The Enhancement of Breast Cancer Radiotherapy by Using Silver Nanoparticles with 6 MeV Gamma Photons

Nihad Abdulameer Salih
Physics department, College of Science, Babylon University -Iraq.
E-mail: nb200320022000@yahoo.com

Abstract:

The nanoparticles has use emerged to be highly promising for cancer therapy over the past few years, , most commonly the high photons therapy method(radiotherapy), which employs high photons absorbing with injected nanoparticles for enhancing the damage of tumors, the high photons therapy which employs nanoparticales that increase generate free radicals that is capable of tumor destruction. Last development in the field of nanoscience have seen the appearing of noble metal nanostructures with unique properties, well suited for applications in cancer radiotherapy. Metal nanoparticles has the phenomenon of enhanced dose absorption, thermal stability ,easy to detection and increasing the cross section of tissue . Because using nanoparticles as enhanced photo-absorbing agents thus introduced to enhance the efficiency of cancer radiotherapy. The easy synthetic of the silver nanoparticle as a colloidal solution with unique properties and the bio-targeting abilities of the silver nanoparticles make the radiotherapy method furthermore promising. In this project, we discuss the development of the radiotherapy method by injected silver nano particles as a colloidal solution in vivo. i.e. using silver nanosparticles interacted with high energy of gamma photons.

Keywords: Silver nanoparticles (SNPs) . Gamma Photons .Breast Cancer . Free radicals.

Introduction:

Breast cancer is the plenty diagnosed cancer and the second most common cancer following lung cancer lead to death for women[1]. Breast cancer can be treated in several steps include surgery to remove the lump (called a lumpectomy), or sometimes doctors will remove the breast tissue (called a mastectomy) ,surgery flowed by chemotherapy ,radiotherapy and hormonetherapy[2].Radiologist have tried to develop the radiotherapy to destroy the cancer area (tumor) without the need to remove part of the breast. One of these methods is perform by injection nano particles agent then treat the tumor by gamma radiations to destroy the tumor[3].Silver nanoparticles (SNPs) are used in therapeutics due to their properties of small size, high reactivity to the living cells, stability over temperatures and translocation into the cells[4].SNPs are the colloidal suspension of silver particles of nanometer sizes[5].

The size of SNPs is determined mainly by the size range of 1–100 nm or less can be achieved by varying the concentration of silver nitrate and temperature [6].Therapy combined with metallic nanoparticles is a new way to treat cancer, in which silver nanoparticles agent (SNPs) inject and bound to tumor sites[7].

When an external gamma photon-ray interact with these nanoparticles, nano particles can subsequently generate free radicals that damage cancer cells and induce cell apoptosis[8].

Theory

When the photons incident on an attenuator the photons interact with atoms of an attenuator in three main methods. These methods are photo electric effect, Compton scattering and pair production. the probability for each interaction depends on the energy of incident photon and on the atomic number Z of the attenuator . When the energy of photon 6MeV and the attenuator is the silver (Z=47) the pair production process is common .These electrons and positrons generate free radicals then cause damage to DNA of cancer cells. [9]

the equation of irradiation by photons is given by

$N = t\, No\, (\sigma_{ph.} + \sigma_{c.sc.} + \sigma_{p.p.})$ ………………………… (1)

N: The number of cells remains after irradiation , : is the flux of particles (particle/ cm^2.sec.) the number of particles per unit time per unit solid angle, t: is the time of exposure to radiation(second) ,

N_o: is the number of cells cancer per unit volume (cell/cm^3). [10], [11]

For photons of high energy (6MeV.) and the attenuator is the silver (Z=47) the pair production(electron and positron) process is prevailing therefore the equation of irradiation becomes:

$N = t\ N_o\ \sigma_{p.p.}$ …………………………(2)

The linear attenuation coefficient (μ) relate with cross section σ of interaction by the following relation[12]:

$\mu = N_A\, \sigma / A$ ……………………….. (3)

Where $\mu_:$ linear attenuation coefficient (cm^{-1}), N_A is Avogadro’s number, σ: the microscopic cross section for reaction (cm^2) and A is mass no. [12]

Synthesis of Silver nano particles (SNPs)

The chemical reduction of an aqueous solution of AgNO3 is one of the most widely used methods for synthesis of Ag colloids. An aqueous solution containing Ag^+ was prepared by adding 22.5 mg of dextrose to 100 ml of AgNO3 solution . This solution was then alkalized using 20 µl of 0.1 N NaOH and treated in a microwave oven for 60 sec to induce the reduction of metal ions. For this propose, an aqueous suspension containing the Ag NPs was dispersed ultrasonically, and a drop of the suspension was placed on carbon-coated copper TEM grids and dried under an IR lamp. Micrographs were obtained using a TEM operated at an accelerating voltage of 80 kV.[13],[14]

Theoretical Calculation and results :

The mass attenuation coefficient for silver and breast can be calculated through the photon energy and number of atoms. By using data of National Institute of Standards and Technology (NIST2004) [15], and encyclopedia of medical devices and instrumentation [16]. Fractionation was assumed to create a suitable therapeutic because the tolerance of normal tissues increased relative to that of tumors and because malignant cells had a greater reproductive capacity and were, therefore, more likely to be in a radiosensitive phase [17].

Computer simulation program was developed by using equation (5) for a breast with Silver nanoparticles (SNPs) in weights (0.001;0.01;0.1; 0.002;0.02; 0.2; 0.003;0.03;0.3;0.004;0.04;0.4;0.005,0.05;0.5) grams. The energy of incident photon was 6MeV. The flux was 10^{18} (photon/cm^2.s) and time of irradiation was 1200 sec.(20 min.). The results in table (1) and table 2 were in agreement in dose fractionation with the dose fractionation of radiotherapy[17] [18][19] [20] [21].The results are tabulated in table 1 and table 2

Notes: 1- W: represent the concentration of silver nanoparticles in gram. 2- S.Sh. : Single shot, F.: Fractionation.

Discussion

From the results in table 1 and table 2 we note that when we apply equation of irradiation with silver nanoparticles by simulation program and input the parameters there were increasing in number of destroyed cancer cells this result due to existence of silver nano-particles in cancer cells with high concentration[22]

Silver nanoparticles (SNPs) have biocompatibility and ability to increase dose deposited in tissue because of their high mass energy absorption coefficient, which in turn caused breaks in DNA by generating free radicals that damage cancer cells . Results have shown improvement in the treatment effects on cancer cells. Maximum damage noted in small weights because these nanoparticles formed in nano size to become capable to enter inside the cancer cells and make maximum damage .

Conclusions

The use of nano particles in oncology offers interesting possibilities. The results in table 1 and table 2 showed that use of silver nanoparticles conjugated to cancer tumor enhanced radiotherapy in breast cancer. These nanoparticles are allows high possibility of destroying large number from cancer cells in tumor . The use of silver nanoparticles in radiotherapy in vivo could allow detection and targeting of cancer tumor in the same time .Silver nanoparticles offer a new method of tumor targeting, can improve the efficacy of radiotherapy by increase the number of destroyed cancer cells in minimum dose that given to patient.
Silver nanoparticles could be great promise for cancer radiotherapy, It is distinguished by stability, biocompatibility, bioconjugates in physiological environments and the small size of the silver nanoparticles , these characters make it suitable agent in radiotherapy . The use of nanotechnology could occur revolution in oncology.

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Table(1): Number of destroyed cancer cells by dose fractionation when photon energy 6MeV.,flux 10^{18} (photon/cm^2.sec.), irradiation time 1200 sec. ; silver density 10.49 g/cm^3 ,mass number of silver 107.878 ; breast average atomic weigh(A) 9.673, breast density 0.960 g/cm^3,cocentration of silver nanoparticles(0.001-0.04)g.

Dose (Gy)	*Cancer Cell Number*	*Number of destroyed cancer cells by dose fractionation at concentrations:*								
		W=0.001g.	**W=0.002g.**	**W=0.003g**	**W=0.004g.**	**W=0.005g**	**W=0.01g.**	**W=0.02g.**	**W=0.03g**	**W=0.04g**
2	1,000,000,000	62871414163	31435898813	20957394510	15718141139	12574590482	6287486973	3143935219	2096084634	1572159341
4	500,000,000	31851726521	15925960395	10617372098	7963077332	6370501164	3185347717	1592770993	1061912085	796482631
6	250,000,000	16136625776	8068362098	5378941081	4034230259	3227404116	1613751268	806924844	537982703	403511632
8	125,000,000	8175088759	4087569310	2725062933	2043809585	1635057755	817553808	408801834	272551177	204425848
10	62,500,000	4141638849	2070832055	1380563177	1035428657	828348036	414186648	207105954	138079056	103565607
12	31,250,000	2098224602	1049118700	699416759	524565748	419655187	209833992	104923395	69953195	52468096
14	15,625,000	1062996229	531501356	354336412	265753920	212604447	106305465	53155974	35439477	26581228
16	7,823,500	538531949	269267616	179512846	134635450	107709025	53856154	26929719	17954241	13466502
18	3,906,250	272829434	136415549	90944257	68208606	54567221	27284442	13643053	9095923	6822358
20	1,953,125	138220026	69110434	46073905	34555638	27644681	13822762	6911802	4608149	3456322
22	976,562	70024613	35012520	23341823	17506473	14005265	7002846	3501636	2334566	1751031
24	488,281	35475658	17737937	11825364	8869076	7095305	3547760	1773988	1182731	887102
26	244,140	17972571	8986340	5990930	4493225	3594602	1797355	898732	599191	449421
28	122,070	9105210	4552632	3035107	2276344	1821086	910571	455313	303560	227684
30	61,035	4612854	2306441	1537636	1153234	922593	461310	230669	153789	115348
32	30,517	2336950	1168482	778992	584248	467401	233707	116861	77912	58437
Dose (Gy)		**Number of destroyed cancer cells by dose fractionation at concentrations:**								
		W=0.001g.	**W=0.002g.**	**W=0.003g**	**W=0.004g.**	**W=0.005g**	**W=0.01g.**	**W=0.02g.**	**W=0.03g**	**W=0.04g**
34	15,258	1183938	591972	394651	295990	236793	118400	59203	39471	29605
36	7,629	599803	299903	199936	149953	119963	59983	29993	19996	14998
38	3,814	303870	151936	101291	75969	60775	30388	15195	10130	7598
40	1,907	153946	76973	51315	38487	30789	15395	7698	5132	3849
42	953	77991	38996	25997	19498	15598	7799	3900	2600	1950
44	476	39511	19756	13170	9878	7902	3951	1975	1317	988
46	238	20017	10008	6672	5004	4003	2001	1000	667	500
48	119	10141	5070	3380	2535	2028	1014	507	338	253
50	59	5137	2568	1712	1284	1027	513	256	171	128
52	29	2602	1301	867	650	520	260	130	86	65
54	15	1318	659	439	329	263	131	65	43	32
56	7	668	334	222	167	133	66	33	22	16
58	4	338	169	112	84	67	33	16	11	8
60	2	171	85	57	42	34	17	8	5	4
62	1	86	43	28	21	17	8	4	2	2
		S.Sh.	S.Sh.	S.Sh.	S.Sh.	S.Sh.	S.Sh.	S.Sh.	S.Sh.	S.Sh.

Table(2). Number of destroyed cancer cells by dose fractionation when photon energy 6MeV.,flux 10^{18} (photon/cm^2.sec.), irradiation time 1200 sec. ; silver density 10.49 g/cm^3 ,mass number of silver 107.878 ; breast average atomic weigh(A) 9.673, breast density 0.960 g/cm^3,cocentration of silver nanoparticles (0.05-0.5)g.

Dose(Gy)	**Number of destroyed cancer cells by dose fractionation at concentrations:**					
	W=0.05g	**W=0.1g**	**W=0.2g.**	**W=0.3g**	**W=0.4g**	**W=0.5g**
2	1257804119	629093792	314738628	209953568	157561046	126125532
4	637224935	318709602	159451936	106366044	79823102	63897337
6	322828977	161463699	80781059	53886845	40439740	32371476
8	163550644	81800253	40925057	27299991	20487459	16399939
10	82857535	41441397	20733329	13830639	10379294	8308488
12	41977034	20994916	10503856	7006836	5258327	4209221
14	21266279	10636381	5321432	3549782	2663957	2132463
16	10773858	5388571	2695928	1798380	1349606	1080341
18	5458219	2729941	1365802	911089	683733	547319
20	2765226	1383034	691938	461573	346391	277281
22	1400910	700668	350548	233841	175487	140475
24	709725	354970	177593	118467	88904	71167
26	359558	179834	89971	60017	45040	36054
28	182158	91107	45581	30406	22818	18265
30	92284	46156	23092	15404	11560	9253
32	46752	23383	11698	7804	5856	4688
Dose(Gy)	**Number of destroyed cancer cells by dose fractionation at concentrations:**					
	W=0.05g	**W=0.1g**	**W=0.2g.**	**W=0.3g**	**W=0.4g**	**W=0.5g**
34	23685	11846	5926	3953	2967	2375
36	11999	6001	3002	2002	1503	1203
38	6079	3040	1521	1014	761	609
40	3079	1540	770	514	385	308
42	1560	780	390	260	195	156
44	790	395	197	131	99	79
46	400	200	100	66	50	40
48	202	101	50	33	25	20
50	102	51	25	17	12	10
52	52	26	13	8	6	5
54	26	13	6	4	3	2
56	13	6	3	2	1	1
58	6	3	1	1	0.8	0.6
60	3	1	0.8	0.5	0.4	0.3
62	1	0.8	0.4	0.2	0.2	0.1
	S.Sh.	F	F	F	F	F