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Using Manchester System for the Treatment of Cervix Carcinoma for a Selected Oncology Facility in Ghana

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Abstract: ***The conventional treatment for carcinoma of the cervix is a combination of both the external Teletherapy and Low Dose-Rate (LDR) intracavitary brachytherapy. However, there has been an increasing trend toward the use of High Dose-Rate (HDR) brachytherapy, in combination with external beam radiotherapy (EBRT) in the treatment of cervix carcinoma.The Manchester system has been used for the treatment modality at the facility. The various cancer stages were diagnosed and found to be from stage I to stage IIIB according to FIGO staging guidlines. There were no stage IV cases who reported at the facility during the period of investigation. It has been argued that, for the unique case of radio-therapeutic treatment of carcinoma of the cervix, the criterion for producing an equivalent treatment should be based on the matching of early, rather than not late effects. In essence, the dose to the normal tissues at risk for late effects is usually significantly smaller than the prescribed dose. For such a treatment modality of treatment, the mode of calculation of the Biologically Effective Dose(BED) has being used during the cervical carcinoma at the facility.***

Keywords: Low dose rate, radiotherapy, cervix carcinoma, brachytherapy and effective dose

1. Introduction

After X-rays were discovered by W. C. Roentgen in 1895, ionizing radiation has been used for the treatment of cancer. Nowadays, the three main modalities for cancer treatment are surgery, radiotherapy and chemotherapy. Radiotherapy consists of teletherapy and brachytherapy but in this current study, only brachytherapy will be considered.The word 'brachytherapy' comes from a Greek word; meaning 'brachos' and it refers to a short-range therapy.Brachytherapy is the short distance treatment procedures of malignant diseases or tumours with radiations coming from encapsulated sources. The purpose of brachytherapy treatment is to destroy the cancer cells with ionizing radiation by localizing high radiation dose in the tumour volume while the normal tissues or critical organs receive as low dose as possible [1,2]. Brachytherapy is important for the achievement of local disease control in the treatment of cervical cancer. In this mode of treatment, high radiation dose can be delivered to the target volume with rapid dose fall-off in the surrounding normal tissues. This type of treatment is always temporal and lasting only for some few days.It should therefore be performed under strict rules of standard source-application systems such as the Manchester system orICRU system [1]. The treatment unitsin these facilities are an AMRA-Curietron in which photons are made to travel through special tubes called channels to deliver the treatment doses into the tumor volume of the cancer patients. In this treatment unit, the sources usually emit photons during treatment,which is considered as a stream of photons moving into the treatment volume and consequently depositing dose into the tissue.

The primary objective of this study is to determineradiation doses to critical organs of cancer patients undergoing intracavitary brachytherapy treatment using the Manchester system.

The specific objectives of the study are

1) To group tumor stages of patients according to the International Federation of Gynecology and Oncology(FIGO) staging guidelines as stated or used by Radiation Oncologists
2) To specify the doses to the tumor volume based on the prescribed dose to the reference point
3) To assess the risk of radiation doses to both the rectum and bladder of patients undergoing intracavitary brachytherapy treatment

Principles of brachytherapy

Over the last hundred years, ionizing radiation has been increasingly applied in medicine and is now firmly established as an essential tool in both diagnosis and therapy. Brachytherapy or radioactive implantation has been employed since the discovery of radioactive isotopes such as radium in 1903. In brachytherapy the sources are inserted into the treatment volume or close to the treatment volume. The different types of brachytherapy implants are intracavitary, intraluminal, interstitial, surface plaques and intravascular brachytherapy. The brachytherapy implant can either be temporal or permanent. For temporal implants, the dose is delivered over a period of time which is short as compared to the half-life of the sources [3]. The sources are also removed after the prescribed dose is reached. In the case of permanent implant, the dose is delivered over the life time of the source until the sourceundergoes complete radioactive decay.The main characteristic of brachytherapy is the rapid dose fall-off with distance from the radiation

source whereby the tumour in contact or close to the source receive high amount of radiation dosebut outside the tumour, normal tissues receive doses at considerable much lower levels [4]. The physical advantage of the effectiveness of brachytherapy as compared to teletherapy is when the tumour is small with well-defined geometry or sometimes it may be used as a boost dose to more advanced or ill-defined tumours [5]. During brachytherapy treatment, the following considerations are crucial and should always be considered; these are:

1) Using a suitable dosimetric model for the calculation of dose distributions and treatment time.
2) Prevention or avoidance of geometrical misses due to accurate positioning of sources.
3) Using a calibrated source with its calibration traceable to a standard laboratory.

Importance of Low Dose Rate brachytherapy treatment

There are main advantages of Low Dose Rate (LDR) brachytherapy. These are positioning of the source at short distances from the tumour volume, this allows a very good dose distributions in the target volume; that is good radiation dose distribution is the ability to locate radioactive sourcesin or close to the tumour, either by topical mold, intracavitary or interstitial implant, which represents the optimal conformal dose delivery system. Specifically, it is generally easier to compare with external beam radiotherapy to deliver high doses of radiation to target tissues, while minimizing radiobiological damage to normal adjacent tissues hence, good radiation dose distributions sparing; (1) early responding normal tissues,which in external beam radiotherapy,typically produce the complications thatforce treatments to be prolonged over more than one month;and (2) late-responding normal tissues,which, in externalbeam radiotherapy, often represent the dose-limiting endpoint [6]. short overall treatment times, to counter tumour repopulation; It is now generally accepted that long overall treatment times can be a significant cause of local failure in radiotherapy, because accelerated repopulation during the treatment means that tumour cells start to divide more rapidly than they can be killed [7-9].

Intracavitary brachy therapy in gynaecology

This is the type of brachytherapy treatment in which the applicators are inserted into a body cavity to reach the volume of the tumour. It is mainly used for the treatment of cancer of the cervix, uterine body and the vagina. Various applicators are used to hold the sources in an appropriate configuration in the tumour volume. These include the Fletcher-Suit-Delcos and the Tandem-Ring applicators as shown in Figures.1 and 2 respectively.

The most commonly used applicator for intracavitary brachytherapy treatment is the Fletcher-Suit-Delcos system which consists of a central tube called the tandem and lateral capsules also called ovoids or colpostats. The most widely used brachytherapy source for the treatment of gynaecological cancers is Cs-137. It is often necessary to use sources of different strength in order to achieve the desired dose distribution [10].

Figure 1: Fletcher-Suit-Delcos applicator

Figure 2: Tandem-Ring applicator

Different systems are used for dose specifications in brachytherapy treatment. These include; Stockholm, Memorial, Paris, Quimby, Manchester and the ICRU systems. The two most commonly used systems in gynaecology are the Manchester and ICRU systems. The Manchester system uses the Fletcher-Suit-Delcos applicator and is characterised by doses to four points, namely point A, B, bladder and rectum as depicted in Figure 3.

Ideally, point A represents the location where the uterine vessel crosses the urethra and also relates to the position of the sources. The dose at point A is very sensitive to the position of the ovoid sources relative to the tandem. Point A is defined to be 2cm superior to the external cervical end of the tandem and also 2cm lateral to the cervical canal. Point B is defined as 3cm laterally to point A or 5cm from the midline of the tandem or when the central canal is not displaced. The duration of the irradiation is based on the dose rate calculated at point A or B depending on the reference point adopted by the Oncology unit or facility.

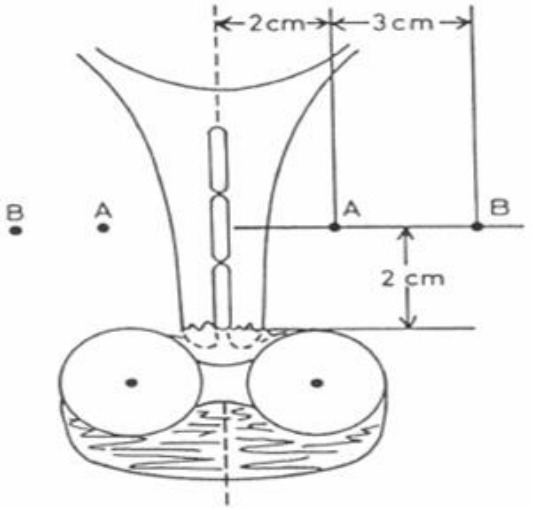

Figure 3: The reference points A and B according to the Manchester system

The diagram above shows the reference points A and B used in intracavitary brachytherapy when using the Manchester system for the treatment of gynaecological cancers.

Organs at risk (OAR)

Organs at risk are sometimes called critical normal structures. They are normal structures,but because of their radiosensitivity and their location close to the target volume may significantly influence the treatment planning or the prescribed dose level [1].

Organs at risk such as the bladder and rectum often limit the prescribed dose to the target volumes in cervical cancer patients undergoing intracavitarybrachy therapy treatment. The diagram in Figure 4 shows the female anatomy and placement of applicators for intracavitary brachytherapy treatment in gynaecological cancers using the Manchester system[11].

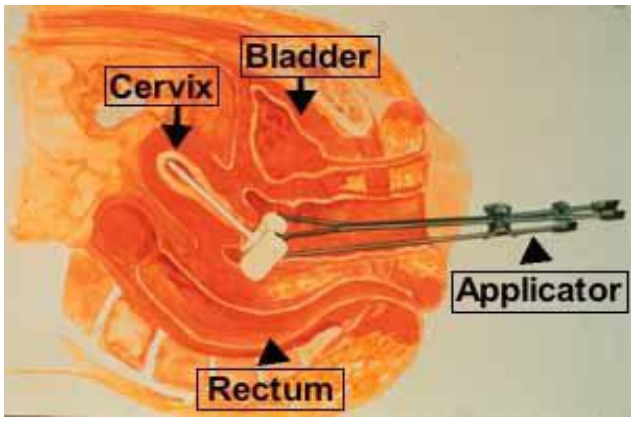

Figure 4: Fletcher-Suit-Delcos system in gynaecology

Calculation of Biological Effective Dose (BED)

The various treatment techniques should be done based on the calculations of Biologically Effective Dose (BED) which normally allows for easy comparison and addition of the effects of various complete or partial treatment regimens no matter how the method of radiation dose delivery to patients at the facility.

For External Beam Radiotherapy (EBRT), the BED could be calculated using equation 1 as follows

$$BED_{(EBRT)} = nd\left[1+\frac{d}{\alpha/\beta}\right] \quad (1)$$

Where n is the number of fractions, d is the dose per fraction and α/β is the ratio of the linear quadratic (LQ) parameter of the tissue being investigated.

In the case of Low Dose Rate(LDR) brachytherapy where significant repair of damaged takes place during treatment duration, the BED for each session could also be calculated using equation 2 as follows

$$BED_{(BT)} = D\left\{1+\frac{2D}{(\alpha/\beta)\mu T}\left[1-\frac{1}{\mu T}\left(1-e^{-\mu T}\right)\right]\right\} \quad (2)$$

Where D is the radiation dose, T is the duration of the brachytherapy(BT) session andμ is a parameter characterizing the repair of sub lethal damage in the irradiated tissues; this could also be calculated from the relation $\mu = \frac{\ln 2}{T_{1/2}}$ where $T_{1/2}$ is the half-life of the sub lethal damage repair.

2. Materials and Method

The cancer stage is of major concern to the radiation Oncologist at every facility. The Oncologist determines the treatment modality for the patient, prescribed dose, positions of the applicators for the treatment. Initially the patient is taken to a simulator machine so that at least two orthogonal radiographs to be taken by the radiographer. The orthogonal radiographs would be taken using a conventional X-ray(C-arm) machine with radiopaque markers in the applicators. This is to assist in visualizing the positions of the applicators before the actual treatment is performed. The facilities under consideration both use AMRA-Curietron Machines manufactured by Cis-Bio International with model numbers of CA 9610 and 9611 respectively. The patients under study were all female adults of ages ranging from 20 to 82 years old. The prescribed radiation dose for the patients ranges between 25Gy and 30Gy. After this, it is the duty of the dosimetrist to compute the doses to both the normal tissues (i.e. rectum and bladder). The radiographs are reconstructed and the treatment planning was done using the Oncentra Planning System (version 3.3 Nucletron) at the facility. The radioactive sources were positioned according to the standard loading of the Manchester system. In all cases it was found that these doses to the normal tissues are less than the dose to the reference point after the computerization by the dosimetrist.

3. Results

Table 1: Patient characteristics

Minimum Age	20 years
Maximum Age	80 years
Median Age	55 years
Modal Age	70 years
Total number of cervical cancer patients(*n*)	150

Table 2: A table showing the cancer stage and number of patients

Cancer Stage	Number of Patients	Percentage (%)
IA	02	1.33
IB	06	4.00
IIA	18	12.00
IIB	52	34.67
III	01	0.67
IIIA	12	8.00
IIIB	59	39.33
Total (*n*)	150	100

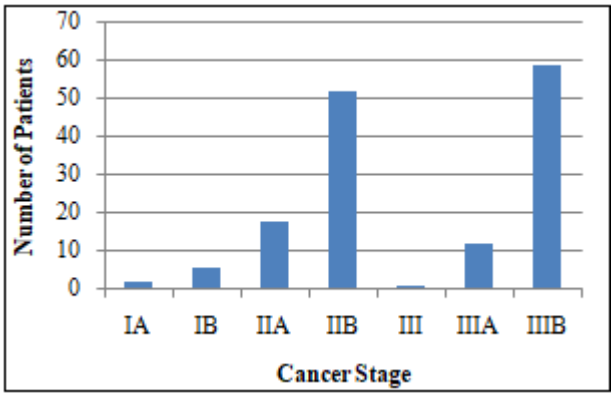

Figure 1: A histogram showing the number of patients with cancer stage

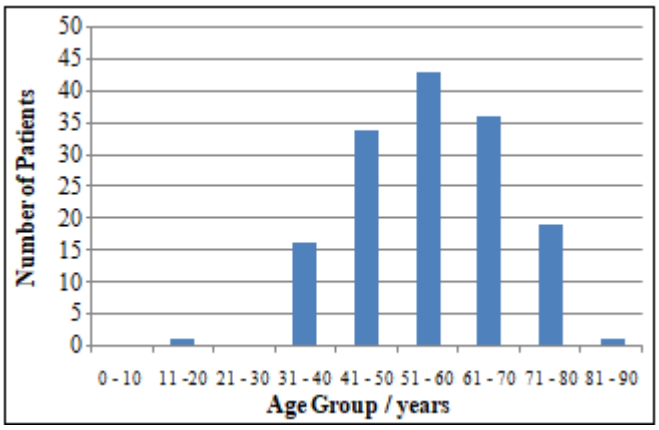

Figure 2: A histogram showing the distribution of patient with corresponding age group in years.

4. Discussions

A total of 150 patients have been collated and they were all adults with the ages ranging from 20-82 years old. These patients were diagnosed for different cancer stages of cervical cancer. From the Table 2; a total of 59 patients were having an advanced stage IIIB and lowest number for the cancer stage was stage IIIwas only one patient. However stage IIA, IIB and IIIA happens to be the most moderately advanced stages. The two most advanced stages were IIB and IIIB which gives a total of 111 patients out of the 150 patients who were diagnosed for cervical cancer at the facility which represents a percentage of 74% of the cervical cancer patients who came for treatment at the facility. From Fig 2;the highest number of patients reported for diagnosis and treatment of cervical cancer occurs between the age group of 51-60 was 43 patients for which they were all women adults.This represents about 28.67% out of the whole percentage of cervical cancer patients reported at the facility. The lowest number occurs in stage IA and stage III which gives total of 3 cervical cancer patients representing a percentage of 3%. This occurs for stage IA having 1.33% and stage III also having 0.66% respectively. However there were no cases for stage IV cervical cancer patients during the period of investigation at the facility.

5. Conclusion

The cervical cancer patients who were reported to the facility have been analyzed and found that most patients come to the facility for treatment after the cancer has been grown into the advanced stages. This proves that the advanced stages are difficult to cure which shows a small survival rate. Since it clear out that cancer can be cured at early stages it is therefore important that patients should report at the facilities for early detection and cure. The Manchester system was used during the investigation at the facility.

6. Acknowledgement

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Appendix

Patient characteristics with cancer stages, prescribed and critical organ doses

Patient ID Number	Age/yrs	Cancer Stage	Prescribed doseto tumour/cGy	Dose to reference pointA/cGy	Rectum dose/cGy	Bladder dose /cGy
001	37	IIB	2500	86.61	45.39	37.69
002	56	IIIA	3000	143.13	18.84	38.80
003	50	IIIB	3000	93.71	26.28	29.14
004	62	IIIB	3000	98.81	18.94	28.83
005	71	IIIB	3000	79.60	45.86	36.40
006	54	IIA	2500	86.10	76.45	50.01
007	62	IIB	2500	105.95	52.93	56.47
008	70	IIIB	3000	81.52	58.23	36.14
009	46	IIB	2500	84.63	38.43	30.04
010	59	IIA	2500	96.66	17.62	42.53
011	40	IIB	2500	80.60	47,03	35.09
012	38	IIA	2500	80.49	30.44	62.59
013	68	IIB	2500	80.30	72.43	68.37
014	69	IIIA	3000	107.68	27.08	38.75
015	52	IIIB	3000	85.06	57.29	26.99
016	43	IIB	2500	90.18	33.63	50.18
017	43	IIB	2500	122.94	47.30	70.90
Patient ID Number	Age/yrs	Cancer Stage	Prescribed doseto tumour/cGy	Dose to reference pointA /cGy	Rectum /cGy	Bladder /cGy
018	56	IIA	2500	79.78	34.86	45.69
019	65	IIA	2500	86.16	69.54	40.47
020	45	IIIB	3000	97.21	19.26	38.97
021	48	IIB	2500	117.20	19.32	30.13
022	59	IIIB	3000	90.96	74.71	30.28
023	67	IIA	2500	69.63	23.55	56.22
024	57	IIB	2500	86.79	30.16	67.47
025	58	IIB	2500	81.31	25.22	43.22
026	47	IIA	2500	74.00	42.45	40.23
027	60	IIB	2500	81.88	62.43	50.86
028	72	IIB	2500	61.33	23.34	48.39
029	71	IIB	2500	89.94	45.87	51.77
030	67	IIB	2500	96.65	10.13	28.69
031	33	IIIA	3000	88.65	62.55	43.95
032	71	IIB	2500	94.98	22.52	61.62
033	54	IIIB	3000	94.53	51.97	30.53
034	44	IIA	2500	83.46	30.77	41.35
035	65	IIA	2500	93.57	33.01	45.53
036	48	IIIA	3000	98.39	37.33	42.44
037	49	IIIA	3000	87.47	54.46	67.05
Patient ID Number	Age/yrs	Cancer Stage	Prescribed doseto tumour/cGy	Dose to reference pointA/cGy	Rectum /cGy	Bladder /cGy
038	54	IIIB	3000	88.92	50.32	36.25
039	59	IIIB	3000	87.88	53.58	38.12
040	64	IIIB	3000	90.69	75.93	59.59
041	46	IIIB	3000	91.91	34.83	43.19
042	53	IIIB	3000	84.92	54.43	37.20
043	50	IIIB	3000	72.03	42.18	30.72
044	55	IIB	2500	92.59	36.60	50.30
045	44	IIIB	3000	85.75	56.64	25.62
046	43	IIIB	3000	78.43	55.74	38.64
047	40	IIIB	3000	81.68	43.45	38.19
048	56	IIB	2500	88.28	57.10	68.66
049	63	IIIB	3000	92.18	50.97	40.76
050	71	IIB	2500	79.73	38.03	43.40
051	72	IB	2500	94.29	68.47	70.61
052	56	IIB	2500	86.77	53.30	65.24

053	61	IIIA	3000	98.36	30.36	43.90
054	40	IIIA	3000	94.87	77.47	65.95
055	40	IIA	2500	109.26	85.67	69.56
056	52	IIA	2500	92.12	57.17	44.19
057	35	IIA	2500	91.05	78.21	58.91
Patient ID Number	Age/yrs	Cancer Stage	Prescribed doseto tumour/cGy	Dose to reference pointA/cGy	Rectum /cGy	Bladder /cGy
058	63	IIA	2500	97.62	43.54	78.81
059	55	IIA	2500	95.94	60.68	37.01
060	49	IIIB	3000	94.43	53.35	65.85
061	51	IIB	2500	100.43	76.05	32.94
062	70	IIIB	3000	70.25	28.85	58.78
063	45	IIIB	3000	84.17	62.11	52.82
064	53	IIA	2500	81.07	33.70	65.18
065	53	IIIA	3000	87.55	61.78	43.50
066	53	IIIA	3000	91.33	77.87	42.59
067	70	IIB	2500	92.12	37.17	24.19
068	72	IIIB	3000	86.41	42.24	68.85
069	52	IIIB	3000	82.17	26.41	40.67
070	35	IIB	2500	82.39	40.80	35.02
071	58	IB	2500	87.72	55.30	48.38
072	55	IB	2500	86.05	60.36	31.16
073	69	IIB	2500	86,63	59.57	37.52
074	48	IIIB	3000	98.05	67.54	58.88
075	80	IIIB	3000	92.40	35.57	60.07
076	61	IIIB	3000	94.87	70.79	61.46
077	62	IIB	2500	94.98	22.52	34.62
Patient ID Number	Age/yrs	Cancer Stage	Prescribed doseto tumour/cGy	Dose to reference pointA/cGy	Rectum /cGy	Bladder /cGy
078	75	IIB	3000	83.13	69.20	49.06
079	48	IIIB	3000	90.26	38.19	59.48
080	50	IIIB	3000	93.83	48.37	53.43
081	52	IIIB	3000	99.40	45.07	30.16
082	43	IIIB	3000	88.71	53.09	37.68
083	46	IIIB	3000	79.93	54.64	38.84
084	72	IB	2500	112.61	75.68	38.37
085	78	IB	2500	87.43	39.62	28.68
086	53	IIIB	3000	109.12	34.77	63.41
087	45	IIIB	3000	91.02	53.88	39.07
088	35	IIA	2500	91.59	25.44	58.56
089	65	IIIB	3000	86.74	31.39	48.40
090	46	IIA	2500	82.10	28.05	32.00
091	65	IA	2000	109.09	35.31	51.32
092	44	IIIA	3000	105.46	56.74	38.24
093	53	IIB	2500	88.12	33.11	48.64
094	45	IIB	2500	97.94	45.44	63.91
095	57	IIIB	3000	87.23	39.86	51.69
096	69	IIIB	3000	91.14	39.48	21.32
097	65	IIIB	3000	103.57	33.01	45.53
Patient ID Number	Age/yrs	Cancer Stage	Prescribed doseto tumour/cGy	Dose to reference pointA/cGy	Rectum /cGy	Bladder /cGy
098	55	IIIB	3000	94.27	51.51	39.26
099	70	IIB	2500	90.04	33.90	40.56
100	56	IIIB	3000	81.88	42.43	62.50
101	48	IIIB	3000	86.24	38.46	50.75
102	79	IIIB	3000	89.82	34.77	63.41
103	82	IIIB	3000	71.32	27.44	58.42
104	70	IIB	2500	128.91	28.61	35.33
105	51	IIB	2500	84.23	57.14	47.44
106	52	IIB	2500	98.13	78.52	50.28
107	61	IIIB	3000	82.50	57.11	60.02
108	70	IIIB	3000	92.31	80.40	72.99
109	63	IIB	2500	98.75	44.51	70.38
110	36	IIB	2500	106.96	52.28	33.69
111	75	IIIB	3000	86.09	34.36	56.16
112	51	IIB	2500	88.11	50.94	62.79
113	64	IIIB	3000	88.13	50.40	54.82

114	62	IIB	2500	89.15	58.34	47.89
115	65	IIIB	3000	85.82	52.28	43.39
116	45	IIIB	3000	79.86	46.06	39.87
117	46	IIIA	3000	78.87	34.80	46.54
Patient ID Number	Age/yrs	Cancer Stage	Prescribed doseto tumour/cGy	Dose to reference pointA/cGy	Rectum /cGy	Bladder /cGy
118	60	IIIA	3000	74.01	38.60	54.34
119	75	IIIB	3000	95.83	44.52	68.89
120	54	IIB	2500	88.89	36.50	41.53
121	70	IIB	2500	88.51	36.39	47.84
122	70	IIB	2500	109.04	45.80	32.62
123	62	IIB	2500	89.99	54.74	67.80
124	55	IIB	2500	92.05	26.76	36.60
125	47	IIB	2500	89.91	36.70	25.64
126	57	IIB	2500	91.49	65.77	51.32
127	55	IIB	2500	93.55	41.63	53.91
128	75	IIB	2500	87.66	46.52	50.25
129	46	IIB	2500	88.57	39.93	50.03
130	61	IIIB	3000	91.85	39.25	50.79
131	39	IB	2500	89.84	33.01	43.42
132	71	IIIB	3000	91.60	58.95	44.03
133	78	IIIB	3000	83.49	66.54	56.53
134	50	IIIB	3000	89.87	55.03	60.60
135	70	IIB	2500	82.22	57.81	65.00
136	38	IIB	2500	94.01	42.68	56.68
137	75	IIB	2500	90.20	55.45	67.65
Patient ID Number	Age/yrs	Cancer Stage	Prescribed doseto tumour/cGy	Dose to reference pointA/cGy	Rectum /cGy	Bladder /cGy
138	55	IIIB	3000	94.43	75.48	61.55
139	49	IIB	2500	90.32	22.47	73.73
140	77	IIB	2500	109.97	53.51	70.25
141	39	IIIB	3000	93.29	27.67	57.87
142	20	IIB	2500	92.93	64.72	43.09
143	40	IIB	2500	121.77	59.51	39.54
144	36	IIIB	3000	92.51	46.48	62.96
145	45	IA	2500	71.53	35.03	55.67
146	70	IIIB	3000	91.13	60.05	38.61
147	55	IIIB	3000	94.21	33.91	44.07
148	56	IIA	2500	81.01	27.54	51.34
149	54	III	3000	153.67	64.33	54.28
150	42	IIIB	3000	88.80	35.56	49.01