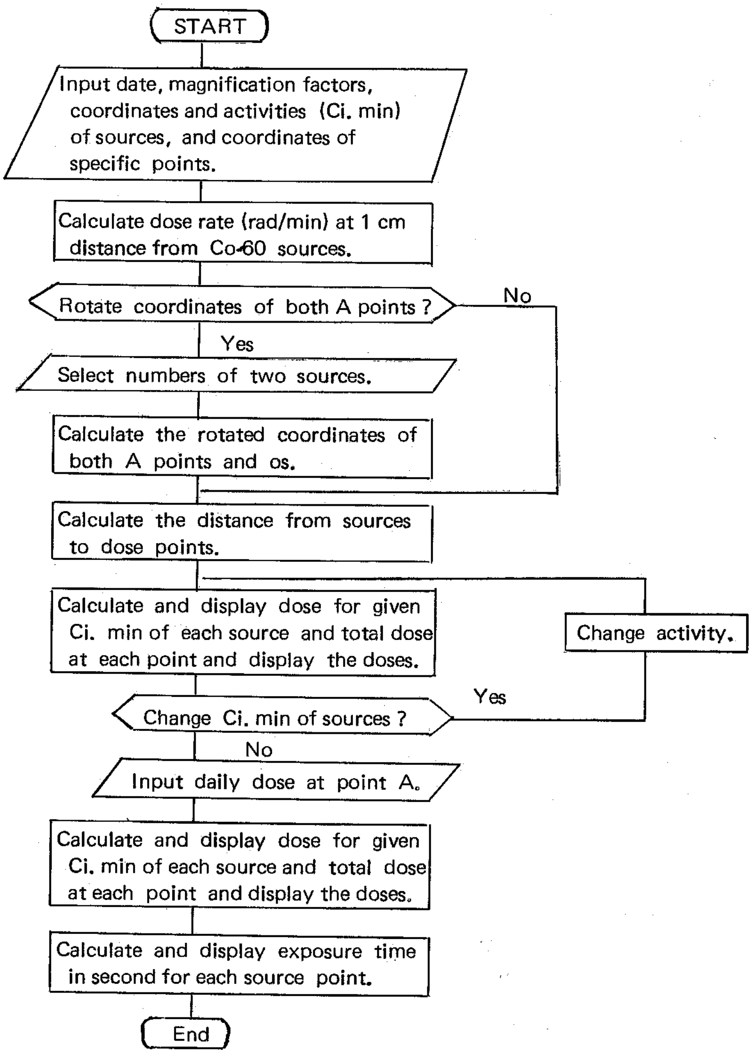

Fig. 1. Flow chart of the program.

distribution, operator can rearrange source activity of Ci-min for the most optimal dose distribution.

1. Dose calculation of point source

The dose contribution of an active ^{60}Co pellet to a point P is calculated by $D_p = \frac{A.\Gamma.T.S(d).f}{d^2}$ rad/min. A is the effective activity in Ci, Γ is the exposure rate in air, given by a point source of 1 Ci of the radioactive substance; T is the time factor during which the active pellet remains in the applicator; S(d) is the correction factor for the absorption and scattering of the radiation in tissue along path d, the distance between the active pellet and point P; f is the roentgen to rad conversion factor. For ^{60}Co Γ is 13.07 Rxcm^2/mCi-hr[4] and f=0.95 rad/R. Correction for the source decay can be calculated by the formula[4] $D_p = D_o x\, 0.5^{t/(5.27x365.25)}$ D_o is the dose rate measured at day zero;t is the elapsed days of radioactive source. Correction factor for tissue absorption and scatter (S(d)) followed the Meisberger relation[5], $S(d) = A + Bd + Cd^2 + Dd^3$, based on a compilation of published measurements, where $A = 9.9423x10^{-1}$, $B = -5.318x10^{-3}$, $C = -2.61x10^{-3}$, and $D = 1.327x10^{-4}$.

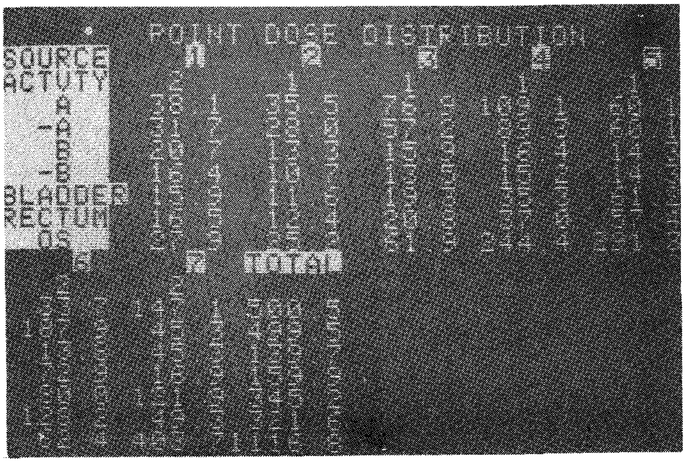

Fig. 2. Computer screen display of point dose distribution of the point A, B, os, bladder, and rectum.

2. Localization of point source

Authors use the reconstruction method from orthogonal radiographs[6)] for the localization of point source. After orthogonal radiographs are taken at right angle with isocentric method (SAD 80 cm), determine the coordinate of source (x_1, y_1, z_1). Using the coordinates (x_2, y_2, z_2) of Manchester A, B points, rectum, and bladder, the distance from specific point is given by:

$$d=\sqrt{(X_1-X_2)^2+(Y_1-Y_2)^2+(Z_1-Z_2)^2}.$$

3. Determination of irradiation time

Calculation of treatment time at each point can be calculated by the following equation:

$$D=S(d)\cdot Dt\cdot f/d^2$$

where D is the absorbed dose rate (rad/min) at the distance d, and Dt is the measured exposure rate (R/min) at 1 cm. Then actual treatment time can be calculated by the following equation:T=

$$\frac{DD}{\sum Di.\ Wi(Dall)}$$

where Di is absorbed dose rate from the i-th point source, Wi is the weight of i-th source, Dall is total dose rate from all of the point sources, T is the time per unit weight for giving DD dose, DD is the dose to be given.

The software program also provides an option to change the weight or Ci-min at each point source for ideal dose distribution at specific point. It take about several minutes to reconstruct completely dose calculation and irradiation time for intracavitary irradiation after localization of source, and specific point.

DISCUSSION

In recent years, the use of personal computers in radiation therapy department has been increased considerably, with primary applications in the business related aspects. Personal computers also should be useful in dose calculation and planning. Computerization of these calculation and planning would reduce the probability of computational error.

There are three methods available for reconstruction of applicator:reconstruction from orthogonal radiographs[6)], the stereo-shift method[7)], and the isocentric method[8)]. Reconstruction from orthogonal radiographs is probably the most common reconstruction method, and the only method which can calculate the specific points in the patient structures[8)].

The most commonly used correction factor for tissue absorption and scatter is the Meisberger relation[5)], $S(d)=A+Bd+Cd^2+Dd^3$, authors use this equation. Recently the more simple relation $S(d)=(1+bd^2)/(1+bd^2)$ has been proposed by Van Kleffens et al[9)]. Small effect of dose reduction due to the applicator wall can partly be eliminated by incorporating the air attenuation in the air layer between pellet and applicator wall. Dose contribution from the override mechanism of radioactive source within the applicator can be corrected, but the dose is negligible, 1-1.3 rads by calculation, and we do not correct this factor in software.

There are some limitations to our system. The drawing of isodose curve is under way of development. The position of radioactive sources, and specific point may be entered by the digitizing tablet instead of the coordinates input by keyboard.

Although the accuracy of these calculation using the personal computer is not as great as those results using more sophisticated algorithms, however, the accuracy is certainly comparable to that obtained via manual calculations, and far more easily obtained.

REFERENCES

1. **Todd-Pokropek A:** The use of microprocessors in oncology in computers in radiotherapy and oncology. Mould RF, Bristol, Adam Hilger 1984, pp 1-6
2. **Todd MC, Meredith WJ:** A dosage system for use in the treatment of cancer of the uterine cervix. Br J Radiol 11:809-823, 1938
3. **Todd MC, Meredith WJ:** Treatment of cancer of the cervix uterine revised "Manchester method". Br J Radiol 26:252-257, 1953
4. **Khan FM:** Intracavitary therapy, In The physics of Radiation Therapy. Khan FM, Baltimore, Williams & Wilkins, 1984 pp 385-388
5. **Meisberger LL, Keller RJ, Shalek RJ:** The effective attenuation in water of the gamma rays of Gold-198, Iridium-192, Cesium-137, Radium-226, and Cobalt-60. Radiology 90:953-957, 1968
6. **Shalek RJ, Stovall M:** Dosimetry in implant therapy, In Radiation Dosimetry, 2nd ed, Vol III, FH Attix and E Tochilin, New York, Academic Press, 1969 pp 743-807
7. **Fletcher GH:** Cervical radium applicators with screening in the direction of bladder and rectum. Radiology 60:77-84, 1953
8. **Van der Laarse R:** The Selectron treatment planning system. Chapter 6, Thesis, Computerized radiation treatment planning, Rodopi, Amsterdam, 1981
9. **Van Kleffens HJ, Star WM:** Application of stereo X-ray photogrammetry. Int J Rad Oncol Biol Phys 5:557-563, 1979

＝국문초록＝

Personal computer를 이용한 자궁경부암의 고선량율 강내치료 계획

순천향대학병원 치료방사선과

허 승 재

서울대학교 의과대학 치료방사선과학교실

강 위 생

고선량율을 이용한 자궁강내 치료시 정확하고 신속한 계산을 위하여 저자들은 개인용 컴퓨터를 이용하여 기준점의 선량분포 및 방사선조사 시간을 간편하게 계산할 수 있는 software를 개발하였다. 치료 계획용 software를 이용하여 짧은 시간내에 선량 분포 및 조사시간을 용이하고 정확하게 계산할 수 있으며, 고선량율 자궁경부암 임상적용에 효과적으로 이용할 수 있어서 보고 한다.