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التحقق من الجرعة الإشعاعية الممتصة المحسوبة بواسطة جهاز تخطيط العلاج الإشعاعي.

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الملخص :

يعتبر جهاز تخطيط العلاج الإشعاعي من أهم أدوات تخطيط العلاج لمرضي الأورام السرطانية. عليه، فإن التحقق من تخطيط وحسابات الجرعة الإشعاعية التي يتم إيصالها إلي الورم السرطاني داخل المريض والمتحصل عليها بواسطة جهاز تخطيط العلاج الإشعاعي كان الهدف من هذه الدراسة. ومن أجل هذه الغاية استخدم جهاز تخطيط علاج إشعاعي نوع PLATO-RTS في بعدين لحساب الجرعة الإشعاعية عند نقاط محددة داخل مماثل بشري (Alderson Rando phantom). الجرعة الإشعاعية الممتصة داخل المماثل البشري استخدم لقياسها كواشف التألق الحراري المصنوعة من الليثيوم فلورايد. حيث قورنت نتائج حسابات الجرعة الإشعاعية الممتصة المسحوبة بواسطة جهاز تخطيط العلاج الإشعاعي بنتائج الجرعة المقاسة بواسطة كواشف التألق الحراري. كان أكبر اختلاف بين الجرعة المحسوبة الجرعة المقاسة 12.5 cGy وأن متوسط الخطاء كان يتراوح بين 2.53% و 8.82% حيث تعتبر هذه النسبة مقبولة عند إجراء القياسات بواسطة كواشف التألق الحراري.

Verification of radiation absorbed dose calculated by treatment planning system

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Abstract:

A computerized Treatment Planning System (TPS) is an important tool for designing a treatment plan of cancer patients. Testing the accuracy of planned and calculated radiation dose obtained by TPS delivered to the tumor inside the cancer patients was the purpose of this study. For this purpose, a 2D PLATO-RTS Treatment planning system was used to calculate the dose at specific points inside an Alderson Rando phantom. The absorbed radiation dose inside the phantom was measured using the thermoluminescent dosimeter TLD-100s Lithium Flouride (LiF:Mg;Ti). The results of absorbed radiation dose obtained by TPS were compared with the results obtained by TLD. The largest difference between planned and measured radiation dose was found 12.5 cGy, and the mean percentage error was found 8.82% and 2.53% which is considered to be acceptable with TLD 100 (LiF: Mg, Ti).

1. Introduction:

Due to the fact that radiation has biological effects on living cells, it is used to treat cancer patients. Radiation dose delivered to tumor cells must be accurate in both quality and quantity **[1]**. The International Commission on Radiation Units and measurements (**ICRU**) recommended in its report numbered 62 released in 1999 and other publications that the delivered prescribed tumor dose must be accurate within

5% to ensure adequate tumor control **[2-6]**. Therefore, in order that radiation treatment to be effective and efficient, a quality assurance program should be applied carefully during each step of treatment process. Treatment planning is one of main parts of radiation treatment which provide a radiation dose distribution in patient using a Treatment Planning System (TPS). The quality assurance program of TPS is indispensable part of appropriate treatment. Many International organizations and agencies are recommended and provided guidelines for TPSquality assurance, for instance, International Atomic Energy Agency **(IAEA)** in its technical report series 1540 **[7]**, and American Association of Physicists in Medicine **(AAPM)** in its task groups 53 and 55**[8, 9]**. The aim of this paper is to verify the radiation absorbed dose distribution at specific points calculated by TPSinside anthropomorphic phantom (Alderson Rando phantom) as a patient with measured value obtained by using thermoluminescent dosimeter **TLD**.

2. Material and methods:

This study was undertaken in Tripoli Medical Center **(TMC)**, Radiotherapy Department, Tripoli, Libya. The machine used is Theratronics 780C Cobalt-60 Unit to provide an external radiation beam. The treatment head of the machine unit consists of a cubic Cobalt-60 radioactive isotope of side 2cm, two jaws to define the field size of treatment area from 5×5 cm^2 to 35×35 cm^2, and gantry which is capable to rotate around the machine central axis 360^o**[10]**. An Alderson Rando radiation therapy anthropomorphic phantom **(ART)** was used for creating treatment plans and then for investigation of delivered dose to specific points in the phantom. The ART Phantom has designed following the ICRU report 44 and 48 **[11, 12]** and made of materials that equivalent to a natural human organics. The materials, for example, which simulate a soft tissue, lung and skeleton have densities of 0.997 g/cm^3, 0.32

g/cm^3 and 1.61 g/cm^3, respectively **[13, 14]**. The ART phantom is transected horizontally into 34 slices. Each slice with 2.5 cm thickness and has holes where thermoluminescent rods dosimeter can be inserted **[15]**. The region of the phantom which the TLD rods placed was abdomen. The external body contour of the phantom in the interest region, and the internal organics were delineated manually.

The TPS used to calculate radiation dose distribution inside the phantom was a 2D PLATO-RTS Treatment planning system manufactured by Nucletron B.V. in The Netherland. Beam data entered into the TPSwere measured using WELLHOFER WP 700, computerized 3D-radiation field analyzer dosimetry system.

The measurements of radiation dose at specific points inside the phantom were carried out using a TLD 100 (LiF: Mg, Ti), in the shape of rods, measuring 1mm in diameter and 6 mm in length, and the TLD reader was Harshaw TLD model 5500 with control software Teledyne system 310 manufactured by Thermo Fischer Scientific Inc. A group of 27 TLD rods were calibrated using 100 cGy gamma radiation of Co-60 at the first, and then used to perform measurements. From this group, 7 rods were chosen to be used for reader calibration, remains were divided into two groups (each group contains 10 rods), the first group labeled from R1 to R10 while, the second group labeled from D1 to D10. These two groups were used for dosimetry measurements. The response of TLDs to 100 cGy is shown in table 1 and 2.

Two plans were created to deliver radiation dose to the target area inside the phantom. The first plan was three fields of size 10×10 cm^2 and a SSD (Source to surface distance) of 80 cm to deliver a radiation dose of 100 cGy to the target area. The three fields were anterior, right lateral and left lateral with gantry angle at 0^O, 90^O and 270^O respectively. The second plan was four open fields with SSD of 80 cm to deliver a radiation dose of 200 cGy to the target area. The four fields were anterior, posterior, right lateral and left lateral with gantry angle at 0^{O}, 180^{O}, 90^{O} and 270^{O} respectively. The radiation fields were of size 9.5×10 cm^2 for anterior and posterior fields while the radiation fields were of size 6.5×10 cm^2 for right and left lateral fields. The dose distribution of two plans is shown in figure 1 and 2. The measurements of the second treatment plan were repeated twice with the same previous conditions.

3. Results and discussions:

The results of the first group of the TLDs, which has labeled from R1 to R10, are shown in Table (1) which presents the response of the TLDs to 100 cGy radiation absorbed dose. It is found that the mean percentage errors in calculations are typically 3.34%, while that for the second group labeled from D1 to D10 are 4.69% as shown in Table (2).

Table (1): Shows the response of the TLDs to 100 cGy radiation absorbed dose, and the percentage error between them, for the first group of TLDs.

Dedicator No	Given dose (cGy)	Measured dose (cGy)	% error
R1	100.00	96.80	3.20
R2	100.00	98.60	1.40
R3	100.00	96.92	3.08
R4	100.00	95.24	4.76
R5	100.00	95.78	4.22
R6	100.00	98.52	1.48
R7	100.00	96.04	3.96
R8	100.00	96.63	3.37
R9	100.00	95.46	4.54
R10	100.00	97.79	2.40

Table (2): Shows the response of TLDs to 100 cGy radiation absorbed dose, and the percentage error between them, for the second group of TLDs.

Dedicator No	Given dose (cGy)	Measured dose (cGy)	% error
D1	100.00	102.60	2.60
D2	100.00	103.70	3.70
D3	100.00	107.30	7.30
D4	100.00	105.50	5.50
D5	100.00	103.70	3.70
D6	100.00	106.20	6.20
D7	100.00	105.00	5.00
D8	100.00	105.50	5.50
D9	100.00	104.70	4.70
D10	100.00	102.70	2.70

By comparing the mean percentage error of two groups, the second group was excluded.

Figures (1) and (2) show schematic of the first and the second treatment plans obtained by the TPS respectively. The colored lines represent isodose curves normalized to 100% at maximum dose, and the black stars represent the points were TLDs can be inserted inside the ART phantom. Figures (3) and (4) show the places of the TLDs and their planed dose according to the first and second plan respectively.

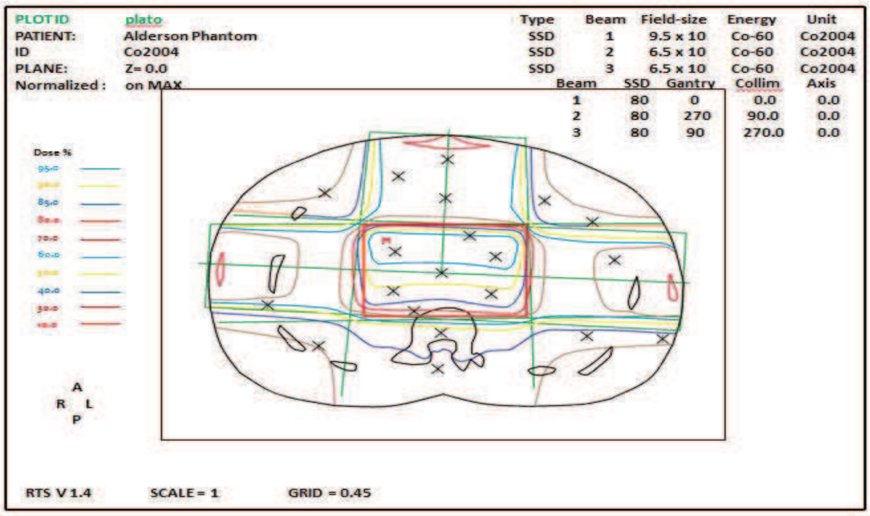

Fig. 1: shows the first treatment plan with three open beams.

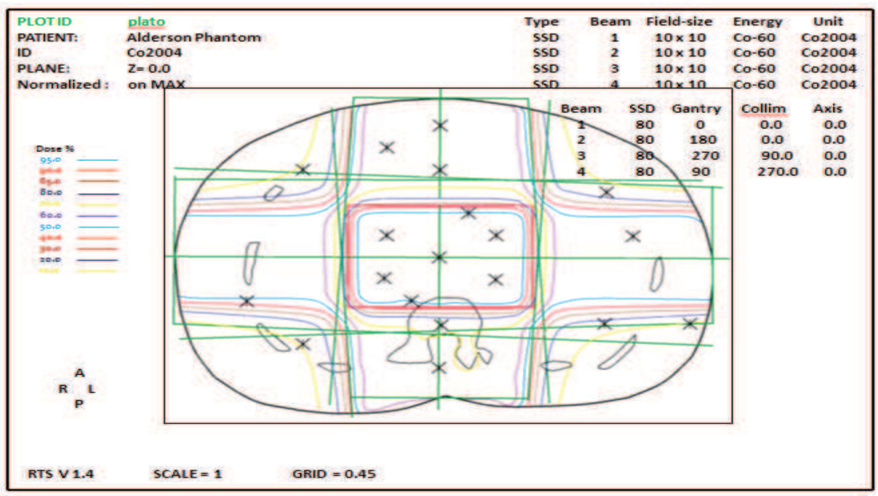

Fig. 2: shows the second plan with four open beams.

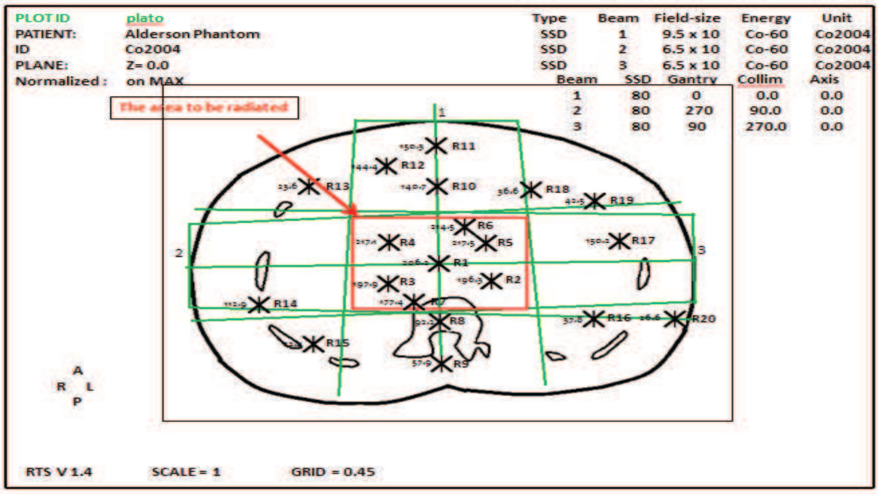

Fig. 3: shows the radiation absorbed dose at specific points inside the phantom using four open beams.

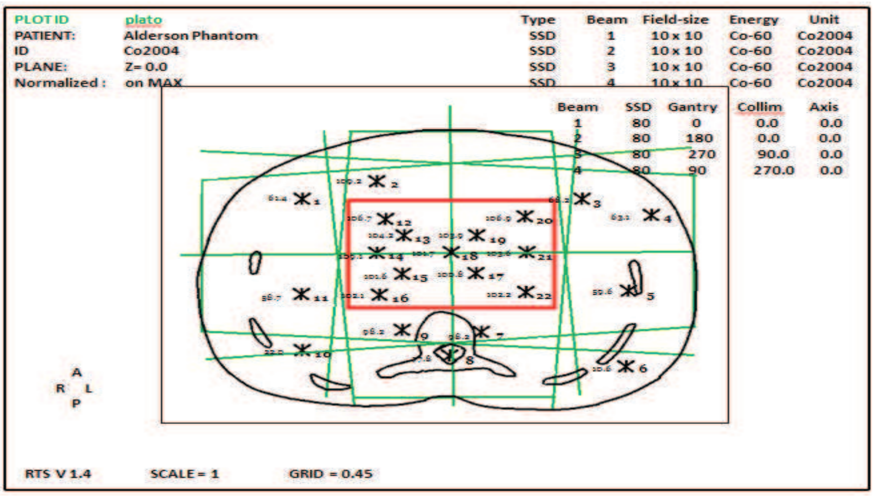

Fig. 4: shows the radiation absorbed dose at specific points inside the phantom using three open beams.

For the first plan, the isodose curve line of 90% was selected as treatment isodose line to deliver 100 cGy to the target volume. For the second plan, the isodosecurve line of 85% was selected as treatment isodose line to deliver 200 cGy to the target volume.

The comparison of measured radiation absorbed dose by TLDs and planned radiation dose calculated by TPS at specific points inside the ART phantom are shown in Tables 3 and 4.

Table (3) : Shows the comparison between standard dose values and measurement dose values, and the percentage error between them, for the third group of TLD.

Dedicator No	Planned dose	Measured dose	Percentage error
R1	61.4	67.78	9.4
R2	63.1	69.81	9.6
R3	59.6	64.83	8.1
R4	77.8	85.38	8.9
R5	22.0	20.37	8.0
R6	58.7	64.21	8.6
R7	109.1	113.3	3.7
R8	102.1	113.7	10.2
R9	101.6	114.1	11.0
R10	98.2	110.0	10.7

Table (4) : Shows the comparison between Planned dose values by TPS, and measured dose values by TLD, in the first and second experiments, and also the percentage errors of average measured dose.

Detector No	Planned dose	Measured dose (1)	Measured dose (2)	Average measured dose	% error
R1	217.5	209.7	210.9	210.3	3.42
R2	196.3	200.7	205.1	202.9	3.25
R3	217.1	221.3	222.5	221.9	2.16
R4	177.4	170.6	169.1	169.85	4.45
R5	92.2	92.51	91.00	91.76	0.48

R6	57.9	58.58	60.28	59.43	2.57
R7	144.4	150.0	149.7	149.85	3.64
R8	23.6	24.57	24.13	24.35	3.08
R9	112.9	114.0	113.8	113.9	0.88
R10	42.5	42.03	41.81	41.92	1.38

In table 3, the largest difference between the planned dose and measured dose of 12.5 cGy for R9 TLD. This difference is due to the calibration error and the position of the TLD. Also, the next big difference is with R8 and R10 of approximately 12 cGy. However, the mean percentage error for all TLDs is typically 8.82%.

In table 4, the largest difference between planned and measured dose of -7.55 cGy for R4 TLD which is located at point 4 inside the irradiated area. The next big difference is with R1, R2 and R7 of -7.7, 6.6 and 5.45 cGy, respectively. The mean error for all TLDs is 2.53%.

In both plans, the percentage mean error values are in the range of the allowed values, which is 10% when using the TLD-100s of such measurements.

4. Conclusion:

An investigation of radiation absorbed dose calculated by TPS was the propose of this study. The results showed that the TPS provides adequate accuracy of absorbed radiation dose calculation, and are in reasonably good agreement with the recommended values. However, the results can be improved by considering all organics of the anthropomorphic phantom.

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