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Theoretical Study of Improving Radiotherapy at High Energies (2-15) MeV for Lung Cancer using Nanocomposites

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Abstract:
In this research shows how radiation therapy can be improved and developed using different structures of glucose molecules (α-D glucose) $C_6H_{12}O_6$ and $C_{12}H_{24}O_{12}$ after adsorption on silver nanoparticles-AgNPs surface. This is by enhancing the radiation sensitivity (SER) of cancer cells in the human lung and meanwhile preserving the healthy cells surrounding the tumour itself. The primary role of AgNPs is as radiosensitizers that work to increase the absorbed dose of radiation in the presence of nanocomposites. Using a mathematical model to calculate the number of cancer cells remaining when exposed to radiation doses, where radiation sensitivity of $C_6H_{12}O_6Ag_3$ and $C_{12}H_{24}O_{12}Ag$ compounds were calculated theoretically. It was found that the $C_6H_{12}O_6Ag_3$ compound SER increases upon an increase in the absorbed dose of radiation. It equals 15.6 at the maximum energy value of (15MeV). Increasing radiation sensitivity values is accompanied by a decrease in the number of radiotherapy sessions by half. This is considered a noticeable improvement in radiotherapy. However, with the $C_{12}H_{24}O_{12}Ag$ configuration, SER values were found to be 12.9 at the maximum energy value. This value corresponds to a decrease in the number of radiotherapy sessions. Consequently, the $C_6H_{12}O_6Ag_3$ molecule structure could be the best radiosensitizer in cancer treatment.

Keywords: Glucose-AgNPs, lung cancer, Radiotherapy, sessions, SER.

دراسة نظرية لتحسين العلاج الاشعاعي عند طاقات عالية (2–15) ميكا الكتروفولط لسرطان الرئة باستخدام مركبات نانوية

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الخلاصة
في هذا البحث وجد أن العلاج الإشعاعي ممكن ان يتحسن باستخدام هياكل مختلفة من جزيئات الجلوكوز (α–D الجلوكوز) بعد امتزازها على سطح جسيمات الفضة النانوية $C_6H_{12}O_6Ag_3$ و $C_{12}H_{24}O_{12}Ag$. وذلك من خلال تعزيز وزيادة الحساسية الإشعاعية (SER) للخلايا السرطانية في الرئة وفي نفس الوقت الحفاظ على الخلايا السليمة المحيطة بالورم نفسه. ان الدور الأساسي لجسيمات الفضة النانوية هو العمل كمحسسات إشعاعية تعمل على زيادة جرعة الإشعاع الممتصة في وجود المركبات النانوية. باستخدام نموذج رياضي لحساب عدد الخلايا السرطانية المتبقية عند التعرض لجرعات إشعاعية في وجود وغياب المركبات النانوية، حيث تم حساب

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الحساسية الإشعاعية للمركبين $C_6H_{12}O_6Ag_3$ و $C_{12}H_{24}O_{12}Ag$. وقد وجد أن SER للمركب $C_6H_{12}O_6Ag_3$ تزداد بزيادة الجرعة الممتصة من الإشعاع تساوي 15.6 عند قيمة الطاقة القصوى البالغة 15 ميكاالكتروفولط ويصاحب زيادة قيم الحساسية للإشعاع انخفاض في عدد جلسات العلاج الإشعاعي بمقدار الى النصف. ويعتبر هذا تحسنا ملحوظا في العلاج الإشعاعي. ولكن مع تركيب $C_{12}H_{24}O_{12}Ag$، وجد أن قيم SER تبلغ 12.9 عند الحد الأقصى لقيمة الطاقة، وتتوافق هذه القيمة مع انخفاض في عدد جلسات العلاج الإشعاعي. وبالتالي، يمكن أن يكون تركيب $C_6H_{12}O_6Ag_3$ أفضل محسس إشعاعي في علاج السرطان.

1. Introduction:

Lung cancer treatment is a complicated case, frequently including various treatment modalities such as surgery, radiation, systemic medicines (chemotherapy, immunotherapy, and targeted drugs) and interventional radiology. Radiotherapy is one treatment method that has positive effects on patients with cancer. It was found that the survival of advanced cancer patients increases when treated by radiotherapy , with progress indications in all stages of illness and across all patient performance status categories [1].

The Medical Linear accelerator Device (LINAC) is an example of a treatment way that utilizes radiation for a period of around five to seven weeks based on the lung cancer stage wherein the dose of radiation administered to the individual receiving treatment is from (50–62 Gy) under a range of therapeutic photons energy around 2 to 15 MeV [2]. Radiotherapy has some side effects during treatment sessions. First of all, the length of period that irradiation needs in the case of patients, and the area under treatment losing a lot of energy is the second parameter. Lastly, and generality importantly, the treated patient is subjected to symptoms such as tiredness and lethargy. As a result of these factors, reducing the number of sessions of radiation treatments and concentrating on ionizing radiation on a particular aim is needed [3]. . As a result, investigators are keen to enhance radiation treatment in different ways. Nanoparticles are considered one of the common approaches used to improve radiotherapy [4]. Based on the fact that interacting with ionizing radiation to create free radicals for deeper cancer therapy, new pharmaceuticals containing high atomic metallic ions have been recognized as appealing substances. The tissue penetration depth may easily reached by using ionizing radiation such as X-rays and gamma rays due to its forms of high-frequency (high-energy) ionizing radiation that can damage the DNA (genes) inside a cell [5]. Metallic nanoparticles, such as gadolinium-based, titanium-based, silver-based, and gold nanoparticles, of high electron density are considered to be the best radiosensitizers [6]. High atomic number (47) for silver nanoparticles with heat stability, non-toxicity, and simplicity to produce, was considered to be a perfect material as a nanomaterial for enhancing the efficiency of radiotherapy [7] and in industrial application [8, 9]. The blood arteries within the tumour are much wider than the blood vasculature in the surrounding normal cells, and hence the concentration of AgNPs within the tumour is higher than concentration in normal tissues [10]. Therefore, NPs have been the focus of many scientists as vital candidates for treating many diseases, healthcare and anticancer being the most important [11-13]. The presence of nanoparticles in tumour cells increases their sensitivity to ionizing radiation. Nanoparticles of high Z strongly absorb high energy photons, which locally amplifies energy deposition directly within the cancer cells by producing photoelectrons or free radicals that contribute to the damage of cancer cells in which the nanoparticles are concentrated [14]. The presence of AgNPs is an essential factor in raising the Sensitivity Enhancement Ratio (SER). SER is an indicator that associate the number of cells damaged through radiation with the nanocomposite to the number of tissue killed via nanocomposite nonexistence in the procedure itself. By enhancing SER using α-D glucose/AgNPs and producing maximal damage in malignant cells with minimal damage to the healthy cells surrounding the tumour [15]. As a result, the time and negative effects of radiation therapy are reduced [16, 17].

Therefore, the target of this work is to investigate the AgNPs effects on the enhancement of radiation therapy applied to the cancerous lung tissues, and for the first time theoretically using mathematical model.

2. Methodology

2.1 Theoretical calculation

A high-energy photon beam is the most effective ionizing radiation for treating lung cancer. In radiotherapy, cancer cells and healthy cells near the tumor are exposed to the same radiation at the same time, it is essential to inflict damage to the cancer cells with minimum damage to the healthy tissues surrounding the tumor [18]. The ideal approach to achieve this concept is to inject silver nanoparticles added to the glucose obtaining Ag/G solution into the tumors under different concentrations of AgNps [19]. Usually, silver nanoparticles are employed to expand the cross-section of the tumour enhancing photon absorbance inside the cancerous tissue without affecting the normal call next for the tissues of malignancy, the cancer cells' radio-sensitivity increases [20, 21].

This research includes a theoretical study to enhance radiotherapy using nanoparticles as a radiation-sensitive agent. Two structures of Alpha-D-glucose molecule (α-D-glucose–$C_6H_{12}O_6$) were utilized with silver nanoparticle surfaces $C_6H_{12}O_6Ag_3$ and $C_{12}H_{24}O_{12}Ag$. This is to test which structure is more active with these calculations. The properties of these configurations were evaluated using Density Functional Theory (DFT) with a hybrid B3LYP function (Becke, three-parameters, Lee-Yang-Parr) and with 6-311+G* as a basis set to get stable structures which is the first part of our work, and it has already been published recently to provide a strong basis for the current proposal[22]. These molecules were employed to enhance the effect of absorbed radiation doses within infected cells in human organs (lungs). The goal of this reaction is to increase the cross-sectional area of interaction within the tumor by α-D glucose/AgNPs enhances the effect of radiation doses. Cell damage increases with the presence of the nanoparticles, as a result of increased number of free radicals produced. It increases the radiation sensitivity of cancer cells. Lung tissue is made up of light elements with individual mass percentages of H (10.3), C (10.5), N (3.1), O (74.9), Na (0.2), P (0.2), S (0.3), Cl (0.3), and K (0.2), resulting in a low cross-section [23]. The cross-section of the lung is increased by directly injecting α-D glucose/AgNPs into the lung tumor [24-26]. It is well known that cancerous tissue has larger vessels than surrounding healthy tissues [10, 27]. As a result, injected AgNPs/G will concentrate more in the tumor than in healthy tissues. The interaction of these nanoparticles with high-intensity X-rays increase free radicals, resulting in an increase in cell damage, i.e., a decrease in surviving cancer cells. Therefore, the presence of nanoparticles enhances the effect of radiation doses.

The mass energy absorption coefficient (μ_{en}/ρ) for Ag- α-D glucose was obtained from the National Institute of Standards and Technology (NIST) [28]. The mathematical model employed the irradiation Equation (1) where it was realized that the number of sessions was reduced to half with the presence of α-D glucose/AgNPs. This is due to the advantages of AgNPs that increase the cross-section of photon energy absorption. The final irradiation, Equation (5), was applied to the lung without and with α-D glucose/AgNP exposed to X-ray photons with energies ranging from 2 (MeV) to 15 (MeV).

The main equations used in current research are clarified as follows:

Total mass energy absorption coefficient $\frac{\mu_{en}}{\rho}$ for photon beam and lung tissue with presence of AgNPS added to α-D glucose (α-D glucose/AgNP)as a contrast agent within aim equivalent two mass energy absorption coefficients added together as shown in Eq. (1).

$$\left(\frac{\mu_{en}}{\rho}\right)_{total} = \left(\frac{\mu_{en}}{\rho}\right)_{lung} + \left(\frac{\mu_{en}}{\rho}\right)_{AgNPS\ adding\ glucose} \quad (1)$$

Where: (ρ) is the lung density, $\left(\frac{\mu_{en}}{\rho}\right)_{lung}$ is the mass energy absorption coefficient of the lung, $\left(\frac{\mu_{en}}{\rho}\right)_{total}$ is the total mass energy absorption coefficients, and $\left(\frac{\mu_{en}}{\rho}\right)_{AgNPS\ added\ to\ glucose}$ is the mass energy absorption coefficient of the AgNPs adding glucose.

The radiation dose absorbed (D) is measured in Gray (Gy) units and given by Eq. (2) [29]**:**

$$D(Gy) = 8.9\times10^{-3}\ \frac{(\mu/\rho)target}{(\mu/\rho)air} * x \quad (2)$$

Where: (x) is the radiation exposure, $(\mu/\rho)_{target}$ = mass attenuation coefficient of the target, and $(\mu/\rho)_{air}$ = mass attenuation coefficient of air, 8.9×10^{-3} is a constant that relates the amount of absorbed dose from x-rays to the amount of organ exposure to x-rays. Using Equations (1 and 2) using nanoparticles in a dose fractionation (absorbed dose fraction formula) model to add glucose as their results show [40]:

$$D(Gy) = 8.9\times10^{-3}\ \frac{\left(\frac{\mu}{\rho}\right)lung + \left(\frac{\mu}{\rho}\right)AgNPS\ added\ to\ glucose}{(\mu/\rho)air} * x \quad (3)$$

(D); The radiation dose fraction formula (absorbed dose fraction formula) and (μ/ρ) air mass absorbance factors **[30].**

The number of cancer cells remaining after irradiation (N_S) is given by:

$$N_S = N_i * E_{XP}\left(-\left(1+\frac{D}{(\alpha/\beta)}\right)\right) \quad (4)$$

Where: N_i is the initial number of cancer cells before irradiation, (α/β) is the radio-sensitivity agent obtained from references equal to 3 [31].

The final irradiation equation is derived from the previous two Eq. (3 and 4):

$$N_S = N_i * E_{XP}\left(-\left(1+\frac{\frac{8.9\times10^{-3}\left(\frac{\mu}{\rho}\right)lung + \left(\frac{\mu}{\rho}\right)AgNPS\ added\ to\ glucose}{(\mu/\rho)air} * x}{(\alpha/\beta)}\right)\right) \quad (5)$$

Radiotherapy is the use of incident ionizing radiation on a cancer tumor in order to eradicate cancer cells. SER is a relationship between survival cancer cells and destroyed cancer cells with and without nanoparticles, where SER is the ratio of survival cells to the beginning cells for irradiation without and with nanoparticles. The incorporation of nanoparticles into malignant tumors is thought to be an ideal strategy for increasing (SER). Increased SER indicates an increase in killed cancer cells and a decrease in surviving cancer cells with and without nano particles [32, 33].

SER is mathematically described by the following equation [34];

$$SER = \frac{number\ of\ survived\ maligninat\ cells\ with\ out\ NPs - number\ of\ survived\ maligninat\ cells\ with\ NPs}{umber\ of\ survived\ maligninat\ cells\ with\ out\ NPs} \quad (6)$$

3. Results and Discussion

Different configurations of glucose molecule were investigated theoretically in published work [22] as mentioned in previous section with nano-silver atoms to obtain: $C_6H_{12}O_6Ag_3$ and $C_{12}H_{24}O_{12}Ag$, as a support to improve the sensitivity of the radiation at energies ranging from (2) MeV to (15) MeV. Using Equation (5), the number of human lung cells remaining after irradiation (N_S) with and without α-D glucose added to AgNPs was calculated. Table (1) shows the (N_S) results with $C_6H_{12}O_6Ag_3$ present in the tumor cells. Table (2) shows the (N_S) results with $C_{12}H_{24}O_{12}Ag$ present in the tumor cells. Both tables show an increase in the number of killed malignant cells and this increase is proportional to the applied radiation energy on the organ, and the tables also show the SER for each photon energy.

Table 1: The decrease of the remaining cancer cells with increasing the photon energy with the presence of $C_6 H_{12}O_6Ag_3$

Sessions	**Day**	**Dose (Gy)**	**Number of remaining cancer cells with glucose addition silver nanoparticles and rise energy from (2Mev – 15 MeV)**				
			Without AgNPs	***E= 2 MeV***	***E= 4 MeV***	***E= 6 MeV***	***E= 8 MeV***
0		0	1.00×10^{20}	1.00×10^{20}	1.00×10^{20}	1.00×10^{20}	1.00×10^{20}
1	Saturday	2	2.00×10^{19}	7.00×10^{18}	7.00×10^{18}	7.00×10^{18}	6.00×10^{18}
2	Sunday	4	4.00×10^{18}	5.00×10^{17}	5.00×10^{17}	5.00×10^{17}	4.00×10^{17}
3	Monday	6	8.00×10^{17}	3.00×10^{16}	3.00×10^{16}	3.00×10^{16}	2.00×10^{16}
4	Tuesday	8	$2.\ 00\times10^{17}$	3.00×10^{15}	3.00×10^{15}	2.00×10^{15}	2.00×10^{15}
5	Wednesday	10	3.00×10^{16}	2.00×10^{14}	2.00×10^{14}	2.00×10^{14}	1.00×10^{14}
6	Saturday	12	7.00×10^{15}	1.00×10^{13}	1.00×10^{13}	1.00×10^{13}	7.00×10^{12}
7	Sunday	14	1.00×10^{15}	1.00×10^{11}	1.00×10^{12}	7.00×10^{11}	4.00×10^{11}
8	Monday	16	3.00×10^{14}	7.00×10^{10}	77762851532	5.00×10^{10}	27861556243
9	Tuesday	18	5.00×10^{13}	5223517319	5650914025	3293769199	1780865179
10	Wednesday	20	1.00×10^{13}	376282905	410643755	225419979	113829994
11	Saturday	22	2.00×10^{13}	27106031	29840888	15427361	7275827
12	Sunday	24	4.00×10^{11}	1952618	2168494	1055822	465059
13	Monday	26	86214613383	140659	157581	72259	29726
14	Tuesday	28	17310829391	10133	11451	4945	1900
15	Wednesday	30	3475800708	730	832	338	121
16	Saturday	32	697897847	53	60	23	8
17	Sunday	34	140129267	0	4	2	0
18	Monday	36	28136226	0	0	0	0
19	Tuesday	38	5649407	0	0	0	0
20	Wednesday	40	1134331	0	0	0	0
21	Saturday	42	227760	0	0	0	0
22	Sunday	44	45731	0	0	0	0
23	Monday	46	9182	0	0	0	0
24	Tuesday	48	1844	0	0	0	0
25	Wednesday	50	370	0	0	0	0
26	Saturday	52	74	0	0	0	0
27	Sunday	54	15	0	0.	0	0
28	Monday	56	3	0	0	0	0
29	Tuesday	58	1	0	0	0	0
30	Wednesday	60	0	0	0	0	0
	SER			**13.86**	**13.86**	**13.86**	**14.75**

			Without Ag NPs	*E= 10 MeV*	*E= 12 MeV*	*E= 14 MeV*	*E=15 MeV*
0		0	1.00×10^{20}	1.00×10^{20}	1.00×10^{20}	1.00×10^{20}	1.00×10^{20}
1	Saturday	2	2.00×10^{19}	6.00×10^{18}	7.00×10^{18}	6.00×10^{18}	5.00×10^{18}
2	Sunday	4	4.00×10^{18}	4.00×10^{17}	4.00×10^{17}	3.00×10^{17}	3.00×10^{17}
3	Monday	6	8.00×10^{17}	2.00×10^{16}	3.00×10^{16}	2.00×10^{16}	1.00×10^{16}
4	Tuesday	8	$2.\ 00\times10^{17}$	1.00×10^{15}	2.00×10^{15}	1.00×10^{15}	7.00×10^{14}
5	Wednesday	10	3.00×10^{16}	8.00×10^{13}	1.00×10^{14}	7.00×10^{13}	4.00×10^{13}
6	Saturday	12	7.00×10^{15}	5.00×10^{12}	9.00×10^{12}	4.00×10^{12}	2.00×10^{12}
7	Sunday	14	1.00×10^{15}	3.00×10^{11}	6.00×10^{11}	2.00×10^{11}	9971631918
8	Monday	16	3.00×10^{14}	1629384269	4.00×10^{10}	1.00×10^{10}	5162685883
9	Tuesday	18	5.00×10^{13}	973927119	3.00×10^{9}	8.00×10^{8}	267291510
10	Wednesday	20	1.00×10^{13}	58214262	2.00×10^{8}	5.00×10^{7}	13838679
11	Saturday	22	2.00×10^{13}	3479624	1.00×10^{7}	3.00×10^{6}	716480
12	Sunday	24	4.00×10^{11}	207988	7.00×10^{5}	2.00×10^{5}	375095
13	Monday	26	86214613383	12432	273	55	1921
14	Tuesday	28	17310829391	743	60	44	99
15	Wednesday	30	3475800708	44	15	8	0
16	Saturday	32	697897847	3	3	2	0
17	Sunday	34	140129267	0	1	0	0
18	Monday	36	28136226	0	1	0	0
19	Tuesday	38	5649407	0	0	0	0
20	Wednesday	40	1134331	0	0	0	0
21	Saturday	42	227760	0	0	0	0
22	Sunday	44	45731	0	0	0	0
23	Monday	46	9182	0	0	0	0
24	Tuesday	48	1844	0	0	0	0
25	Wednesday	50	370	0	0	0	0
26	Saturday	52	74	0	0	0	0
27	Sunday	54	15	0	0	0	0
28	Monday	56	3	0	0	0	0
29	Tuesday	58	1	0	0	0	0
30	Wednesday	60	0	0	0	0	0
	SER			**14.75**	**13.95**	**14.83**	**15.64**

Table 2 :The decrease of the remaining cancer cells with increasing the photon energy with the presence of ($C_{12}H_{24}O_{12}Ag$).

Sessions	***Day***	***Dose (Gy)***	***Number of remaining cells with glucose addition silver nanoparticles and rise energy from (2Mev – 15 MeV)***				
			Without AgNPs	E= 2MeV	E= 4 MeV	E= 6 MeV	E= 8 MeV
0		0	1.00×10^{20}	1.00×10^{20}	1.00×10^{20}	1.00×10^{20}	1.00×10^{20}
1	Saturday	2	2.00×10^{19}	7.00×10^{18}	8.00×10^{18}	8.00×10^{18}	8.00×10^{18}
2	Sunday	4	4.00×10^{18}	7.00×10^{17}	6.00×10^{17}	6.00×10^{17}	6.00×10^{17}
3	Monday	6	8.00×10^{17}	3.00×10^{16}	4.00×10^{16}	5.00×10^{16}	5.00×10^{16}
4	Tuesday	8	$2.\ 00\times10^{17}$	2.00×10^{15}	3.00×10^{15}	4.00×10^{15}	4.00×10^{15}
5	Wednesda y	10	3.00×10^{14}	1.00×10^{14}	2.00×10^{14}	3.00×10^{14}	3.00×10^{14}
6	Saturday	12	7.00×10^{15}	1.00×10^{13}	2.00×10^{13}	2.00×10^{13}	2.00×10^{13}
7	Sunday	14	1.00×10^{15}	7.00×10^{11}	1.00×10^{12}	2.00×10^{12}	2.00×10^{12}

8	Monday	16	3.00×10^{14}	4705149130	1.00×10^{11}	1.00×10^{11}	1.00×10^{11}
9	Tuesday	18	5.00×10^{13}	3211035205	817940529	1060873131	1157966771
10	Wednesday	20	1.00×10^{13}	219137519	619317043	826806407	911302015
11	Saturday	22	2.00×10^{13}	14955069	46892602	64438321	71718065
12	Sunday	24	4.00×10^{11}	1020611	3550550	5022091	5644101
13	Monday	26	86214613383	69652	268836	391404	444182
14	Tuesday	28	17310829391	4753	20355	30505	34956
15	Wednesday	30	3475800708	324	1541	2377	2751
16	Saturday	32	697897847	22	117	185	217
17	Sunday	34	140129267	2	9	14	17
18	Monday	36	28136226	0	1	1	1
19	Tuesday	38	5649407	0	0	0	0
20	Wednesday	40	1134331	0	0	0	0
21	Saturday	42	227760	0	0	0	0
22	Sunday	44	45731	0	0	0	0
23	Monday	46	9182	0	0	0	0
24	Tuesday	48	1844	0	0	0	0
25	Wednesday	50	370	0	0	0	0
26	Saturday	52	74	0	0	0	0
27	Sunday	54	15	0	0	0	0
28	Monday	56	3	0	0	0	0
29	Tuesday	58	1	0	0	0	0
30	Wednesday	60	0	0	0	0	0
	SER			**13.7**	**12.9**	**12.9**	**12.9**

			Without AgNPs	***E=10 MeV***	***E= 12 MeV***	***E= 14 MeV***	***E= 15 MeV***
0		0	1.00×10^{20}	1.00×10^{20}	1.00×10^{20}	1.00×10^{20}	1.00×10^{20}
1	Saturday	2	2.00×10^{19}	8.00×10^{18}	9.00×10^{18}	8.00×10^{18}	8.00×10^{18}
2	Sunday	4	4.00×10^{18}	6.00×10^{17}	7.00×10^{17}	7.00×10^{17}	6.00×10^{17}
3	Monday	6	8.00×10^{17}	5.00×10^{16}	7.00×10^{16}	6.00×10^{16}	5.00×10^{16}
4	Tuesday	8	$2.\ 00\times10^{17}$	4.00×10^{15}	6.00×10^{15}	5.00×10^{15}	4.00×10^{15}
5	Wednesday	10	3.00×10^{16}	3.00×10^{14}	6.00×10^{14}	4.00×10^{14}	3.00×10^{14}
6	Saturday	12	7.00×10^{15}	2.00×10^{13}	5.00×10^{13}	4.00×10^{13}	2.00×10^{13}
7	Sunday	14	1.00×10^{15}	2.00×10^{13}	5.00×10^{12}	3.00×10^{12}	2.00×10^{12}
8	Monday	16	3.00×10^{14}	1.00×10^{12}	4.00×10^{11}	3.00×10^{11}	1.00×10^{11}
9	Tuesday	18	5.00×10^{13}	1.00×10^{11}	36676808035	22403757275	1040527577
10	Wednesday	20	1.00×10^{13}	915666501	3280881853	1897292490	809206849
11	Saturday	22	2.00×10^{13}	72095982	293487528	160674781	62931126
12	Sunday	24	4.00×10^{11}	5676554	26253591	13606961	4894084
13	Monday	26	86214613383	446950	2348485	1152324	380608
14	Tuesday	28	17310829391	35191	210081	97586	29599
15	Wednesday	30	3475800708	2771	18793	8264	2302
16	Saturday	32	697897847	218	1681	700	179
17	Sunday	34	140129267	17	150	59	14
18	Monday	36	28136226	1	13	5	1
19	Tuesday	38	5649407	0	1	0	0
20	Wednesday	40	1134331	0	0	0	0
21	Saturday	42	227760	0	0	0	0

22	Sunday	44	45731	0	0	0	0
23	Monday	46	9182	0	0	0	0
24	Tuesday	48	1844	0.	0	0	0
25	Wednesday	50	370	0	0	0	0
26	Saturday	52	74	0	0	0	0
27	Sunday	54	15	0	0	0	0.
28	Monday	56	3	0	0	0	0
29	Tuesday	58	1	0	0	0	0
30	Wednesday	60	0	0	0	0	0
	SER			**12.9**	**12.5**	**12.8**	**12.9**

Because the vascularity of cancer tumours is greater than that of healthy tissue, AgNPs with $\alpha - D$ glucose are predicted to concentrate more inside tumors compared to normal cells [10, 27, 35]. As a result, because the target has nanoparticles of a high mass energy absorption coefficient within it [36], the quantity of the radiation dose that the cancerous tissues absorb would increase. This could increase the amount of malignant cells killed when compared to with similar energy and goal however absence of nanocomposite [37, 38]. Ionized energy from the X-ray may be considered as another factor that may aid in improving treatment due to its significant contribution in enhancing the number of free radicals when the absorbed dose is concentrated in the tumour that is injected exclusively with nanoparticles. As a consequence, the number of destroyed malignant cells would be increased.

The current study found that the SER increased upon increasing the energy in the presence of silver nanoparticles [39], with glucose as shown in Table (1). Moreover, at the lowest value of the energy (2 MeV), the SER was 13.8. However, at the highest value of energy at (15 MeV), it was found that the value of SER has increased to become 15.64. Furthermore, a rise in the quantity of killed cancer tissue was obtained (this is met by a decrease in cancer cells or their complete death). [15], as illustrated in Fig. 1.Revised

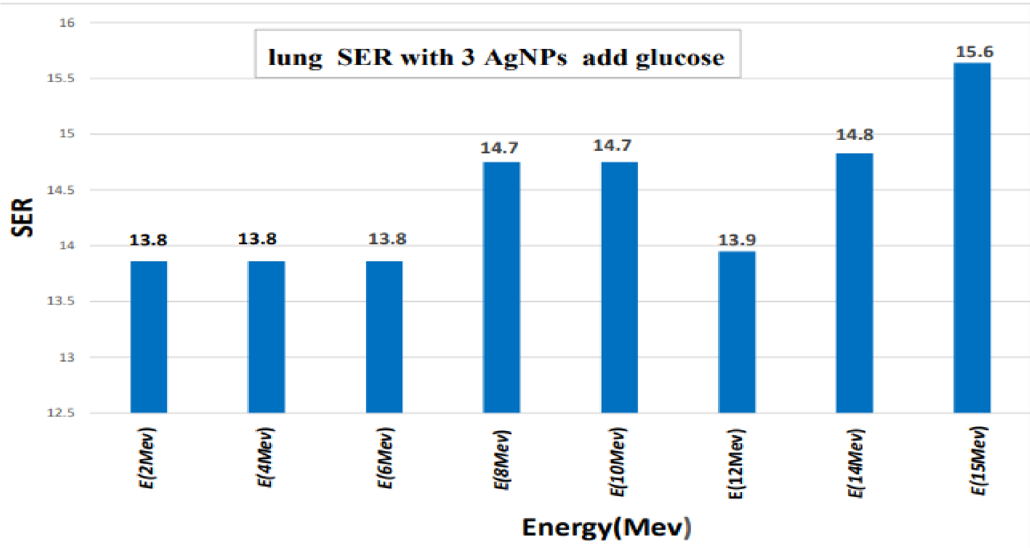

Figure 1: Sensitivity Enhancement Ratio (SER) for different photon energies using $\alpha - D$ glucose added to 3AgNPs ($C_6H_{12}O_6Ag_3$)

Table 2 data, on the other hand, showed a decrease in SER values despite an increase in energy in the presence of $2\alpha - D$ glucose molecules with one silver atom. The drop in SER values may be explained at the maximum energy of 15Mev, which is equivalent to 12.9. There are two possible explanations for the reduction in radiation sensitivity. The first explanation is that the compound has an abundance of glucose molecules, which is compensated by a poverty of silver nanoparticles. Glucose is the body's main supply of energy. The α-D glucose molecule can take as much energy from the lung organ as possible and deliver it to the body. This results in a drop or loss of a portion of the radiation interaction with silver atoms, i.e. a decrease in the reaction's cross-sectional area, followed by a decrease in the radiation sensitivity value as clarified in Fig. 2.

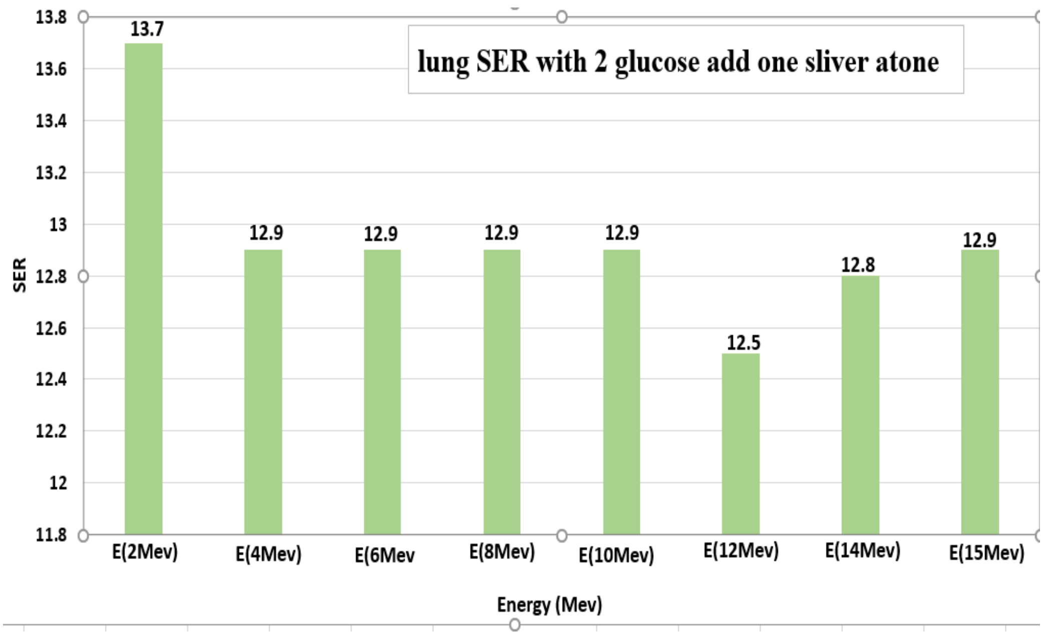

Figure 2: Sensitivity Enhancement Ratio (SER) for different photon energies by usage $2\alpha - D$ glucose add AgNPs ($C_{12}H_{24}O_{12}Ag$).

It is obvious that enhancing the SER strongly depends on photon energy and, hence, on cross-section and beam energy. The presence of nanocomposites resulted in the total elimination of cancer cells in fewer radiotherapy sessions, i.e., a decrease in radiotherapy sessions. In general, the results of Tables (1 and 2) show a reduction in the number of radiotherapy sessions by around 15-19 sessions, i.e. almost half of the 30 radiotherapy sessions performed without the nanocomposites, as shown in Figure 3.

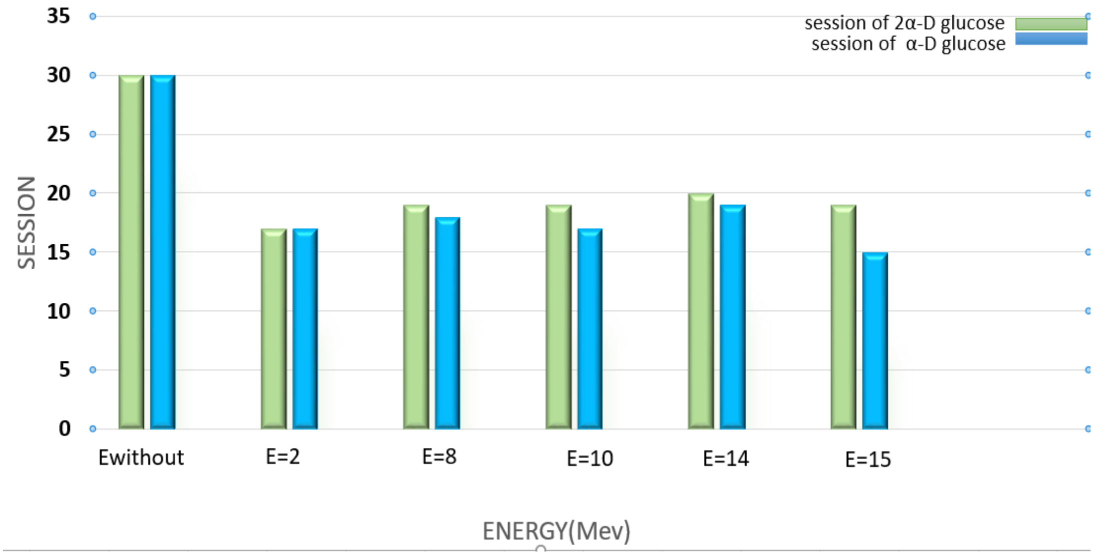

Figure 1: Relationship between energy and radiotherapy sessions with for 2 α-D glucose/AgNPs represented by green coulmns, and for α-D glucose/3AgNPs represented by blue coulmns.

4. Conclusion

Combining α-D glucose with AgNPs under high radiation energies could play a vital role in helping set up radiation treatments and receive doses. Depending on the photon beam energy, this could reduce radiotherapy sessions from 30 to 19 or 15 sessions. The number of infected cells in lung organs that were exposed to the X-ray radiation was calculated using a mathematical model before and after being injected with α-D glucose/AgNP. It was found that the structure of $C_6H_{12}O_6Ag_3$ molecule has more impact on reducing the number of radiotherapy sessions than the $C_{12}H_{24}O_{12}Ag$. Where it was realized that the number of sessions was reduced to half with the presence of α-D glucose/AgNPs. This is due to the advantages of AgNPs that increase the cross-section of photon energy absorption.

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7. Conflict of Interest

The authors declare that they have no conflicts of interest.

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