COMPUTATIONAL PROGRAM OF ISODOSE AND TREATMENT PLANNING SYSTEM (TPS) FOR BRACHYTHERAPY USING ^{125}I-SEED-SOURCES

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ABSTRACT

COMPUTATIONAL PROGRAM OF ISODOSE AND TREATMENT PLANNING SYSTEM (TPS) FOR BRACHYTHERAPY USING ^{125}I-SEED-SOURCES. To reach the goals of a brachytherapy treatment, a guaranteed dose rate calculation as well as a treatment planning system (TPS) are absolutely needed. Therefore, a local computational program for isodose and TPS calculations has been developed. The program has been performed using Microsoft Visual Basic for Windows and its supporting tools based on dosimetry calculation models developed and updated by the Association of American Physicist in Medicine. The program was started from the dose rate calculation of the of ^{125}I-seed-source assumed as a line source with 0.3 cm of active length. This program can display two dimensions-isodose contour of the single or poly-^{125}I-seeds presented in the directions of lateral, anterior and caudal by changing the polar coordinate system (r, θ) into a Cartesian coordinate system (x,y). The dose rate at the distances of 1, 2, 3 and 4 cm from the center point as well as the effect of single-seed-source rotation can also be calculated. The entered data as well as the resulting calculation and the isodose contour presentation can be saved, quickly traced and redisplayed at any time necessarily. It was found that this computer program is in agree with the referenced data so it is hopefully able to assist physicians in the domestic implementation of ^{125}I seeds implants for brachytherapy.

Keywords: ^{125}I-seed-source, brachytherapy, isodose contour, treatment planning system, computer program

ABSTRAK

PROGRAM KOMPUTASI ISODOSIS DAN *TREATMENT PLANNING SYSTEM* (TPS) UNTUK BRACHITERAPI MENGGUNAKAN ^{125}I-*SEED-SOURCES* Dalam aplikasi teknik brachiterapi, perhitungan dosis dan perencanaan terapi (*treatment planning system*, TPS) mutlak diperlukan, oleh karena itu program komputasi lokal untuk perhitungan isodosis dan TPS perlu dikembangkan. Program komputasi isodosis dibuat menggunakan *Microsoft Visual Basic for Windows* beserta perangkat pendukungnya berdasar pada model perhitungan dosimetri yang dikembangkan dan diperbarui oleh *The Association of American Physicist in Medicine*. Program dimulai dengan perhitungan laju dosis ^{125}I-*seed-source* yang diasumsikan sebagai sumber garis sepanjang 0,3 cm. Program ini dapat menampilkan kontur isodosis dua dimensi dari ^{125}I-*seed-source* yang disajikan dengan arah *lateral*, *anterior* dan *caudal* dengan mengubah sistem koordinat polar (r, θ) menjadi sistem koordinat Cartesian (x,y). Laju dosis pada jarak 1, 2, 3 dan 4 cm dari titik pusat dan efek rotasi ^{125}I-*seed-source* tunggal juga dapat dihitung. Data masukan (*input*) dan hasil perhitungan serta tampilan kontur isodosis dapat disimpan, ditelusuri dan ditampilkan kembali secara cepat setiap saat. Hasil perhitungan isodosis dengan program komputer ini sesuai dengan data acuan sehingga diharapkan program ini dapat membantu para dokter dalam implementasi ^{125}I-*seed-source* untuk brachiterapi.

Kata kunci: ^{125}I-*seed-source*, brachiterapi, kontur isodosis, *treatment planning system*, program komputer

1. INTRODUCTION

Brachytherapy, also known as internal radiotherapy, sealed source radiotherapy, curietherapy or endocurietherapy (1, 2) is a technique of radiotherapy using an ionizing radiation source implanted or placed inside or near to the area of the organ or tissue being treated. The radiation dose, therefore, is delivered continuously into the organ, either over a short time, in case of temporary implants, or over the life time of the radiation source, in case of permanent implants. This technique refers to cancer therapy and is commonly used as an effective treatment for cervix, prostate, breast cancers and also be used for treating tumors in many other body sites (2, 3). Brachytherapy sources for permanent implants are usually encapsulated as mini or even microcapsules made from biocompatible material, usually titanium, so that no untoward chemical reactions are experienced for the long indwelling times of these permanent implants. The radioactive iodine (^{125}I) and palladium (^{103}Pd), having average photon energies (γ-rays and x-rays) in the 20 –30 keV range, are widely used as brachytherapy sources, resulting in significantly higher Linear Energy Transfer (LET) values than those associated with megavoltage external beam systems and, consequently, they have significantly greater radiobiological effect (4).

The CRR-BATAN is nowadays promoting local produced ^{125}I-seed-sources for domestic application of brachytherapy, especially for treating prostate and breast cancers. The ^{125}I-seed implantation brachytherapy has been claimed to be safe and effective for examining short term outcomes of localized prostate cancer (5). Many applications of ^{125}I-seed to treat various kinds or sites of cancers have also been reported elsewhere (6 - 8).

A brachytherapy treatment, however, will not reach its goals if there are severe position misses in placing the sources relative to their intended positions. Such geometrical misses may be seriously detrimental to the intended treatment. Thus there is a need to have the program guaranteeing that the treatment is given in accordance with its purposes. The availability of a ready-used and suitable dosimetry model for the dose calculation as well as for treatment planning system in brachytherapy is therefore one of important aspects in any brachytherapy treatments. By using such dosimetry model, an isodose map, i.e. a map of point positions receiving similar radiation dose rate emitted by a source located at a certain position within the cancer, for a certain treated cancer can be predicted meaning that the conformity of the required radiation dose to the shape and dimension of the cancer can be achieved safely and accurately.

Such dosimetry calculation models for this purpose have been developed and updated by the Association of American Physicist in Medicine - Radiation Therapy Committee, Task Group No. 43 (also known as AAPM-TG43), over the past decades (9,10). Unfortunately, as like as the ^{125}I-seed-source that is still in domestic promotion stage, the existing dosimetry model and its practical implementation as a TPS for brachytherapy is not yet well-understood by the domestic stake holders.

In order to support the domestic application of ^{125}I-seed-sources in brachytherapy, a computational program based on the recommendation of the AAPM-TG43 (9, 10) has been developed using Microsoft Visual Basic for Windows and its supporting tools. This computer program is hopefully able to assist physician in the domestic implementation of ^{125}I-seeds implantation for brachytherapy. The most important advantage of the presented computer program over such other program is that the presented program is fully designed and developed locally so that it will be easily well-understood, implemented and maintained by the domestic stake holders independently to foreign sides.

2. MATERIALS AND METHODS

2.1. Tools for Program Preparation

A personal computer with processor of Intel® Core™2 Duo @ 2.20 GHz, capacity of RAM 4 GB and hard disk of 520 GB was used for preparation of the program using operational system of 32-bits Window-7. The isodose and TPS programs including the graphic visualization were developed using the soft-ware of Microsoft Visual Basic 6.0 for Windows and its supporting tools. The soft-wares of Paint Shop Pro and Corel Video Studio were used in the editing of pictures and videos (11 - 13).

2.2. Description of the Program

The program was started from the calculation of the dose rate of ^{125}I-seed-sources assumed as a line source with 0.3 cm of active length referring to the dimension of the actual ^{125}I-seed produced by the CRR-BATAN. The scheme of point position subjected to the dose rate calculation and its corresponding variables are shown in Fig. 1, while the base mathematical formulation for the calculation is presented by Eq. [1] (9, 10).

$$\check{D}(r,\theta) = S_k \, . \, \Delta \, . \, \frac{G(r,\theta)}{G(r_o,\theta_o)} \, . \, g(r) \, . F(r,\theta) \qquad [1]$$

$\check{D}(r,\theta)$	=	dose rate at the point $P(r,\theta)$ (cGy/hr)
S_k	=	Air kerma strength constant (U) or (cGy.cm^2/hr)
Δ	=	dose rate constant (cGy/hr/U)
$G(r,\theta)$	=	geometry factor at the point P
$G(r_o,\theta_o)$	=	geometry factor at r = 1 cm and $\theta = 90^o$
$g(r)$	=	radial dose function
$F(r,\theta)$	=	anisotropy function

If the radioactive source is assumed as a point source, the geometry factor is then calculated as:

$$G(r) = \frac{1}{r^2} \qquad [2]$$

In the presented program, the ^{125}I-seed source is assumed as a line source with the active length of L = 0.3 cm. The geometry factor is then calculated as (10):

$$G(r,\theta) = \frac{\beta}{L \, . \, r \, . \, \sin(\theta)} \qquad (\text{for } \theta \neq 0) \qquad [3]$$

$$G(r,\theta) = \frac{1}{(r^2 - ¼ \, . \, L^2)} \qquad (\text{for } \theta = 0) \qquad [4]$$

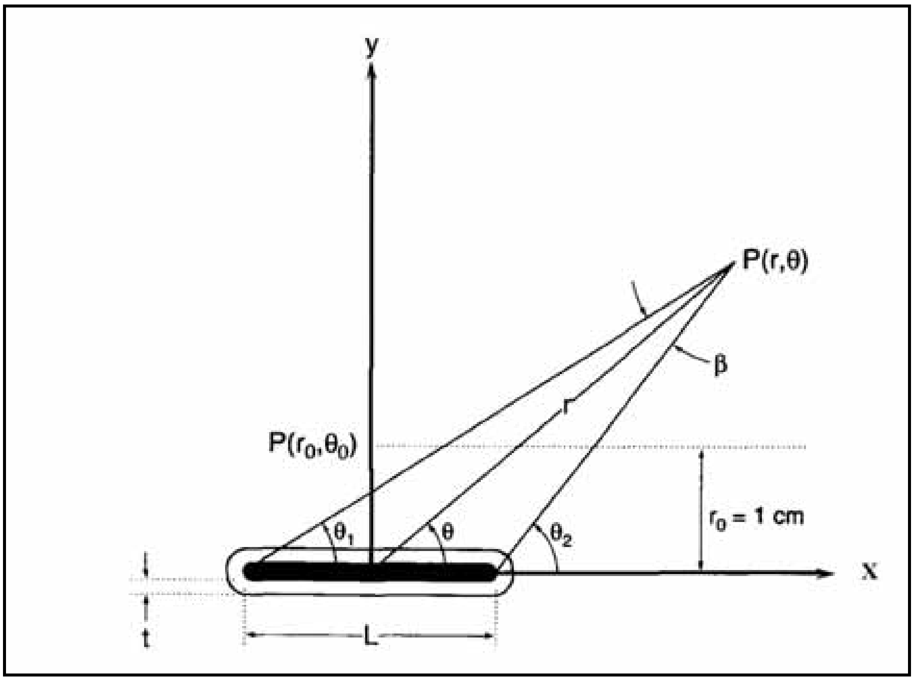

Fig. 1. Point subjected to dose rate calculation and the related variables (9, 10). r = distance from the point, P(r,θ) to the center point (0,0) of the radioactive seed source (cm); L = active length of the seed source (cm); β = angle-width at the point P(r,θ) to the left and right-edges of the seed source (radian); θ = angle-width at the point edges or the center of source to P(r,θ) and axes of the source (°).

Both radial dose function, g(r), and anisotropy function, F(r, θ), in Eq.[1] were then calculated using the data set recommended and reported by the AAPM-TG43 (10). As the applied data set for the radial dose function consists of 11 data pairs, the calculation was carried out by 10^{th}-order of polynomial equation (14, 15) based on self-improved computer program for solving polynomial equations (16). The calculation for anisotropy function was performed using AAPM-TG43 data set consisting of 6 variable values of r and 11 variable values of θ (10), so that the function was solved by 5^{th}-order of polynomial equation for the value of F as a function of r at a most certain θ, and by 10^{th}-order of polynomial equation for the value of F as a function of θ at a most certain r (14, 15). Finally, by substituting the corresponding calculation results and the constant values of Sk and Δ into Eq. [1], the value(s) of Ď(r, θ) can be obtained. The resulting program was demonstrated to calculate the value(s) of Ď(r, θ) for the radius of less than 5 cm (17), but it can be applied as well for longer radius anticipating the higher dimension of the cancers

2.3. Display Program of Two-dimensions-Isodose Contour

The term of isodose refers to the positions of a certain distance from the source those have a similar value of dose rate, Ď(r, θ). The contour of the isodose can be displayed as a two-dimensions-visualization by changing the polar coordinate system (r, θ) into Cartesian coordinate system (x, y). The basic correlations between variables shown in Fig. 1 are simplified as follow:

$$tg(\theta) = y / x \rightarrow y = x \cdot tg(\theta) \quad [5]$$

$$r^2 = x^2 + y^2 \rightarrow r^2 = x^2 \{1 + tg^2(\theta)\} \rightarrow x = \{r^2 / (1 + tg^2(\theta)\}^{1/2} \quad [6]$$

$$\beta = 180^\circ - \theta_1 - \theta_3 = 180^\circ - \theta_1 - (180^\circ - \theta_2) = \theta_2 - \theta_1 \quad [7]$$

$$tg(\theta_1) = \frac{y}{x + 0.5\,L} \qquad \theta_1 = arc.tg\left(\frac{y}{x + 0.5\,L}\right) \quad [8]$$

$$tg(\theta_2) = \frac{y}{x - 0.5\,L} \qquad \theta_2 = arc.tg\left(\frac{y}{x - 0.5\,L}\right) \quad [9]$$

By knowing the given values of r and θ, the developing program can accordingly provide quick calculation to obtain the values of variables consisted in Eq. [1] and then visualize the values of the dose rate, Ď(r, θ), in a Cartesian coordinate system as a display of two-dimensions-isodose contour. The program was also developed for calculating and displaying the two-dimensions-isodose contour of poly-seed sources considering that the treated patient maybe need more than one ^{125}I-seed source. Moreover, the program can also display the two-dimensions-isodose contour in 3 directed orientations, i.e. anterior, lateral and caudal.

3. RESULT AND DISCUSSION

The developing program has been successfully applied to calculate the values of geometry factor, G(r,θ), radial dose function, g(r), and anisotropy function, F(r, θ). By substituting the calculating values and the constants in the Eq.[1], the dose rate values can be then obtained. Table 1 shows the resulting calculation of G(r, θ) times r^2 values as compared to the reference-reported-result (9). It can be seen that the results from the present work are consistently similar to those from the reference.

The radial dose function data set used for the presented work was partially subtracted from the data set recommended by the AAPM-TG43 corresponding to the ^{125}I-seed-source of Amersham model 6711 (10), as the CRR-produced-^{125}I-seed-sources are similar to that model. As the subtracting data consists of 11 data pairs (see Table 2), a 10th-order of polynomial equation was developed using self-improved computer program for solving polynomial equations (16). The resulting polynomial equation for calculating radial dose function, g(r), was formulated as Eq.[10] below :

$$g(r) = 1.10380 - 0.22841\,r + 0.98594\,r^2 - 2.18019\,r^3 + 2.30786\,r^4 - 1.41104\,r^5 + 0.52915\,r^6 - 0.12308\,r^7 + 0.01726\,r^8 - 0.00133\,r^9 + 0.00004\,r^{10} \ldots\ldots\ldots \quad [10]$$

Referring to Eq.[10], the radial dose function values for various r excluded of the data set can be calculated. Examples of the calculation result are shown in Table 2, demonstrating that the developing program has been successfully applied to calculate the values of radial dose function. The data set in Table 2 is an updating data of, and thus is slightly different from, the prior reported data set (9). However, by fitting the recommended and the calculated data sets, the profiles of radial dose functions were obtained as shown in Fig. 2 as compared to the elder data (9). It can be seen that the overall accuracy of the presented work was excellent.

Table 1. The calculated values of G(r,θ) times r^2 from the present works as compared to the reference values (9), for a line-seed-source having 0.3 cm of active length.

Angle θ (deg)	r = 0.5 cm		r = 1.0 cm		r = 2.0 cm		r = 5.0 cm	
	1)	2)	1)	2)	1)	2)	1)	2)
0	1.099	1.0989	1.023	1.0230	1.006	1.0057	1.001	1.0009
10	1.094	1.0941	1.022	1.0221	1.006	1.0054	1.001	1.0009
20	1.081	1.0808	1.019	1.0193	1.005	1.0048	1.001	1.0008
30	1.062	1.0615	1.015	1.0151	1.004	1.0038	1.001	1.0006
40	1.039	1.0394	1.010	1.0101	1.002	1.0025	1.001	1.0004
50	1.018	1.0176	1.005	1.0048	1.001	1.0012	1.000	1.0002
60	0.998	0.9985	0.9999	0.9999	1.000	1.0000	1.000	1.0000
90	0.9715	0.9715	0.9926	0.9926	0.9980	0,9981	1.000	0.9997

1) Reference-reported-values (9).
2) Calculated values from the presented works.

Table 2. Recommended data set for radial dose function (10) and the calculated data based on Eq.[10].

Recommended Data Set			Calculated Data by Eq.[10] Excluded of the Data Set		
#	r (cm)	g(r)	#	r (cm)	g(r)
1	0.25	1.082	1	1.25	0.954
2	0.50	1.071	2	1.75	0.862
3	0.75	1.042	3	2.25	0.765
4	1.00	1.000	4	2.75	0.671
5	1.50	0.908	5	3.50	0.567
6	2.00	0.814	6	4.25	0.452
7	3.00	0.632	7	4.75	0.376
8	4.00	0.496	8	5.50	0.292
9	5.00	0.364			
10	6.00	0.270			
11	7.00	0.199			

Table 3. The data set for anisotropy function, F(r, θ), corresponding to the ^{125}I-seed-source of Amersham model 6711 (10)

θ (deg)	Values of F(r,θ) for various r (cm) and θ (deg)					
	r = 0.5	r = 1	r = 2	r = 3	r = 4	r = 5
0	0.333	0.370	0.442	0.488	0.520	0.550
5	0.400	0.429	0.497	0.535	0.561	0.587
10	0.519	0.537	0.580	0.609	0.630	0.644
20	0.716	0.705	0.727	0.743	0.752	0.760
30	0.846	0.834	0.842	0.846	0.848	0.852
40	0.926	0.925	0.926	0.926	0.928	0.928
50	0.972	0.972	0.970	0.969	0.969	0.969
60	0.991	0.991	0.987	0.987	0.987	0.987
70	0.996	0.996	0.996	0.995	0.995	0.995
80	1.000	1.000	1.000	0.999	0.999	0.999
90	0.973	0.944	0.941	0.942	0.943	0.44

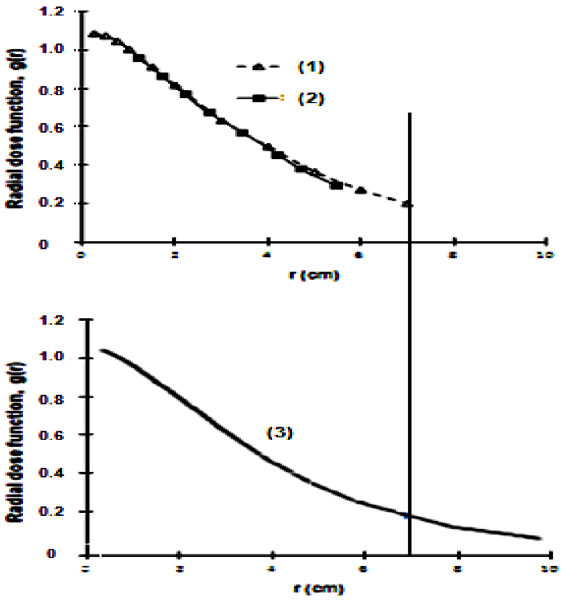

Fig. 2. Radial dose functions from the updated data set (1,10), the present work (2) and the elder reference (3, 9).

The anisotropy function values, F(r, θ), were calculated for certain values of r and those of θ corresponding to the seed source of Amersham model 6711, based on the referenced data set consisting of 6 values of r and 11 values of θ, as being shown in Table 3 (10). The solution was accordingly performed using 5th-order of polynomial equation in r (at any fixed θ) and using 10th-order of polynomial equation in θ (at any fixed r). The polynomial equations were formulated respectively as follow (both A_i and B_i are constants):

$$F(r,\theta) = A_0 + A_1 . r + A_2 . r^2 + A_3 . r^3 + A_4 . r^4 + A_5 . r^5 \quad [11]$$

$$F(r,\theta) = B_0 + B_1 . \theta + B_2 . \theta^2 + B_3 . \theta^3 + B_4 . \theta^4 + B_5 . \theta^5 + B_6 . \theta^6 + B_7 . \theta^7 + B_8 . \theta^8 + B_9 . \theta^9 + B_{10} . \theta^{10} \quad [12]$$

Referring to the data in Table 3 and by using an available computer program for solving polynomial equations (16), the 5th-order of polynomial equations in r, were then developed having values of A_i constants which are depending on the given value of r. As an example, Table 4 shows the resulting values for A_i as well as the values of F(r, θ) at a given value of r = 2.35 cm and various corresponding values of θ based on Eq.[11].

A calculation to formulate the Eq.[12] was demonstrated to obtain the anisotropy function at r = 2.35 cm. The 10th-order of polynomial equation in θ at a corresponding value of r = 2.35 cm was accordingly found and can be presented as Eq.[13].

Substituting a value of θ = 58º, as an example, into Eq.[13], a value of F(r,θ)= 0.98428 was then obtained. This is the value of F(r, θ), for r = 2.35 cm and θ = 58º. The values of F(r, θ) for other r and θ values can be calculated similarly after finding the corresponding values of A_i and B_i constants.

$$F(r,\theta) = 0.46091 + 4.56229E\text{-}03.\ \theta + 1.66962E\text{-}03.\ \theta^2 - 1.08381E\text{-}04.\ \theta^3 + 2.80484E\text{-}06.\ \theta^4 + 3.63608E\text{-}09.\ \theta^5 - 2.09364E\text{-}09.\ \theta^6 + 5.52398E\text{-}11.\ \theta^7 - 6.84420E\text{-}13.\ \theta^8 + 4.26669E\text{-}15.\ \theta^9 - 1.07891E\text{-}17.\ \theta^{10} \quad [13]$$

Table 4. The constants of the 5th-order of polynomial equation related to Eq.[11] and the corresponding F(r,θ) value for r = 2.35 cm.

θ (deg)	VALUES OF A_i CONSTANTS (Eq.[11])						F(r, θ) for r = 2.35 cm
	A_0	A_1	A_2	A_3	A_4	A_5	
0	+0.31070	+0.01711	+0.07032	-0.03407	+0.00371	-0.00043	0.46091
5	+0.40270	-0.06024	+0.13796	-0.06242	+0.01174	-0.00080	0.51365
10	+0.51790	-0.02611	+0.07104	-0.03129	+0.00583	-0.00040	0.59192
20	+0.77450	-0.18956	+0.17566	-0.06627	+0.01143	-0.00074	0.73473
30	+0.89370	-0.15058	+0.13386	-0.05151	+0.00909	-0.00060	0.84481
40	+0.93230	-0.02164	+0.02256	-0.01022	+0.00210	-0.00016	0.92598
50	+0.96980	+0.00800	-0.00856	+0.00327	-0.00054	+0.00003	0.96944
60	+0.98330	+0.02851	-0.03284	+0.01460	-0.00283	+0.00020	0.98644
70	+0.99700	-0.00398	+0.00534	-0.00289	+0.00064	-0.00005	0.99557
80	+1.00125	-0.00496	+0.00644	-0.00339	+0.00074	-0.00006	0.99943
90	+1.05520	-0.24456	+0.19272	-0.07080	+0.01227	-0.00081	0.94210

Table 5. The dose rate values, Ď(r,θ), at any distances, r, of single ^{125}I-seed.

Distance, r (cm)	Dose rate, Ď(r,θ), (cGy/hr/U)		Remarks
	1)	2)	
0.5	3.937	3.93730	1). Reference data based on Amersham model 6711 (10)
1	0.911	0.91096	
1.5	0.368	0.36855	2). Present work
2	0.186	0.18582	Air kerma strength constant (10):
3	0.0643	0.06426	S_k = 1 U
4	0.0284	0.02841	Dose rate constant (10):
5	0.0134	0.01336	Δ = 0.965 cGy/hr/U

The presented program has been then demonstrated to calculate the Ď(r, θ) by means of Eq.[1] using the value of constant S_k = 1 cGy.cm^2.hr^{-1} (or 1 U) and that of constant Δ = 0.965 cGy.hr^{-1}.U^{-1} (10). The resulting values as compared to the referenced data (10) are presented in Table 5 showing that the results from the present work are consistently similar to the reference data.

The two-dimensional isodose contour of a ^{125}I-single-seed can be presented after collecting the values of the dose rate, Ď(r, θ), at various r and θ values, and changing the polar coordinate system into Cartesian coordinate system. The results are shown in Fig. 3 assuming that the source is in the form of a point source (Fig. 3.a) or is in the form of a line source having 0.3 cm of active length (Fig. 3.b) as compared to the work reported by Badragan (Fig. 3.c) (18).

To demonstrate that the result of the presented work is insignificantly differ from that of Badragan's report (18), the dose rate data for several positions were normalized to the position of r = 1 cm and then compared each other. The result presented in Table 6, which is in high conformity with the contour shown in Fig. 3, indicates that this present work is in accordance with Badragan's report.

The present isodose and TPS program has also been developed for calculating total dose rate as well as presenting the profile of the isodose contour coming from poly-seed sources (up to 20 ^{125}I-seed sources) implanted individually on an accurate position respectively. It is necessary to anticipate that the treated patient is maybe need much more than one seed source. Moreover, the program can also display the two-dimensions-isodose contour in 3 directed orientations, i.e.: lateral (X-Y coordinate**),** anterior (X-Z coordinate**)**, and caudal (Z-Y coordinate**)**.

As an example, a prostate cancer was simulated to be observed in the directions of lateral (X-Y coordinate), anterior (X-Z coordinate), and caudal (Z-Y coordinate) as presented in Fig. 4. Four ^{125}I-seed-sources are accurately positioned into the cancer and the resulting isodose contour surrounding the cancer can be displayed being able to aid the physicians in the decision of requiring dose.

The presented program is also able to calculate the dose rate at the distance of 1, 2, 3 and 4 cm from the center point of (0,0) affected by the rotation of a single-seed-source. All the calculations were normalized to the original position, e.g. 0° of rotation angle.

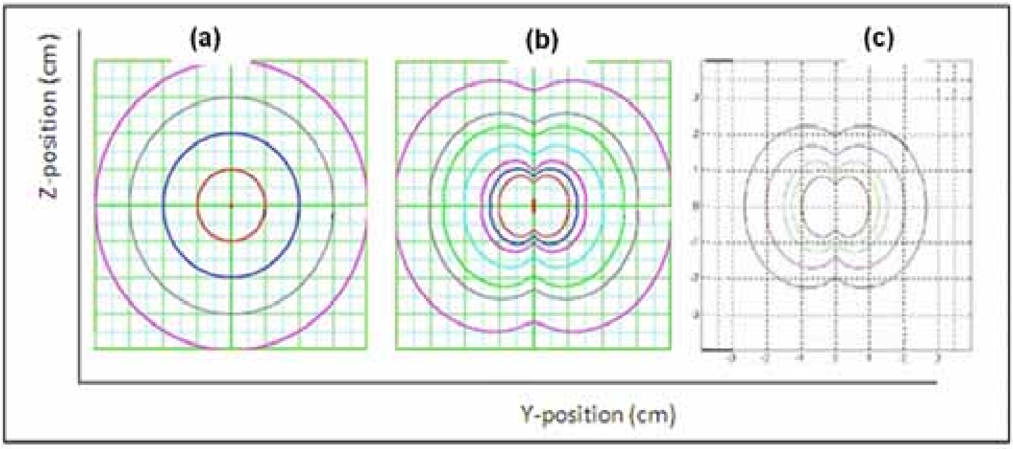

Fig. 3. Isodose contour of ^{125}I-seed as a point source (a), as a line source having 0.3 cm of active length (b) as compared to Badragan's report (c).

Table 6. Normalized dose rate to the dose rate at r = 1 cm as compared to Badragan's report.

Distance, r (cm)	**Dose rate as normalized to r = 1 cm (%)**		**Remark**
	1)	**2)**	
1.0	100.00	100	1) Present work 2) Badragan's report (18).
1.25	61.17	60	
1.5	40.46	40	
2.0	20.40	20	
2.6	10.47	10	
3.0	7.05	Not reported	
4.0	3.12	Not reported	

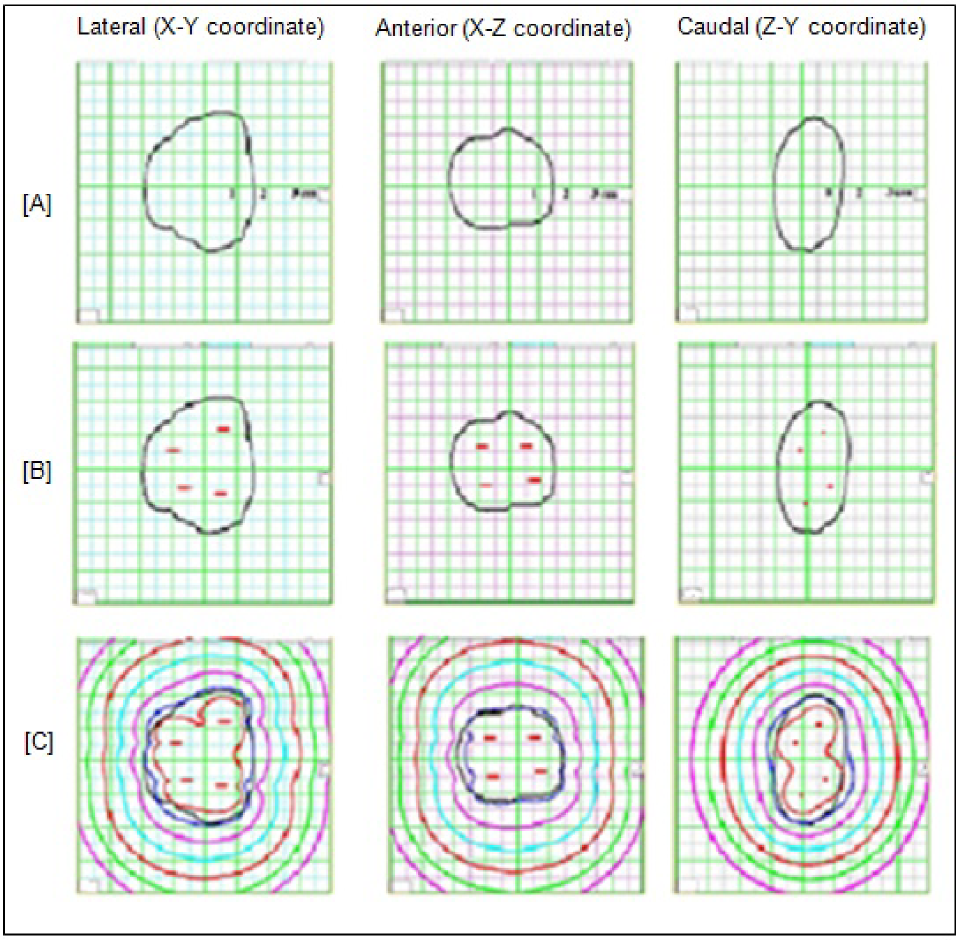

Fig. 4. Simulated-two-dimensions-isodose contour of four ^{125}I-seed-sources.
[A]. A cancer is simulated in lateral, anterior and caudal directions direction.
[B]. Four ^{125}I-seed-sources are accurately positioned in the cancer.
[C]. The display of the resulting isodose contour surrounding the cancer.

This calculation is considered to be important to anticipate whether the moving-orientation of the seed-source during the post-implantation period will affect the dose rate. The result presented in Fig. 5 is showing that a moving-orientation less than 40° does not significantly change the dose rate at any distances studied. At a rotation of more than 50°, the decrease of dose rate affected by the moving-orientation of the seed source was observed higher at the position closer to the center point (0,0).

As a computational program, the presented program is not only used for numeric calculation related to dosimetry and TPS for brachytherapy. It can also be used in terms of documentation and information keeping system. The entered data as well as the resulting calculation and the isodose contour presentation can be saved, quickly traced and redisplayed at any time necessarily or even transferred as electronic files. The implementation study on the application of the presented program is now being done as collaboration with the Radiotherapy Department of Hasan Sadikin Hospital, Bandung (19).

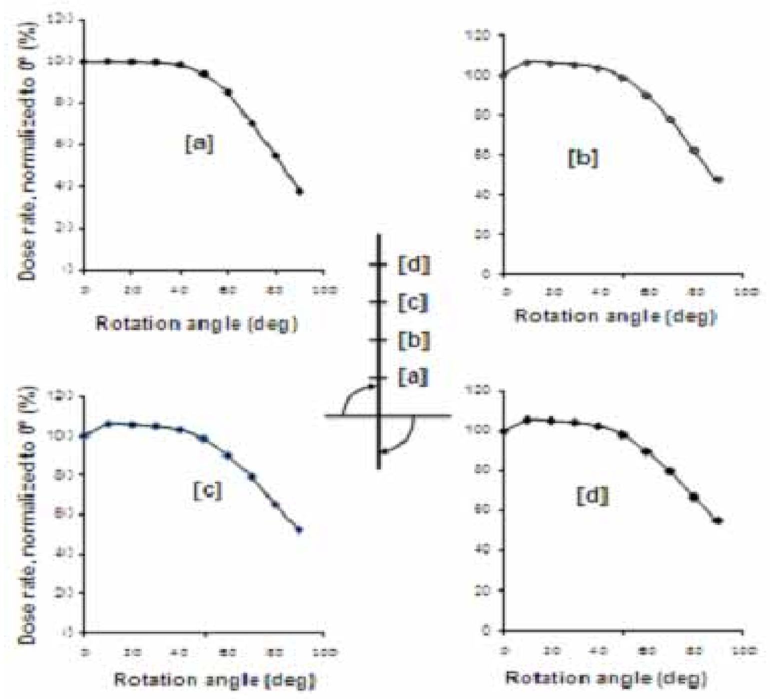

Fig. 5. Effect of the moving-orientation of the seed to the dose rate at various of r (r = 1 cm [a], 2 cm [b], 3 cm [c] and 4 cm [d], perpendicular to original position of the seed).

4. CONCLUSION

An isodose and TPS program for ^{125}I-seed-source brachytherapy, specifically for prostate cancer, had been successfully developed. The computer program provides calculation of dose rate based on the parameters recommended by AAPM-TG43 corresponding to the Amersham model 6711-^{125}I-seed-source. The presentation of two-dimensional-isodose contour can also be displayed in the lateral, anterior and caudal directions for either single or poly-seed-source(s).

The presented program is also able to calculate the dose rate at the distance of 1, 2, 3 and 4 cm from the center point of (0, 0) affected by the rotation of a single-seed-source. It was found that a moving-orientation less than 40° does not significantly change the dose rate at any distances studied. At a rotation of more than 50°, the decrease of dose rate affected by the moving-orientation of the seed source was observed higher at the position closer to the center point (0, 0).

It has been demonstrated that the execution of the presented program gives satisfied results in terms of being in agree with the reports used as references. Accordingly, related to the implementation of brachytherapy, the presented program is hopefully able to assist the domestic physician in ^{125}I-seeds implantation for cancer treatment.

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