A Dosimetric study of different MLC expansion aperture For the radiotherapy of pancreas cancer

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Abstract: Radiotherapy is using of ionizing radiation in the treatment of cancer. The aim of radiotherapy is to annihilate the tumor tissue while minimizing damage to the normal surrounding tissues. We can do that by using shielding like custom blocks and MLCs. Uses the MLCs now in all the sites, but does not use blocks except in the necessity of it, as there are different types of MLCs in thickness (1 cm and 0.5 cm, and finally 0.3 cm). The MLCs are not limited to the use of three-dimensional planning only, but also using in the most modern techniques like IMRT and IGRT. When shaping the radiotherapy treatment field size of the tumor, there are some concepts must be included in the accounts, such as the concept of penumbra and radiotherapy field size and the impact of change that field size on the dose distribution within the tumor and dose receiving by OARs. When the field size is shaped where the MLCs ends are attached with tumor (the MLCs margin = 0.0 cm) the penumbra effects on the tumor cover percentage, so the distance between tumor and MLCs ends (MLC margins) must be existing to overcome the penumbra effects. To determine the most adequate MLC margins which achieve the tumor dose coverage a many plans with difference MLC margins were compared from 0.0 cm to 1.2 cm the comparison included the tumor coverage percentage and the received dose to OARs and if it under tolerance or not. After that we can selection the best MLC margins to work out in most famous techniques for pancreas cases.

Results: the tumor is not cover when the MLC margins less than 0.5 cm, and from MLC margins 0.5 cm to 0.7 cm the tumor is cover very well and OARs are under tolerance, the MLC margins more than 0.7 cm the tumor cover is very well but OARs received unnecessary doses. After 1.2 cm MLC margin, the saturation occurs of the tumor cover percentage.

Conclusions: The best MLC expansion apertures for the radiotherapy of pancreas cancer are from 0.5 cm to 0.7 cm.

I. Introduction

Radiotherapy is one of the three principal modalities used in the treatment of malignant disease (cancer), the aim of radiotherapy is to kill cancer cells by deliver as much dose as possible to the target while minimizing the dose to surrounding healthy tissues by radiotherapy machines like linear accelerator which exits the radiation as certain area called field size determined by collimator jaws. These fields must take the shape of the tumor as much as possible; there are many ways to do that ether using custom blocks or using MLCs.

The using of MLCs has many advantages and become the most common in modern devises. When the MLCs is used to shape field size around tumor we must take the penumbra in our accounts and then we should chose adequate MLC margin (the distance between tumor and MLCs end). As the MLCs margin increase as the field size increase, so our study like study of effects of increasing field size on dose distribution within tumor, and all parameters which are affected by field size and contribute in dose distribution. The study is divided into two main parts. The first part includes the study of beam behavior with PDD, dose profile and penumbra for difference regular field size (with only by collimator jaws) with large increasing in field size, and then apply it to difference irregular field size (with MLCs) with small increasing in field size (the increasing rate is 0.1 cm). The second part includes the study of effects of increasing field size on tumor and OARs for irregular fields using MLCs in shaping for pancreas cancer cases. There are many technique are used in pancreas cancer treatment, the most common three techniques were used in our study and the data of all were recorded. For all plans, the comparison held, and the best margins were chosen.

II. Material and methods

Materials: 10 patients during the period September 2012 to October 2013, Linear Accelerator DMX (Varian with photon energies 6 and 15 MV), Multi leaves Collimator (MLCs), Detectors (0.6 cc waterproof Farmer and

semi – flex ionization chamber), water phantom (PTW - MP3-M water tank), dosimetry system with software (MEPHYSTO mc²), TANDEM Dual Channel Electrometer, Treatment planning System (Eclipse).

Method: two parts were done; the first part was measurements of PDD & DP for regular and irregular fields and studies the effects of field size increasing on D_{max}, PDD, penumbra and opening collimator factor for dual energy 6 & 15 MV. The second part was 10 patients during the period September 2012 to October 2013; the cases were delineated carefully by doctors and the prescribed treatment dose was determined, then the three different treatment techniques plan were worked by the medical physicist and these plans were repeated with the only difference in MLC margin, the MLC margin started from 0.0 Cm to 1.2 Cm, that is mean 39 plans were done for every patient. The percentage of dose that cover 95% of PTV volume and the mean dose for parallel OAR and point dose for serial OAR were taken and written in tables, three PTV cover curves in the dose percentage & MLC margins relationship were plotted for every patient.

III. Results

The results were taken into two parts:

Part 1 physical parameter:

Irregular field sizes were shaped by MLC.

Measurements of beam profile for circular field size with radius 5.67 Cm (equivalent field size to 10 x 10 cm²) as example, with different beam energies (6MV and 15 MV X- rays) as show in Fig. 1.
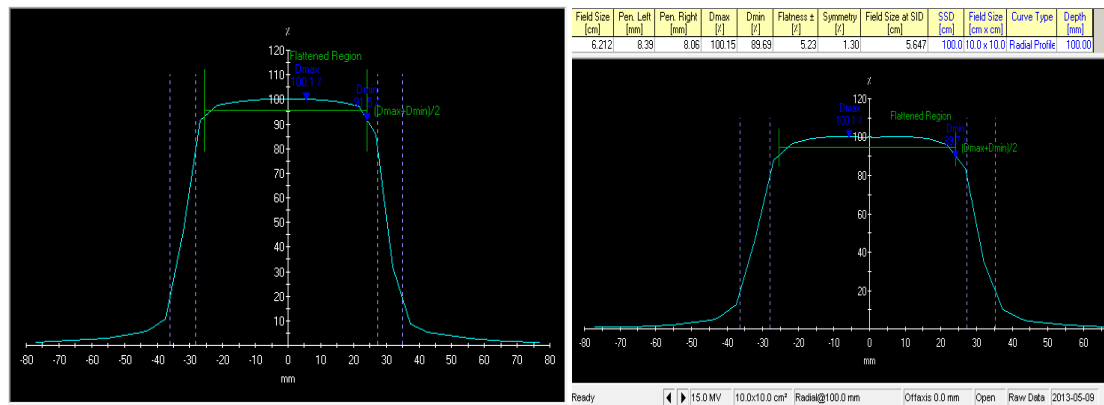
Fig. 1: the Beam Profile for field size 10 x10 cm² and analysis for different parameters description for photon beam 6 & 15 MV.

MLC margin	Energy 6 MV	Energy 15 MV
	Penumbra (mm)	Penumbra (mm)
0.0 Cm	7.650	10.835
0.1 Cm	7.765	8.300
0.2 Cm	7.555	8.110
0.3 Cm	7.275	8.115
0.4 Cm	7.420	8.240
0.5 Cm	7.880	8.325
0.6 Cm	7.965	8.405
0.7 Cm	7.575	8.205
0.8 Cm	6.880	7.630
0.9 Cm	7.240	8.320
1.0 Cm	9.115	10.030
1.1 Cm	11.045	11.295
1.2 Cm	11.720	11.755

Table 1: penumbra reading for dual energy 6 & 15 MV for different MLC margin for circular field sizes.

We note that the beam behavior for regular field size with relatively large increasing is the same for irregular circular field size with small increasing in field area "penumbra is sharper for higher energy and it is greater for high energy".

Measuring Percent Depth Dose (PDD) curve.

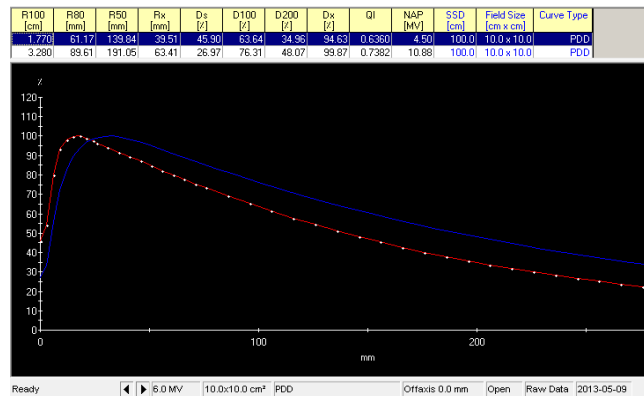| R100 [cm]	R80 [mm]	R50 [mm]	Rx [mm]	D s [%]	D100 [%]	D200 [%]	Dx [%]	QI	NAP [MV]	SSD [cm]	Field Size [cm x cm]	Curve Type
1.770	61.17	139.84	39.51	45.90	63.64	34.96	94.63	0.6360	4.50	100.0	10.0 x 10.0	PDD
3.280	89.61	191.05	63.41	26.97	76.31	48.07	99.87	0.7382	10.88	100.0	10.0 x 10.0	PDD

Fig. (2) Comparative PDD curves for 6 MV &15 MV

Beam	0 cm	$Z_{max.}$	PDD at 5cm	PDD at 10cm	PDD 20	PDD 20/10	Beam quality
6 MV	45.9	1.77 cm	85.13%	63.64%	34.96%	0.5493	0.636
15 MV	26.97	3.28 cm	95.44%	76.31%	48.07%	0.6299	0.738

Table 2: analysis of PDD curves for 6 & 15 MV at different depths (0, z_{max}, 5, 10, 20 Cm)
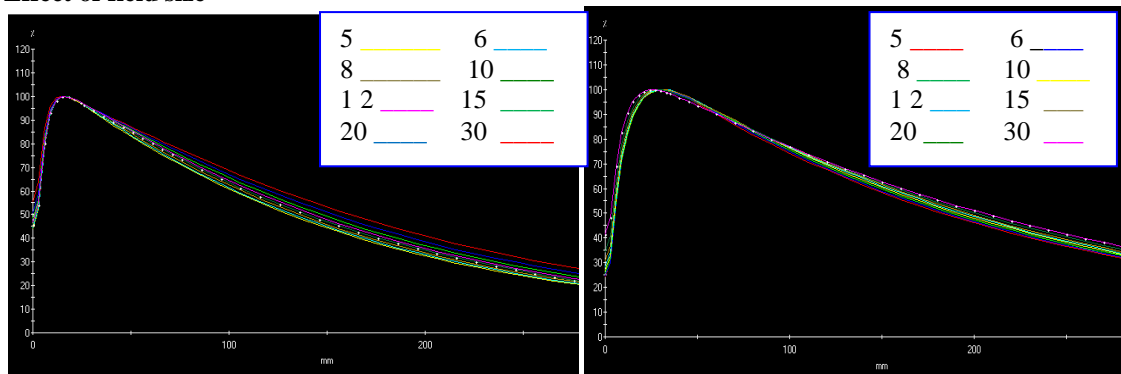
Effect of field size

Fig (3) PDD curves for 6 & 15 MV photon beam at different field sizes

F.S	Energy	PDD %			Depths (Cm)					
equivalent		0 Cm	1 Cm	2 Cm	Z_{max}	90%	80%	70%	60%	50%
5 × 5	6 MV	44.11	94.68	99.02	1.53	3.69	5.62	7.78	10.22	13.1
	15 MV	24.47	75.38	96.28	2.98	6.04	8.47	11.24	14.45	18.31
6 × 6	6 MV	44.52	94.56	99.17	1.54	3.79	5.71	7.88	10.37	13.3
	15 MV	24.65	74.67	95.98	3.01	6.14	8.64	11.42	14.64	18.5
8 × 8	6 MV	45.28	94.69	99.14	1.54	3.88	5.9	8.13	10.68	13.6
	15 MV	25.66	74.83	95.57	3.24	6.27	8.80	11.64	14.9	18.81
10 × 10	6 MV	45.9	94.84	99.27	1.77	3.95	6.12	8.36	10.98	14
	15 MV	26.97	75.54	95.8	3.28	6.34	8.96	11.82	15.2	19.1
12 × 12	6 MV	46.88	95.06	99.13	1.54	4.05	6.23	8.55	11.21	14.3
	15 MV	28.13	76.26	96.1	3.27	6.40	9.04	11.96	15.4	19.34
15 × 15	6 MV	48.41	95.43	99.12	1.54	4.08	6.41	8.83	11.59	14.7
	15 MV	30.68	78.1	96.78	3.02	6.38	9.10	12.11	15.6	19.63
20 × 20	6 MV	50.74	96.01	99.08	1.53	4.18	6.61	9.19	12.04	15.3
	15 MV	34.50	80.69	97.68	2.77	6.26	9.11	12.26	15.8	20.05
30 × 30	6 MV	55.45	97.15	98.71	1.49	4.25	6.87	9.62	12.69	16.3
	15 MV	41.48	85.33	98.84	2.46	6.03	9.00	12.33	16.1	20.51

Table 3: measurements of PDD for different field size for 6 and 15 MV

As field size increases:
- Z_{max} decreases because of the increase scatter component make maximum dose point appears faster at less depth.
- PDD increases at other points along the central beam axis
- The ratio of the penumbra to the central portion of the field decreases

As field size decreases:
- Z_{max} increases because of the decrease scatter component make maximum dose point appears slower at greater depth.
- PDD decreases at points along the central beam axis
- The ratio of the penumbra to the central portion increases, and may lead to complete loss of the central flat section.

Measuring beam profile curves

Beam profile at gradual depths start from d_{max}., 5cm, 10cm, 15cm and 20cm for 6 and 15 MV were measured and analyzed as shown in figures (23, 24). From beam profile we can got to beam flatness, beam symmetry and penumbra
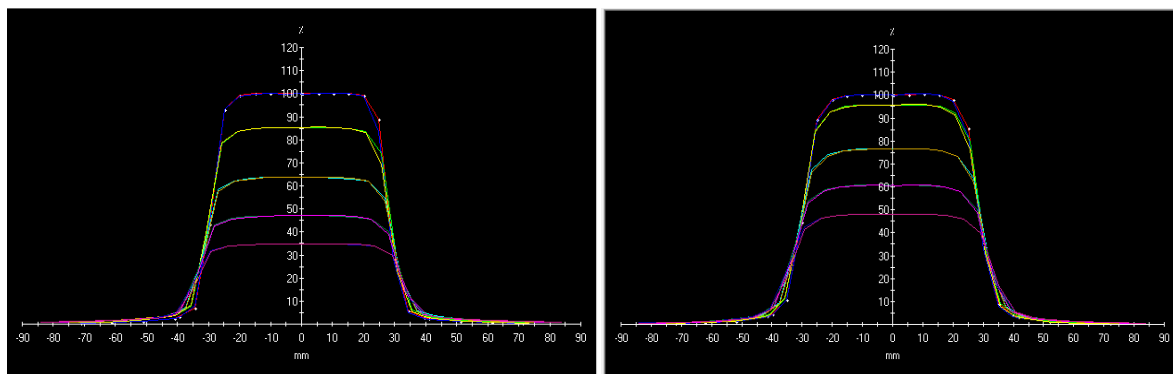
fig(4) 6 & 15 MV beam profile, field size 10 x 10 Cm^2.

		Radial profile			Transverse profile		
Depths	**Energy**	**Pen. (mm)**	**F. %**	**S. %**	**Pen. (mm)**	**F. %**	**S. %**
Dmax	**6 MV**	6.55	3.36	0.2	6.52	4.09	0.24
	15 MV	7.40	4.54	1.24	7.44	5.28	1.46
5 cm	**6 MV**	7.09	4.09	0.25	6.97	4.86	0.38
	15 MV	7.73	5.07	1.30	7.87	6.03	2.11
10 cm	**6 MV**	7.66	4.45	0.4	7.66	4.90	0.18
	15 MV	8.23	5.23	1.30	8.28	5.75	1.45
15 cm	**6 MV**	8.09	4.48	0.69	8.07	4.99	0.55
	15 MV	8.64	5.34	1.58	8.65	5.86	1.65
20 cm	**6 MV**	8.55	4.67	0.82	8.62	4.66	0.45
	15 MV	9.04	5.31	1.72	9.14	5.61	0.98

Table 4: penumbra, flatness and symmetry for radial and transverse profile measured for 6 and 15 MV energy.

Determination of the Opening Collimator Factor (OCF)

The ratio between the maximal absorbed dose and the absorbed dose in the reference depth at depth 10 cm were calculated, and then we make varied the field size. Theses curves are normalized to cyclic field size equivalent to 10cm x 10cm field size. The OFC increases with the field size. So, the dose in the measured point increases with the field size. This increasing is more important for higher photon beam energy and for dose distribution.

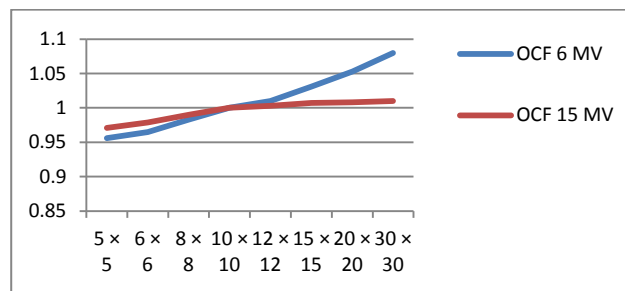| **Filed size**	**OCF**	
	6 MV	**15 MV**
5 × 5	0.956	0.971
6 × 6	0.965	0.979
8 × 8	0.983	0.990
10 × 10	1.000	1
12 × 12	1.010	1.003
15 × 15	1.031	1.007
20 × 20	1.053	1.008
30 × 30	1.080	1.010

Table 5: opening collimator factor for different field size, for 6 and 15 MV & diagram of the reading.

Part 2 Optimization of Conformal Radiotherapy for pancreas cancer patients:-

To illustrate the impact of expansion MLCs margin around the target in conformal 3D treatment planning real patient situations. 13 different plans were generated for 10 patients using the same arrangements and the only different is the MLC settings. A dose of 5040 cGy in 28 fractions was prescribed and normalized to 100% at the mean of target defined. The result unloaded in the following tables.

The case No. 1

A middle age woman (42 y.) with pancreas cancer,

Plan	MLC	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
3 Fields	**PTV**	87.83	90.32	92.06	93.37	94.68	95.60	96.37	96.90	97.20	97.54	97.76	97.92	98.13
	S. Cord	1575	1577	1582	1590	1597	1610	1627	1650	1710	1750	1800	1850	1880
	Lt.kid	380	420	460	500	550	600	650	710	770	840	920	1000	1070
	Rt.kid	1180	1240	1310	1370	1450	1530	1610	1700	1800	1900	2000	2110	2200
	Liver	1060	1100	1140	1200	1250	1310	1370	1440	1500	1560	1630	1690	1750
	Max.Dose	105.6	104.9	104.4	104.5	104.7	105	105.2	105.4	105.6	105.8	105.9	106	106.2
4 Fields	**PTV**	87.46	90.14	91.39	93.39	94.46	95.67	96.31	96.85	97.16	97.46	97.67	97.86	98.00
	S. Cord	2712	2602	2604	2598	2597	2600	2608	2621	2636	2656	2679	2710	2753
	Lt.kid	290	390	410	460	510	550	600	660	720	780	850	920	1000
	Rt.kid	1490	1590	1630	1720	1800	1880	1970	2070	2170	2280	2380	2490	2590
	Liver	880	990	1010	1050	1110	1190	1240	1310	1370	1430	1490	1550	1600
	Max Dose	106.3	106	105.5	105.1	104.8	104.6	104.4	104.3	104.3	104.4	104.4	104.6	104.6
5 Fields	**PTV**	87.67	90.28	92.04	93.43	94.6	95.55	96.33	96.74	97.14	97.44	97.66	97.78	97.92
	S. Cord	2090	2120	2150	2170	2170	2200	2210	2230	2250	2270	2320	2350	2430
	Lt.kid	550	580	610	660	700	780	820	870	920	960	1030	1080	1140
	Rt.kid	1250	1310	1360	1420	1490	1610	1710	1790	1880	1970	2060	2150	2230
	Liver	960	1000	1040	1090	1140	1210	1260	1340	1400	1450	1510	1570	1620
	Max Dose	106.6	105.9	105.4	105.1	104.9	104.7	104.6	104.5	104.5	104.4	104.6	104.7	104.7

Table 6: a table illustrates all OAR value and PTV volume percentage cover for three different techniques with MLC difference margin start from (0.0 cm to 1.2 cm).
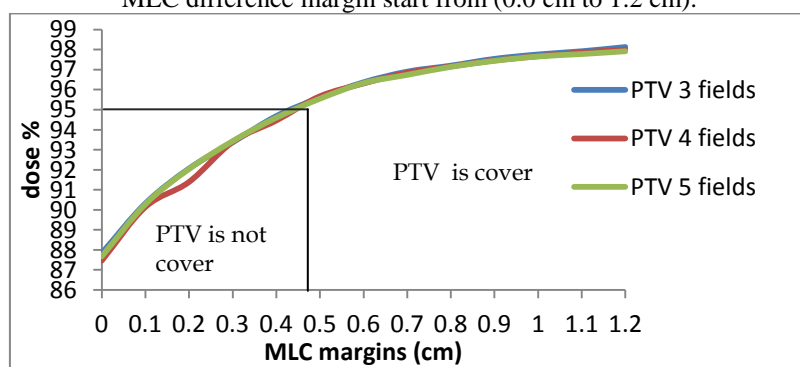

Fig. (5) PTV & MLC margins.

The case No. 2

A woman (56 y.) with pancreas cancer

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Plan	MLC	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
3 Fields	**PTV**	87.26	90.32	93	94.5	95.3	96.3	96.8	97.3	97.4	97.6	97.66	97.66	97.66
	S. Cord	1936	1940	1947	1954	1960	1980	2050	2180	2950	3774	1015	4160	4226
	Lt.kid	1357	1424	1495	1561	1628	1744	1840	1969	2156	2323	2437	2530	2618
	Rt.kid	1886	1950	2023	2091	2160	2280	2380	2520	2700	2892	3019	3110	3195
	Liver	2051	2116	2214	2305	2379	2500	2575	2670	2755	2838	2922	2992	3089
	Max.Dose	104.5	104.3	103.8	103.4	103.2	103	102.9	103	102.9	102.9	102.9	103	103.2
4 Fields	**PTV**	87.26	90.32	93	94.5	95.3	96.3	96.8	97.3	97.4	97.6	97.66	97.66	97.66
	S. Cord	3043	3029	3022	3019	3025	3029	3055	3132	3636	4158	4336	4429	4469
	Lt.kid	1301	1382	1462	1538	1614	1721	1813	1930	2085	2226	2333	2429	2518
	Rt.kid	2122	2206	2291	2372	2455	2566	2674	2814	2968	3125	3241	3331	3417
	Liver	1830	1893	1982	2063	2136	2239	2310	2398	2479	2557	2638	2710	2800
	Max.Dose	105.5	104.7	104.1	103.6	103.3	103	102.8	102.7	102.6	102.5	102.4	102.4	102.3
5 Fields	**PTV**	87.54	90.08	92.52	93.95	94.74	95.75	96.47	96.96	97.18	97.32	97.40	97.44	97.52
	S. Cord	2740	2732	2729	2729	2730	2746	2776	2867	3439	4034	4216	4322	4371
	Lt.kid	1402	1464	1531	1593	1653	1750	1836	1944	2093	2261	2364	2448	2530
	Rt.kid	1987	2051	2123	2193	2264	2375	2479	2607	2772	2929	3046	3130	3216
	Liver	1945	2028	2113	2192	2265	2368	2444	2531	2614	2691	2771	2861	2949
	Max.Dose	105.4	104.6	104	103.6	103.4	103.	103.1	103.1	103	103	103	103.1	103.1

Table 7: a table illustrates all OAR value and PTV volume percentage cover for three different techniques with MLC difference margin start from (0.0 cm to 1.2 cm).
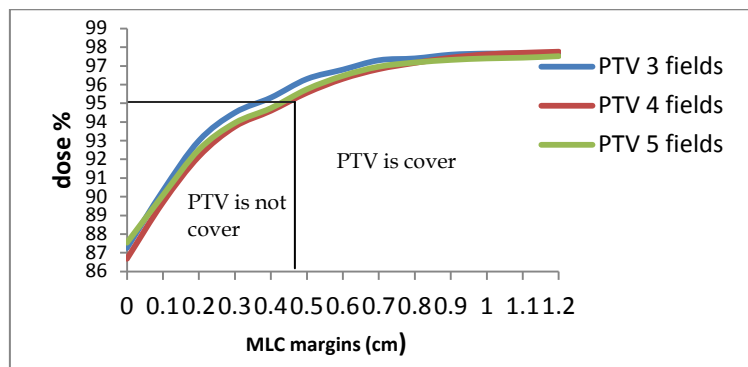

Fig. (6) PTV & MLC margins.

The case No. 3

A woman (38 y.) with pancreas cancer,

Plan	MLC	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
3 Fields	**PTV**	88.37	91.0	92.40	93.40	94.05	94.58	95.14	95.54	95.87	96.11	96.29	96.47	96.63
	S. Cord	1714	1746	1801	1848	1882	1918	1989	2046	2120	2170	2218	2396	2680
	Lt.kid	1361	1400	1430	1480	1508	1620	1700	1741	1800	1846	1910	1967	2021
	Rt.kid	1400	1455	1508	1595	1643	1819	1922	1982	2055	2111	2211	2280	2345
	Liver	1280	1341	1393	1448	1493	1561	1627	1684	1751	1810	1882	1958	2024
	Max.Dose	105.1	104.6	104.3	104.3	104.6	104.9	104.9	104.9	104.9	104.9	105	105	105.1
4 Fields	**PTV**	88.21	90.85	92.34	93.43	94.07	94.70	95.08	95.42	95.73	95.91	96.03	96.11	96.15
	S. Cord	2920	2909	2907	2919	2930	2985	3041	3079	3130	3160	3179	3234	3526
	Lt.kid	2035	2090	2138	2200	2243	2378	2413	2494	2521	2569	2634	2697	2838
	Rt.kid	1851	1928	2000	2096	2163	2362	2419	2460	2578	2646	2745	2819	2988
	Liver	1071	1128	1180	1232	1275	1351	1395	1452	1516	1575	1641	1714	1787
	Max.Dose	105.3	104.7	104.4	104.2	104.1	103.9	103.8	103.8	103.7	103.7	103.6	103.6	105.3
5 Fields	**PTV**	88.93	90.81	92.40	93.31	94.07	94.64	95.14	95.58	95.91	96.13	96.23	96.37	96.47
	S. Cord	2390	2395	2431	2449	2494	2578	2599	2640	2666	2726	2840	2919	3009
	Lt.kid	1543	1580	1672	1720	1779	1850	1886	1929	1973	2028	2118	2166	2309
	Rt.kid	1568	1612	1738	1791	1866	1940	1986	2051	2123	2203	2312	2362	2533
	Liver	1198	1248	1313	1361	1416	1475	1532	1598	1659	1722	1796	1861	1939
	Max.Dose	105.2	104.7	104.2	104	103.9	103.9	103.9	103.9	103.9	104	104.4	104.6	104.7

Table 8: a table illustrates all OAR value and PTV volume percentage cover for three different techniques with MLC difference margin start from (0.0 cm to 1.2 cm).
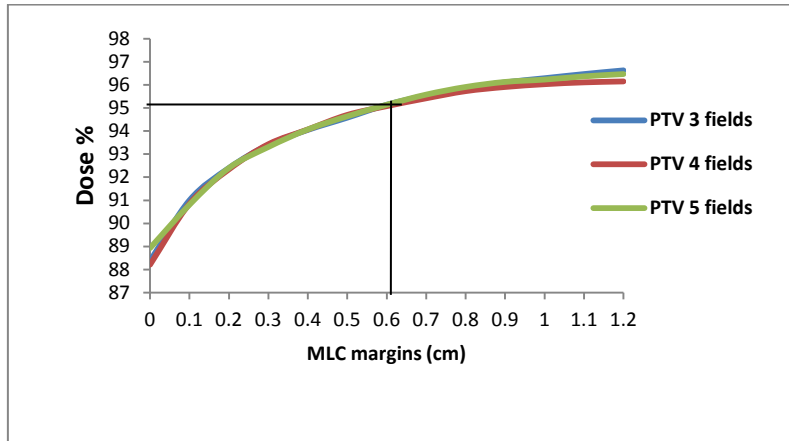
Fig. (7) PTV & MLC margins.

The case No. 4

A man (56 y.) with pancreas cancer,

Plan	MLC	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
3 Fields	PTV	87.10	90.40	92.72	94.11	95.34	96.03	96.55	97.06	97.42	97.70	97.88	97.94	97.99
	S. Cord	1589	1584	1585	1587	1591	1595	1599	1605	1611	1619	1628	1640	1650
	Lt.kid	467	529	586	623	665	705	742	794	841	948	1046	1153	1243
	Rt.kid	349	374	405	423	459	486	518	550	579	620	663	721	775
	Liver	2285	2339	2385	2423	2486	2539	2602	2662	2706	2794	2826	2861	2978
	Max.Dose	105.7	104.9	104.4	104.1	103.7	103.6	103.4	103.3	103.2	103.4	103.6	103.7	103.8
4 Fields	PTV	87.12	90.50	92.82	94.27	95.48	96.31	96.81	97.30	97.62	97.84	97.96	98.02	98.08
	S. Cord	2903	2881	2865	2855	2846	2842	2836	2833	2834	2833	2836	2841	2845
	Lt.kid	507	566	622	662	704	746	783	832	879	967	1053	1145	1228
	Rt.kid	407	437	472	505	539	575	613	651	691	736	786	844	903
	Liver	1900	1948	1991	2030	2088	2138	2195	2250	2294	2368	2428	2486	2535
	Max Dose	105	104.2	103.6	103.3	103.1	102.9	102.9	102.8	102.7	102.6	102.7	102.7	102.8
5 Fields	PTV	87.70	90.80	92.84	94.17	95.18	95.83	96.27	96.79	97.06	97.32	97.48	97.58	97.68
	S. Cord	1744	1784	1843	1884	1929	1955	1980	2001	2020	2040	2057	2071	2086
	Lt.kid	587	641	690	725	763	799	835	882	925	1018	1104	1197	1276
	Rt.kid	506	528	556	578	604	628	657	685	711	747	785	836	882
	Liver	2180	2239	2288	2326	2391	2441	2500	2558	2601	2687	2750	2817	2875
	Max Dose	105.2	104.4	103.9	103.6	103.4	103.3	103.2	103.1	103	103	103	103.1	103.3

Table 9: a table illustrates all OAR value and PTV volume percentage cover for three different techniques with MLC difference margin start from (0.0 cm to 1.2 cm).
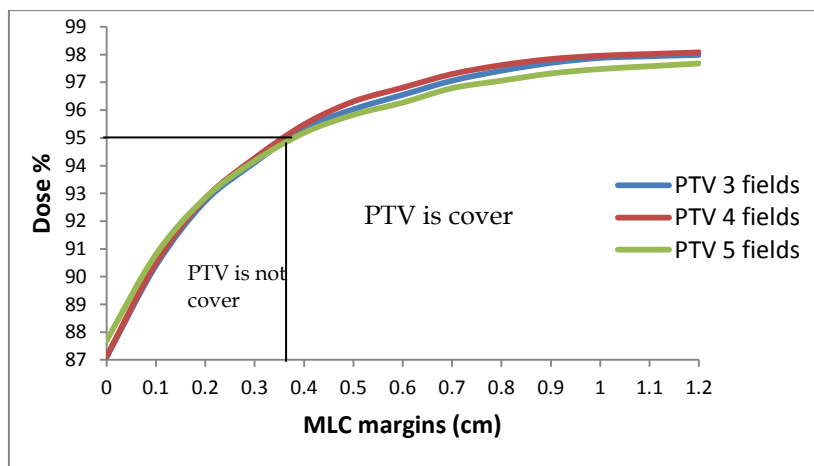

Fig. (8) PTV & MLC margins.

The case No. 5

A man (52 y.) with pancreas cancer,

Plan	MLC	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
3 Fields	PTV	83.83	88.08	91.39	93.73	95.14	96.00	96.70	96.98	97.54	97.84	98.06	98.25	98.39
	S. Cord	1986	1982	1995	2005	2011	2113	2159	2214	2399	2573	2887	3055	3657
	Lt.kid	340	380	433	474	523	606	653	698	756	811	873	937	1009
	Rt.kid	172	192	215	242	266	298	331	359	390	420	451	486	521
	Liver	877	921	961	1008	1050	1093	1141	1187	1235	1281	1325	1379	1430
	Max.Dose	106.4	105.3	104.4	103.8	103.5	103.2	102.9	102.8	102.8	102.8	102.8	102.8	102.9
4 Fields	PTV	83.73	88.23	91.47	93.71	95.24	96.15	96.83	97.12	97.70	98.02	98.21	98.41	98.53
	S. Cord	2950	2928	2921	2916	2912	2940	2965	3046	4182	3303	3531	3651	4086
	Lt.kid	278	310	353	387	429	493	532	570	619	666	720	775	838
	Rt.kid	149	165	185	208	230	257	286	310	338	365	392	426	454
	Liver	774	813	850	890	926	966	1010	1051	1096	1138	1178	1229	1276
	Max Dose	106.6	105.4	104.5	103.9	103.4	103.2	103	103	102.9	102.9	103	102.9	103
5 Fields	PTV	85.97	89.11	91.85	94.01	95.38	96.11	96.75	97.22	97.54	97.82	98.02	98.60	98.27
	S. Cord	2358	2392	2404	2425	2431	2483	2514	2635	2789	2939	3210	3358	3880
	Lt.kid	441	480	529	567	614	685	730	771	825	876	931	990	1054
	Rt.kid	197	218	234	266	290	320	352	379	412	442	473	509	543
	Liver	870	911	955	1001	1044	1087	1136	1182	1232	1279	1324	1380	1432
	Max Dose	106.3	105.1	104.3	103.6	103.3	103.1	102.8	102.7	102.7	102.7	102.8	102.9	102.9

Table 10: a table illustrates all OAR value and PTV volume percentage cover for three different techniques with MLC difference margin start from (0.0 cm to 1.2 cm).
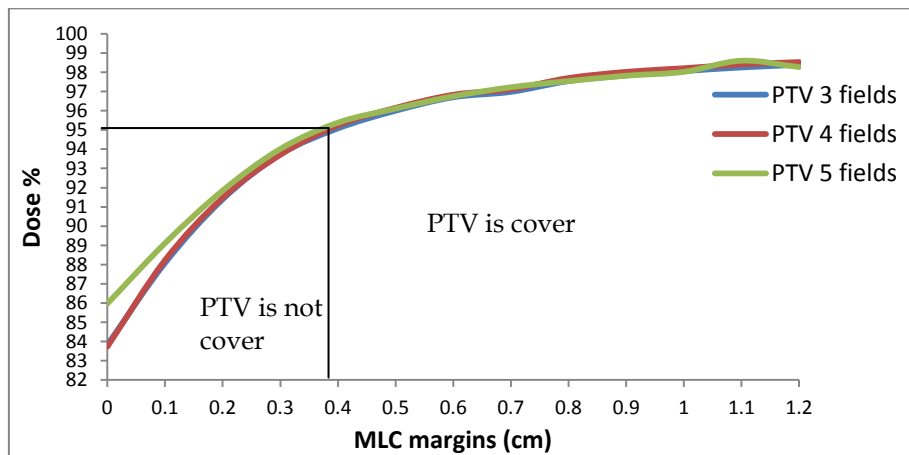

Fig. (9) PTV & MLC margins.

The case No. 6

A man (58 y.) with pancreas cancer,

Plan	MLC	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
3 Fields	PTV	85.97	89.11	91.85	94.01	95.38	96.11	96.75	97.22	97.54	97.82	98.02	98.60	98.27
	S. Cord	1562	1618	1708	1905	2000	2020	2251	2467	2683	2843	2917	3041	3017
	Lt.kid	919	977	1026	1083	1137	1194	1265	1327	1393	1468	1535	1622	1703
	Rt.kid	190	208	226	242	261	291	326	352	380	408	437	469	504
	Liver	2232	2300	2370	2440	2506	2574	2644	2705	2772	2834	2896	2956	3017
	Max.Dose	106.5	106.2	105.8	105.7	105.5	105.3	105.2	105.1	105	105.1	105.1	105.1	105.2
4 Fields	PTV	86.96	90.05	92.12	93.39	94.36	95.23	95.75	96.07	96.41	96.65	96.72	96.76	96.78
	S. Cord	2370	2411	2484	2636	2710	2726	2901	3068	3236	3358	3423	3522	3651
	Lt.kid	1228	1294	1348	1410	1470	1533	1610	1676	1742	1817	1886	1974	2054
	Rt.kid	186	204	221	237	255	285	318	344	372	401	430	463	497
	Liver	1905	1967	2035	2099	2161	2227	2293	2351	2415	2476	2537	2596	2634
	Max Dose	105.3	105	104.9	104.8	104.7	104.5	104.5	104.4	104.3	104.3	104.3	104.3	104.6
5 Fields	PTV	86.66	89.66	91.74	92.95	93.86	94.46	94.92	95.23	95.39	95.55	95.59	95.67	95.89
	S. Cord	1659	1693	1782	1946	2026	2051	2240	2421	2620	2808	2964	3138	3243
	Lt.kid	1085	1150	1206	1270	1329	1393	1469	1535	1606	1685	1756	1845	1928
	Rt.kid	255	274	293	310	330	360	393	419	447	476	504	538	572
	Liver	2023	2086	2153	2226	2288	2357	2430	2490	2556	2618	2682	2742	2801
	Max Dose	105.1	104.9	104.7	104	104.8	104.8	104.8	104.7	105	105.1	105.2	105.3	105.4

Table 11: a table illustrates all OAR value and PTV volume percentage cover for three different techniques with MLC difference margin start from (0.0 cm to 1.2 cm).
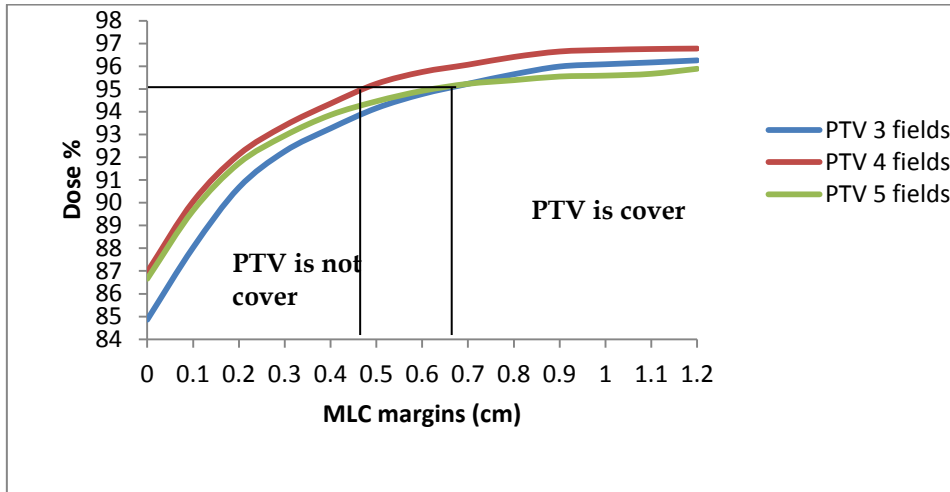
Fig. (10) PTV & MLC margins.

The case No. 7

A man (51 y.) with pancreas cancer,

Table 12: a table illustrates all OAR value and PTV volume percentage cover for three different techniques with

Plan	MLC	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
3 Fields	PTV	86.90	89.82	91.64	93.03	93.94	95.00	95.63	96.03	96.32	96.46	96.68	96.82	96.86
	S. Cord	1520	1517	1524	1535	1551	1580	1595	1611	1635	1682	1736	1776	1896
	Lt.kid	679	714	763	827	902	1060	1150	1202	1257	1360	1439	1493	1573
	Rt.kid	1091	1142	1245	1338	1439	1617	1768	1830	1899	2036	2140	2210	2307
	Liver	1294	1338	1395	1450	1504	1570	1632	1697	1759	1822	1893	1956	2032
	Max.Dose	105	104.2	103.6	103.2	103.1	103.0	103	102.9	102.9	103.2	103.3	103.3	103.9
4 Fields	PTV	86.56	89.50	91.60	92.85	94.10	95.07	95.93	96.38	96.78	97.06	97.22	97.46	97.61
	S. Cord	2710	2694	2685	2685	2689	2701	2707	2713	2727	2756	2791	2817	2894
	Lt.kid	598	636	682	739	805	929	1010	1062	1118	1205	1278	1336	1409
	Rt.kid	1030	1084	1205	1293	1383	1522	1664	1728	1800	1916	2011	2084	2184
	Liver	1100	1141	1198	1250	1302	1369	1425	1489	1549	1610	1678	1741	1817
	Max Dose	104.6	103.8	103.2	102.8	102.6	102.4	102.3	102.2	102.2	102.2	102.2	102.2	102.4
5 Fields	PTV	87.32	89.82	91.70	92.95	94.04	94.84	95.65	96.15	96.48	96.58	96.90	97.08	97.24
	S. Cord	1852	1930	1993	2093	2123	2141	2173	2201	2238	2292	2351	2399	2501
	Lt.kid	803	835	876	931	994	1120	1199	1246	1300	1386	1452	1501	1568
	Rt.kid	1165	1211	1299	1383	1473	1622	1757	1812	1873	1988	2079	2144	2228
	Liver	1183	1227	1283	1337	1395	1462	1526	1589	1650	1712	1784	1850	1925
	Max Dose	104.7	103.9	103.4	103.2	103	102.8	102.7	102.6	102.5	102.6	102.7	102.8	102.9

MLC difference margin start from (0.0 cm to 1.2 cm).
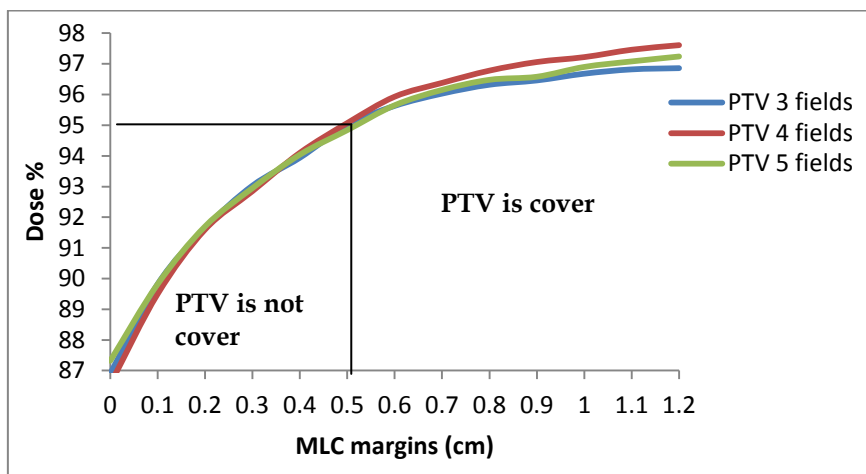
Fig. (11) PTV & MLC margins.

The case No. 8

A woman (55 y.) with pancreas cancer,

Plan	MLC	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
3 Fields	PTV	84.25	88.09	91.21	92.80	93.87	95.34	96.13	96.61	96.98	97.32	97.58	97.73	97.80
	S. Cord	1881	1867	1910	1918	1923	1923	1981	1997	2008	2013	2059	2104	2784
	Lt.kid	315	340	403	443	476	553	621	673	722	767	829	880	1001
	Rt.kid	385	421	460	490	523	583	649	701	754	810	873	932	1013
	Liver	1028	1086	1148	1200	1244	1311	1366	1417	1502	1556	1620	1680	1760
	Max Dose	106	105	104	103.5	103.2	102.8	102.5	102.5	102.5	102.4	102.5	102.5	102.7
4 Fields	PTV	84.76	88.45	91.37	92.96	94.23	95.51	96.41	96.92	97.36	97.68	98.01	98.21	98.31
	S. Cord	2601	2578	2602	2606	2599	2634	2638	2648	2654	2654	2693	2721	3252
	Lt.kid	320	347	407	447	484	559	625	678	729	778	841	896	1006
	Rt.kid	417	458	500	534	570	632	698	754	813	875	941	1006	1087
	Liver	980	1037	1100	1144	1189	1253	1306	1356	1435	1494	1555	1614	1688
	Max Dose	106.2	105.2	104.3	103.7	103.3	102.8	102.5	102.4	102.3	102.4	102.5	102.5	102.4
5 Fields	PTV	85.44	88.67	91.49	92.96	94.13	95.39	96.21	96.69	97.02	97.36	97.66	97.88	97.98
	S. Cord	2554	2556	2558	2574	2577	2612	2617	2628	2636	2639	2672	2687	3230
	Lt.kid	560	583	634	668	700	763	821	867	908	951	1002	1051	1150
	Rt.kid	504	540	578	606	641	697	758	808	855	913	972	1035	1110
	Liver	1041	1102	1160	1208	1261	1322	1376	1426	1506	1562	1622	1686	1759
	Max.Dose	106.2	105.2	104.3	103.8	103.4	103	102.8	102.6	102.8	102.8	102.7	102.7	102.7

Table 13: a table illustrates all OAR value and PTV volume percentage cover for three different techniques with MLC difference margin start from (0.0 cm to 1.2 cm).
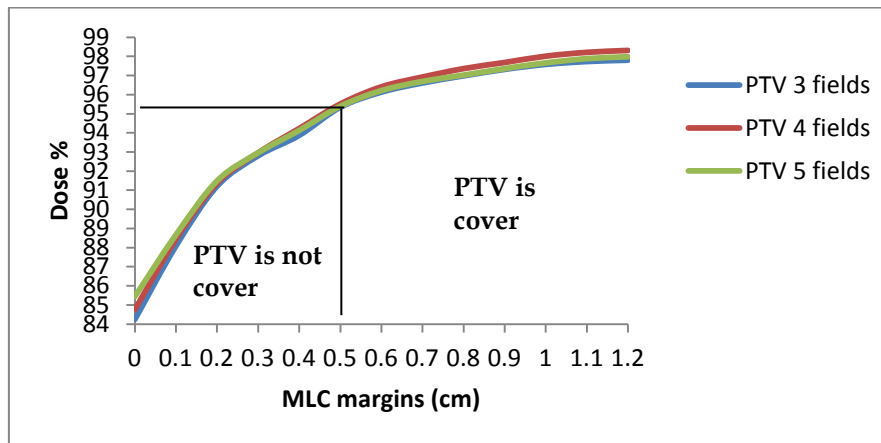

Fig. (12) PTV & MLC margins.

The case No. 9

A man (43 y.) with pancreas cancer,

Plan	MLC	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
3 Fields	PTV	87.94	91.07	93.34	94.40	95.08	95.49	95.81	95.87	95.99	96.03	96.07	96.11	96.15
	S. Cord	1122	1117	1116	1120	1122	1124	1131	1144	1147	1148	1154	1157	1162
	Lt.kid	139	146	154	162	171	180	190	223	237	251	264	276	287
	Rt.kid	235	246	262	278	299	318	336	357	377	403	424	441	462
	Liver	1530	1600	1676	1747	1835	1905	1977	2033	2101	2174	2256	2333	2409
	Max Dose	107.7	107	106.3	105.8	105.6	105.4	105.3	105.2	105.1	105.5	105.7	105.9	106
4 Fields	PTV	88.80	91.81	93.97	95.04	95.73	96.17	96.53	96.67	96.85	97.01	97.12	97.18	97.23
	S. Cord	2981	2962	2942	2928	2918	2912	2910	2907	2904	2900	2805	2802	28
	Lt.kid	166	177	188	200	212	226	239	255	280	305	365	400	455
	Rt.kid	322	340	366	393	423	450	480	510	545	572	598	627	663
	Liver	1502	1568	1639	1706	1794	1871	1940	2020	2103	2190	2275	2350	2434
	Max Dose	106.1	105.4	104.8	104.4	104.2	104.0	103.8	103.5	103.5	103.6	103.7	103.9	104.2
5 Fields	PTV	89.17	91.63	92.94	93.85	94.44	94.80	95.06	95.14	95.23	95.30	95.40	95.45	95.48
	S. Cord	990	1008	1023	1023	1112	1147	1320	1396	1623	1773	1788	1874	1927
	Lt.kid	510	557	598	635	687	727	778	826	869	930	969	1027	1074
	Rt.kid	170	183	195	208	226	240	269	287	301	321	337	358	377
	Liver	1199	1263	1322	1385	1442	1501	1574	1640	1704	1777	1839	1903	1966
	Max.Dose	107.4	106.7	106.2	106	105.8	105.6	105.8	106.1	106.1	106.1	106.2	106.4	106.5

Table 14: a table illustrates all OAR value and PTV volume percentage cover for three different techniques with MLC difference margin start from (0.0 cm to 1.2 cm).
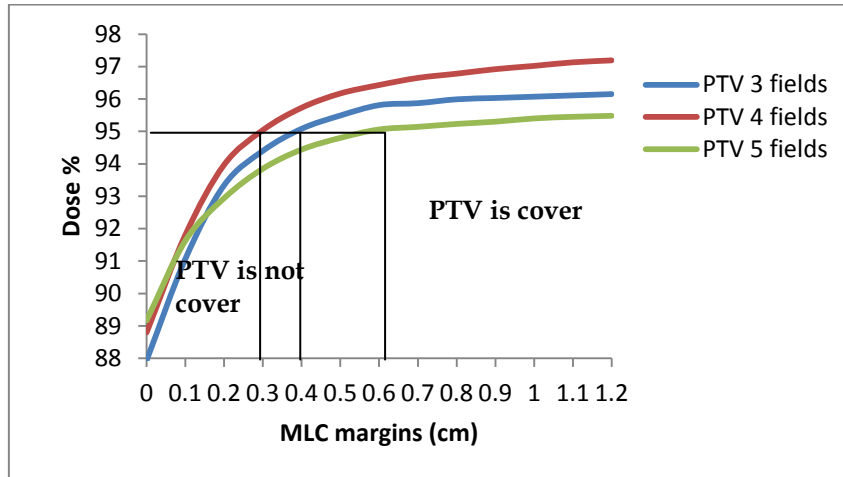
Fig. (13) PTV & MLC margins.

The case No. 10

A man (62 y.) with pancreas cancer,

Plan	MLC	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
3 Fields	PTV	87.30	90.20	92.50	94.00	94.84	95.30	95.80	95.99	96.20	96.26	96.30	96.37	96.45
	S. Cord	2442	2483	3475	3508	3531	3545	3579	4693	4720	4746	4769	4794	4910
	Lt.kid	1454	1517	1886	1968	2020	20.86	2150	2429	2496	2555	2630	2710	3150
	Rt.kid	699	747	967	1020	1065	1113	1165	1325	1378	1432	1490	1560	1860
	Liver	1308	1350	1400	1446	1488	1538	1586	1652	1710	1760	1810	1860	1910
	Max Dose	107.1	106.2	105.6	105.2	105.1	105	105	105	105	105.2	105.3	105.3	105.7
4 Fields	PTV	87.6	90.4	92.5	94.3	94.9	95.5	96.0	96.25	96.6	96.85	96.9	97.05	97.2
	S. Cord	3012	3132	3962	3986	4050	4102	4153	4750	4785	4814	4856	4877	4955
	Lt.kid	1534	1617	2006	2068	2100	2176	2216	2329	2456	2585	2630	2695	3166
	Rt.kid	720	787	997	1080	1106	1145	1197	1345	1398	1449	1500	1566	1732
	Liver	1328	1355	1430	1476	1495	1555	1596	1676	1730	1785	1842	1884	1935
	Max Dose	107	106.2	105.4	105	104.9	104.8	104.7	104.5	104.5	104.5	104.5	104.6	104.6
5 Fields	PTV	87.8	90.3	92.75	94.2	95	95.6	96.1	96.4	96.8	96.9	97.1	97.4	97.5
	S. Cord	2946	2972	3662	3686	3700	3727	3751	4650	4688	4716	4754	4774	4855
	Lt.kid	1703	1757	2076	2150	2190	2250	2310	2547	2605	2658	2725	2791	3178
	Rt.kid	860	900	1060	1107	1152	1192	1240	1373	1419	1467	1520	1580	1810
	Liver	1282	1324	1371	1420	1470	1520	1560	1627	1679	1731	1784	1837	1885
	Max.Dose	107.2	106.4	105.7	105.3	105	104.8	104.6	104.7	104.7	104.7	104.7	104.7	104.6

Table 15: a table illustrates all OAR value and PTV volume percentage cover for three different techniques with MLC difference margin start from (0.0 cm to 1.2 cm).
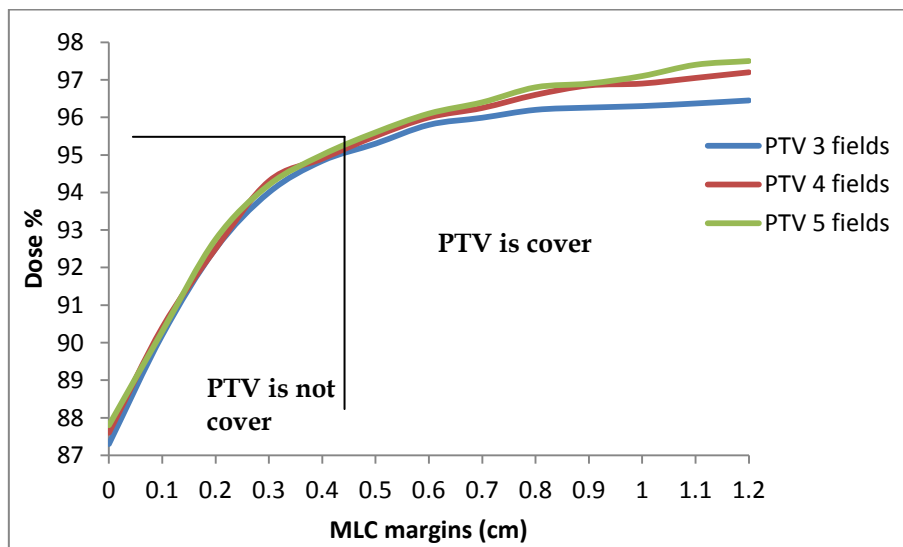

Fig. (14) PTV & MLC margins.

MLC	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
PTV	86.98	89.99	92.23	93.70	94.70	95.51	96.10	96.49	96.79	97.02	97.17	97.33	97.39

The following table contains the averages for each margin for all of three techniques compound for PTV.

Table 16: a table illustrates the averages of PTV volume percentage cover with MLC difference margin start from (0.0 cm to 1.2 cm).
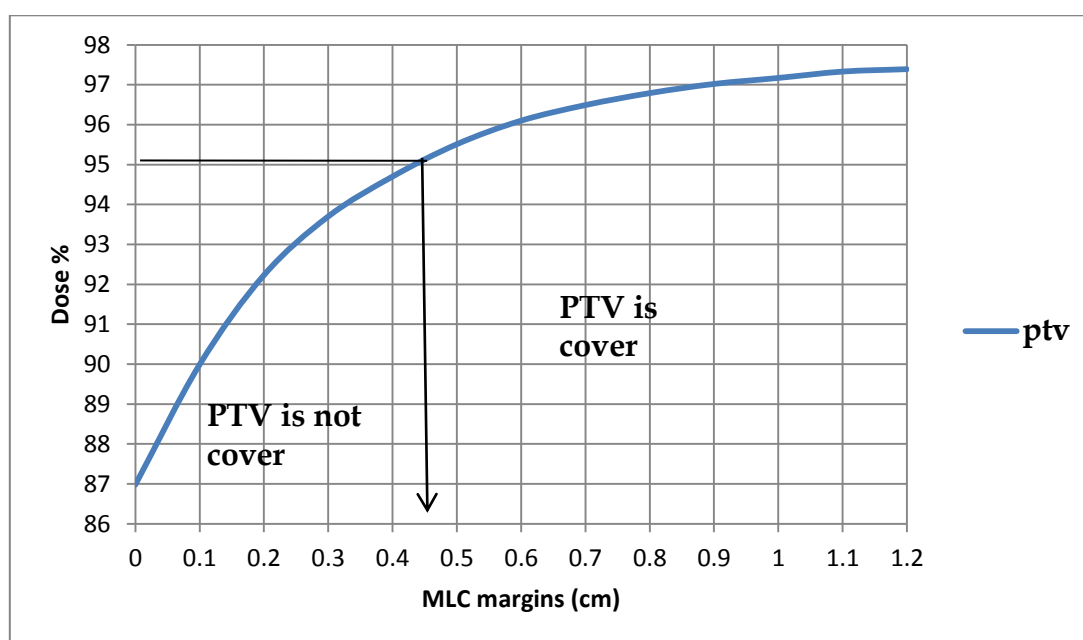
Fig. (15) PTV & MLC margins.

IV.   Conclusions

As field size increase as the dose of target point's increase and the dose distribution become better for tumor but OAR become worst. This fact is true for regular field size which shaped by collimator jaws only (square and rectangular) and true for irregular field size which shaped by custom block or MLCs (circular and irregular) too.

The plans with MLCs margin from 0.0 cm to 0.4cm are not accepted because the 95% of dose doesn't cover 95% of tumor volume and this may lead to the occurrence of recurrence. The plans with MLCs margin 0.5 cm, 0.6 cm and 0.7 cm are the best plans because the 95% of dose cover more than 95% of tumor volume and OAR still under tolerance. Although, the 95% of dose cover more than 95% of tumor volume, the plans with MLCs margin more than 0.7 cm are not accepted because the OAR received unjustified and unnecessary dose and more than tolerance for sometimes.

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