DOSE DISTRIBUTION IN TOTAL BODY PHOTON IRRADIATION

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ABSTRACT

In the total body photon irradiation (TBI) of leukemic and lymphoma patients prior to bone marrow transplantation, bilateral opposing beams of the fully opened collimator produced by a 6 MV Clinac 2100C with perspex beam spoiler of 1 cm thick were used to irradiated the Randophantom at a large target surface distance (TSD). The measurements of the radiation doses at the surface and inside the phantom were performed using LiF Thermoluminescent dosemeters. The dose at the center of the abdomen at the umbilicus level was taken as a reference dose.

The first study without bolus and shieldings showed the high surface doses of 125 % and 128 % at the right and left lateral neck respectively. The rest of them were not more than 17 % higher than the reference dose. The largest different doses from the reference for various organs inside the phantom were 33 % at the larynx and 29 % at the cervical cord. The doses at the brain, right lung and left lung were 12 %, 16 % and 18 % higher than the reference dose respectively.

In the second study, the bolus was added to the neck region for uniformity of dose distribution and one half value thickness of shielding blocks were used for both lungs and brain. The surface doses at right and left lateral neck were reduced to 109 % and 104 % respectively. The doses at larynx and cervical cord were 5 % and 2 % higher than the reference dose. The doses variations within ± 10 % were obtained at the surface and inside the phantom while the dose in the shielding region were reduced to approximately 50 %

1. INTRODUCTION

High dose total body irradiation with megavoltage photon beams is used to destroy the bone marrow and malignant cells, and also immunosuppress the patient prior to receiving a bone marrow transplant [1, 2, 3]. Before instituting the TBI procedure, medical physicists have to establish the available and approriate irradiation method that patients should receive most uniform dose distribution without over tolerance dose to critical organs. AAPM report no.17 recommends AP/PA parallel opposed fields although under some conditions (e.g. pediatric cases, higher energies), a ± 10 % uniformity can be acheived with bilateral fields [1]. Due to the complex geometry of the human body, in total, a degree uniformity of ± 10 % is desired [2,4]. The possibility technique performing in our department is bilateral fields with the patient in supine position.

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2. EXPERIMENTAL DESIGN

The experiments are devided into 2 parts.

part I : Determination of the surface dose and the dose inside the phantom without any bolus and shielding block.

part II : The dose determination are the same as part I but the bolus will be employed to improve the dose homogeneity and the shielding blocks will be provided to reduce the dose in some critical organs.

Part I The Clinac 2100C is the equiptment used for delivering 6 MV photon to patients. Due to the limitation of the size of the treatment room and the difficulty in the shielding of certain organs, the possibility TBI technique has to be bilateral fields with the patient in supine position on the special couch close to the wall. The irradiated beam size is 140 x 140 cm^2 in diagonal shape at 350 cm target surface distance as shown in Fig. 1. The Randophantom was used to represent the patient. Due to the effect of low dose in the build up region of 6 MV photon, a perspex beam spoiler with 1.0 cm thick was placed at 15 cm apart from the skin surface for increasing the dose in this region. The mid point of the level at the umbilicus is selected to represent the point of the reference dose [1,4]. The surface dose and the absorbed dose of various organs inside the Randophantom were measured by the LiF dosemeters as Fig. 1.

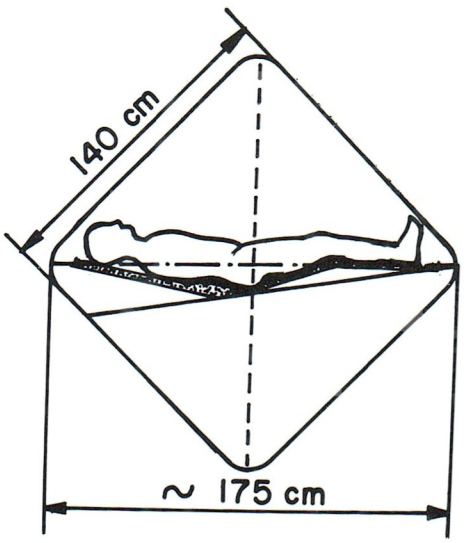

Fig 1. Field size at TSD 350 cm.

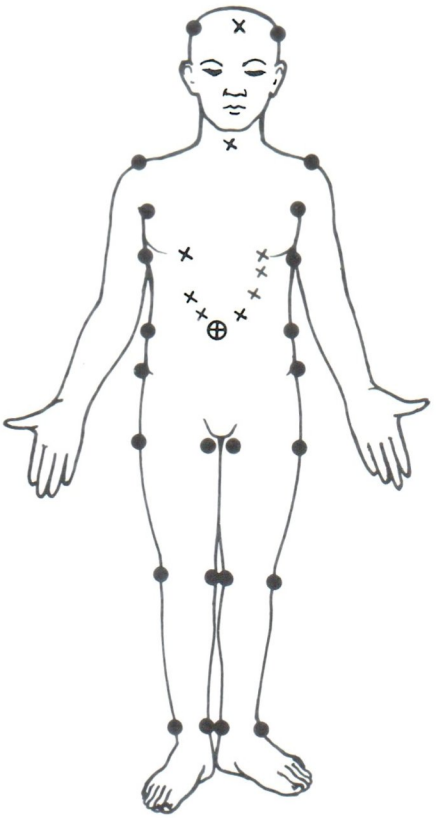

Fig 2. Position of TLD dosemeters for surface doses and doses of the organs inside the phantom.

Part II The blocks with one half value thickness (HVT) were used to reduce the doses of both lungs and brain to be a half of prescribed dose (which is the technique used at Ramathibodi Hospital) to decrease the pulmonary fibrosis and leukoencephalopathy [2]. The small rice bags were used as the bolus for missing tissue at the neck region.

3. DOSE CALIBRATION

A 0.6 cc cylindrical chamber with Ionex Dosemaster electrometer were used for dose calibration in a water phantom at 5 cm depth, 140 x 140 cm^2 in diagonal shape, 350 cm TSD. The percent depth dose along the central ray were measured under the same geometry by the silicon diode detector with RFA-300 scanning system of Scanditronix. The perspex beam spoiler with 1.0 cm thick was also placed at a distance 15 cm from the water phantom surface to produce the scattered radiation to the phantom surface. Fig. 3 shows the plot of the depth dose along the central axis.

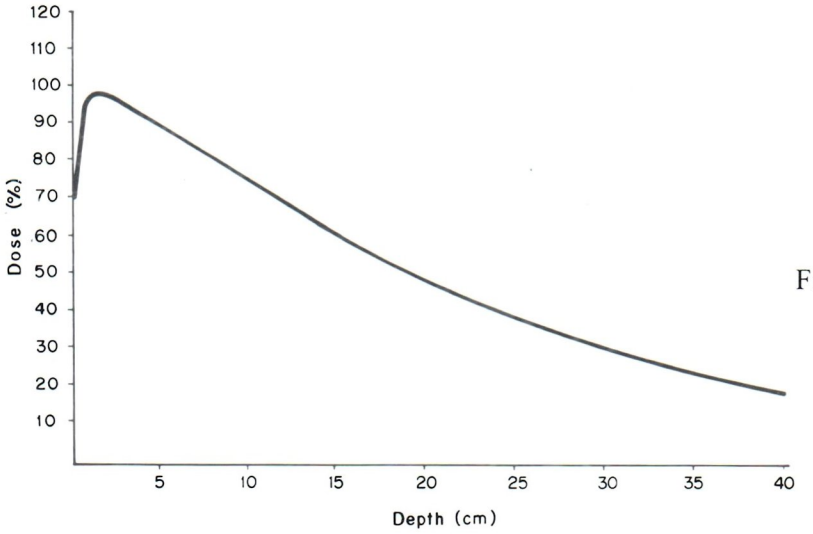

Fig 3. Central axis percent depth dose for 6 MV photon in a water phantom with a perspex beam spoiler of 1 cm thick 15 cm apart from the surface. field size 140 x 140 cm^2 , 350 cm TSD, diagonal setting.

4. RESULTS

4.1 Part 1 experiment

Table IA illustrates the higher doses at the surface of the head, neck and chest than the dose at the reference point for 9, 25 and 16 % respectively. The doses inside the phantom at the brain, the larynx, cervical cord, heart and both lungs in Table IB were more than 10 % higher than the reference dose.

Table I Doses at various points as the percents of the reference at the mid point of umbilical level, without bolus and blocks.

A : Surface doses

Organ	Surface dose (%)	
	Right	Left
head	110	109
neck	125	128
shoulder	90	99
axilla	116	116
chest	117	116
waist	103	102
hip	94	95
thigh	94	95
wax phantom -		
lateral knee	106	101
medial knee	97	98
lateral ankle	107	111
medial ankle	110	106

B : Organ doses

Organ	Organ dose (%)
brain	113
larynx	133
cervical cord	129
heart	112
lung (Rt, Lt)	116 , 118
liver	114
spleen	110
kidneys (Rt, Lt)	87 , 90
mid point at the level of umbilicus	100
ovary (Rt, Lt)	89 , 90

4.2 Part II experiment

The doses at the neck surface from the experiment in part I were reduced by placing the rice bags as the bolus for the missing tissue at the neck region (Table IIA). The doses in the brain and both lungs were reduced about 50 % due to the 1 HVL of MCP 96 were used as the shielding blocks (Table IIB). The doses were remarkly reduced 27 % at the cervical cord and 52 % at the heart due to the bolus at the neck region and the 1 HVL lung blocks (Table IIB).

Table II Doses at various points as the percents of the reference at the mid point of umbilical level, with bolus and blocks.

A : Surface doses

Organ	Surface dose (%)	
	Right	Left
head	52	50
neck	66	96
shoulder	99	102
axilla	60	79
chest	59	58
waist	107	106
hip	95	97
thigh	94	96
lateral knee	104	100
medial knee	102	100
lateral ankle	108	103
medial ankle	110	109

B : Organ doses

Organ	Organ dose (%)
brain	53
larynx	105
cervical cord	102
lung Rt, Lt	62 , 62
heart	60
liver	61
spleen	59
kidney Rt, Lt	67 , 66
mid point at the level of umbilicus	100
ovary Rt, Lt	84 , 93

5. DISCUSSION

The bilateral fields TBI with the patient in supine position can undergo irradiation without discomfort and distortion of some organs. The surface and inside organ doses excluded the shielding organs achieved the uniformity within ± 10 %. The dose at the neck with bolus was 9 % higher than the reference dose because of the thickness of the bolus used was not enough to compensate the missing tissue. So the appropriate bolus thickness should be placed carefully at the neck and should not enlarge to cover the shoulder. The size of the brain and lung blocks should be individualized and have to be located at the correct position that will not protect the irradiated organs.

Before treating the patient, the multiplication of correction factors [1] for adjusting the absolute dose in the patient that is different from that in the phantom due to the larger treatment field size than the patient, should be done.

6. REFERENCES

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