DOSE UNIFORMITY IN ^{60}CO TOTAL BODY IRRADIATION : MULTIPLE FIELD TECHNIQUE

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ABSTRACT

Study of dose uniformity in total body megavoltage photon irradiation (TBI) from Cobalt-60 teletherapy machine were undertaken by using LiF Thermoluminescent dosimeter (TLD) and Alderson Rando phantom. Halfbody technique with multiple adjacent direct field technique is used in conjuntion with AP/PA position. The prescribed dose at mid plane of the rando phantom is 1200 cGy. From the study, the variation in dose throughout the whole body of phantom ranges from the lowest dose 967.2 cGy on a mediastinal region to the highest of 1337.5 cGy maximum dose to the area of neck. The measured organ doses are 901.5- 945.4 cGy at lens , 723.8- 890.8 cGy at lungs , 1131.2-1154.8 cGy at kidneys, 1144.7-1186.4 cGy at liver and 1135.3-1181.4 cGy at small intestine. The dosimetry revealed that this technique of TBI deliver a uniform dose to the entire body within ± 7.05% of the dose at the prescription point.

INTRODUCTION

Total body irradiation is used in conjunction with high dose chemotherapy to achieve tumour eradication and immunosuppression prior a bone marrow transplantation (BMT).[1,2,3] There is considerable variation in the technique used , depend on the machine availability.[4] For large field radiotherapy, the irradiation method must be produced radiation field large enough to cover the entire target volume adequately. Basic dosimetry should be performed prior the initiation of a magna field treatment technique because of the unusual geometric condition. Dose uniformity should be within ±10 % of the dose at prescription point.[5] The anthromorphic phantom measurement by using TLD is required to verify the technique suitability. In this study , the dose distribution of TBI technique , Halfbody technique with multiple adjacent direct field at Division of Radiation Oncology , Siriraj Hospital was investigated for its suitability by using TLD.

MATERIAL AND METHOD

Due to the limited size of our treatment room (5mx6 m) , TBI was achieved by physical arrangement as in fig.1 and was characterized in Table 1.

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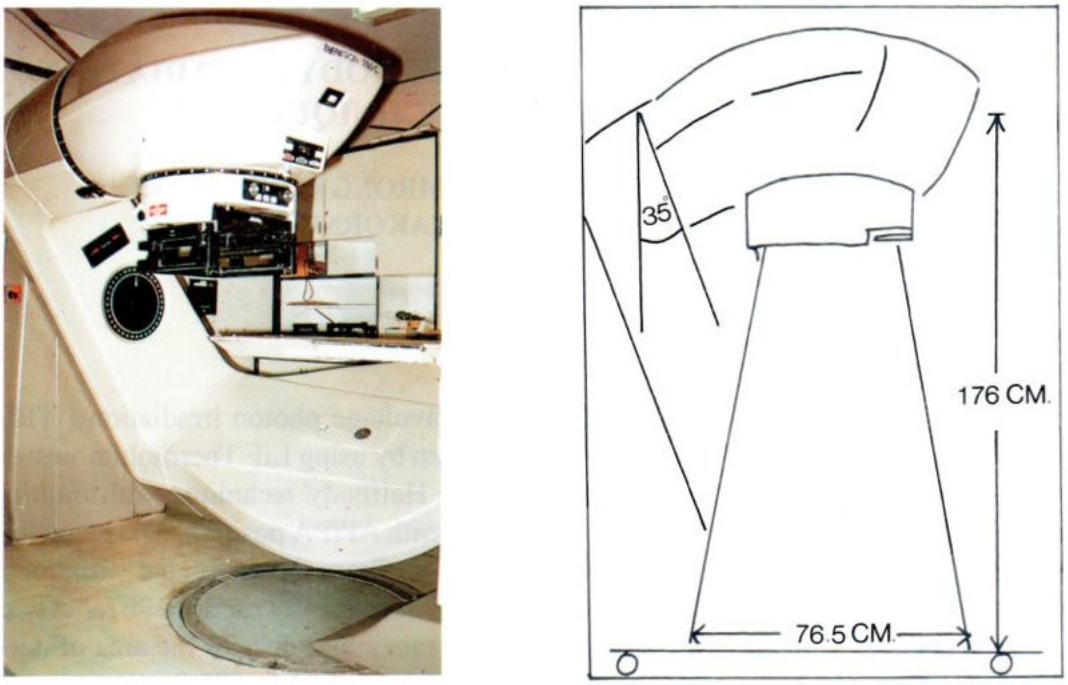


Fig.1 Treatment geometry of Cobalt-60 unit in small therapy room (170 cmSSD)

Table 1. The physical characteristic of ^{60}Co unit for TBI technique

Source	:	^{60}Co gamma-rays
SSD	:	170 cm
Maximum field size	:	76.5 cm x 75.4 cm
Dose rate average	:	40 cGy/min
Patient position	:	supine and prone
Delivery method	:	anterior and posterior
Treatment technique	:	multiple field (half body,adjacent direct field)
Lung shielding	:	1 HVL
Total tumour dose	:	1200 cGy (200 cGy x 6 fractions)

A Rando phantom which is completed with arms and legs made from wax was positioned supine and prone on the special couch on the floor as shown in fig. 2.. Since the maximum field size did not cover the entire body of the phantom, the treatment field was designed to divide into three fields (Fig 3) The mid point of the umbilicus level was chosen to be the reference point and the radiation dose delivered to this point was 1200 cGy to this point. An Lipowitz alloy of 1 HVL lung block thickness was used to reduce lung dose to 50%.

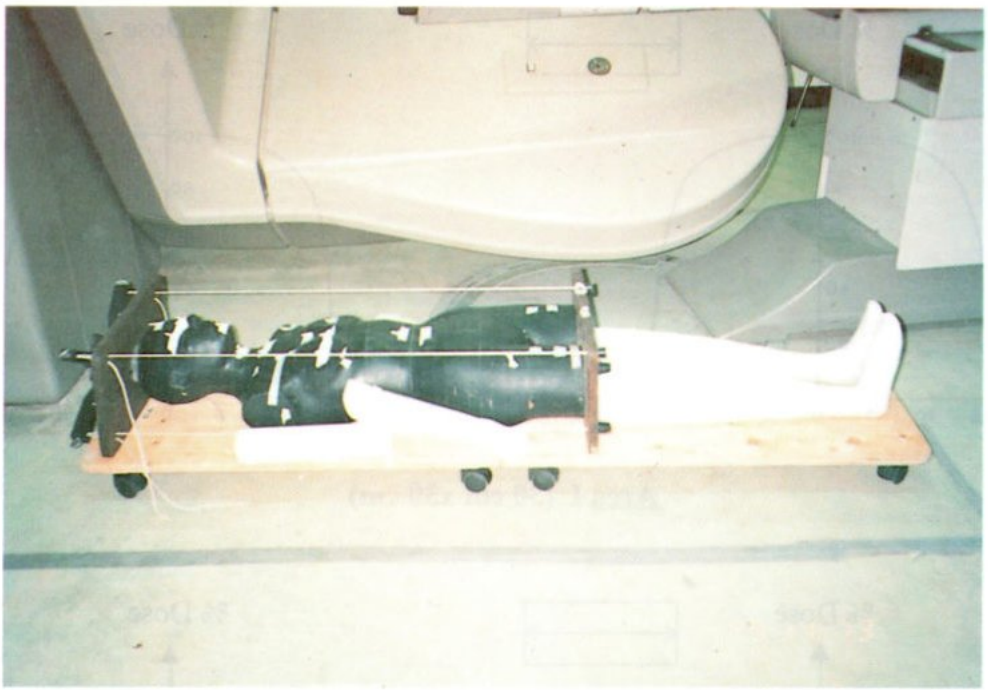


Fig 2. A complete Rando phantom lied on a special couch in treatment geometry.

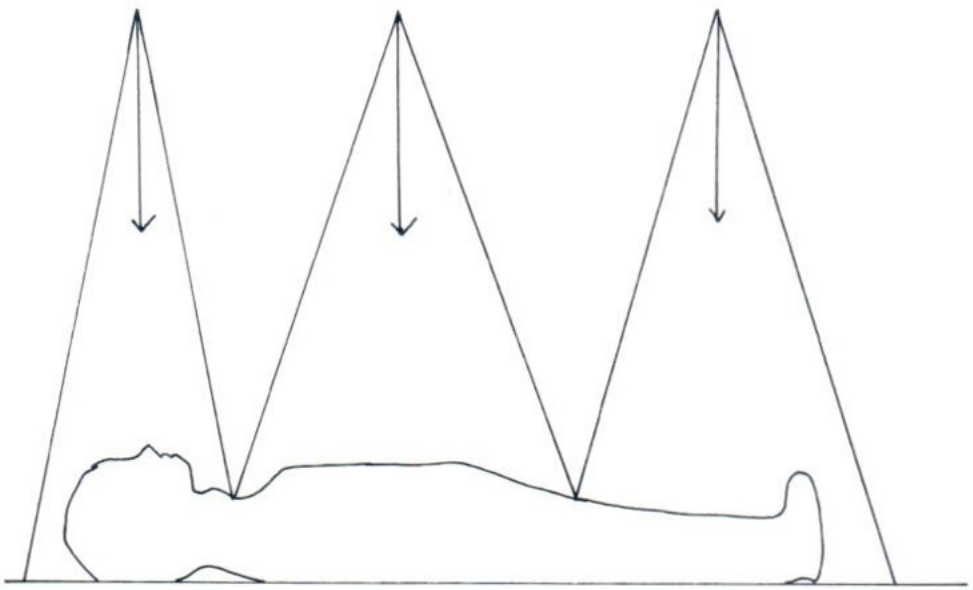
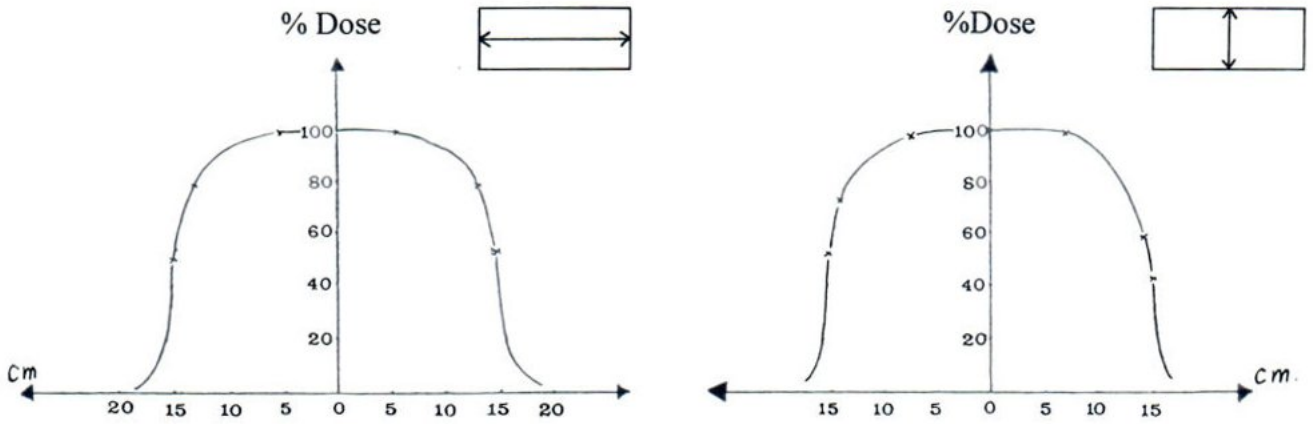
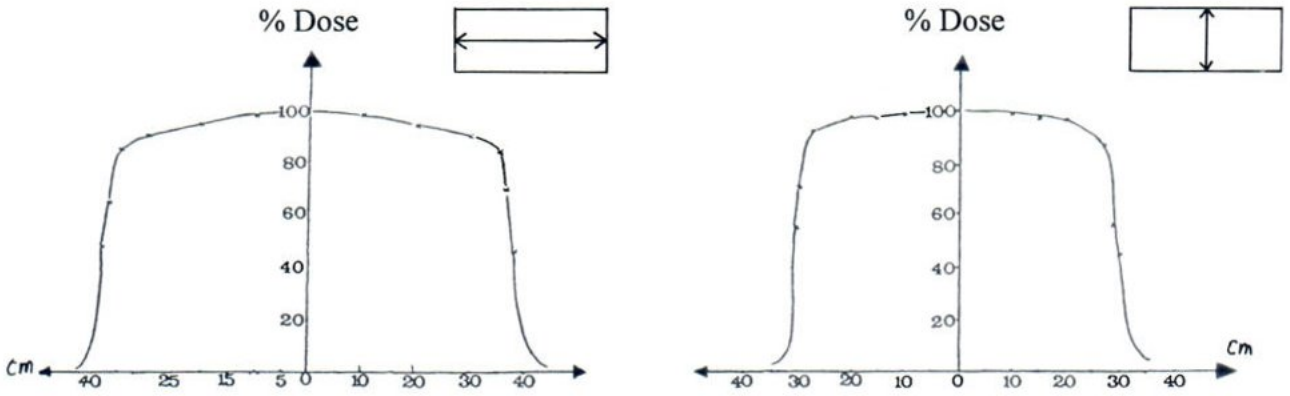


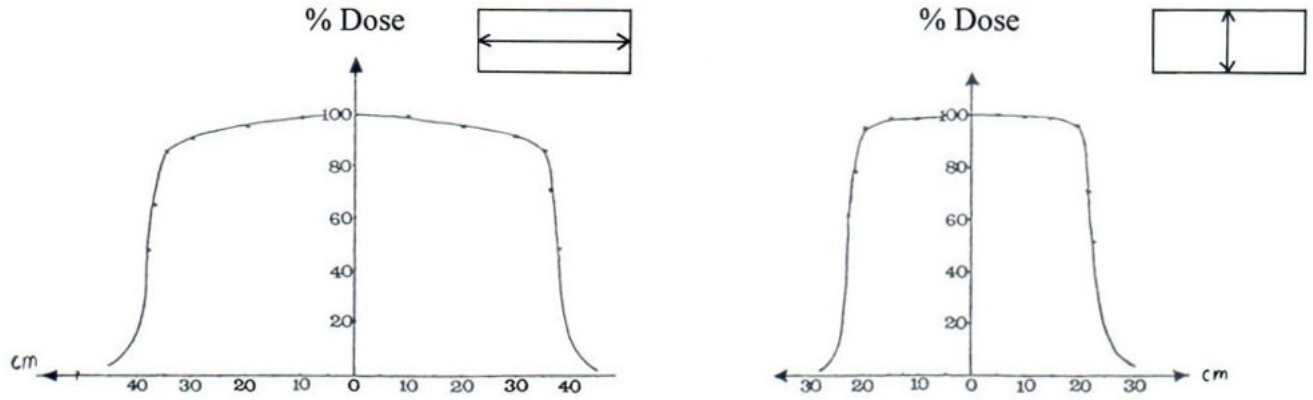
Fig. 3 Irradiation method : multiple field (halfbody, direct adjacent field)



Area I (30 cm x30 cm)



Area II (57 cm x72 cm)



Area III (47 cm x 76.5 cm)

Fig. 4 Beam intensity profile of each treatment field at 170 cm SSD in TBI irradiation

BEAM PROFILE AND OUTPUT MEASUREMENT

The symmetry of the beam intensity across and along the treatment field was measured in air by eight semiconductors (Rainbow type 30-490-80). Output measurement performed in water phantom at the TBI distance of 5 cm depth by the ionization chamber Farmer Dosemeter type 2570/1 NE. The percentage depth dose at TBI distance was converted from the usual 80 cm SSD by Burn's equation.[6]

VERIFICATION DOSIMETRY

Absorbed dose for eleven tranverse sections (brain,neck,mediastinum,abdomen and pelvis region) measured with TLD were accomplished. The surface dose were measured at lens, thighs and legs. The radiation dose was calculated to give 100 cGy to the prescription point for both anterior and posterior port.

RESULT

The results of beam intensity profile for each treatment field was shown in Fig. 4 It can be seen that 80% of field width is fitted in 90% of maximum dose level. Therefore , each treatment field would have a good symmetry. This mean that the most patients whose body width less than 45 cm. can be performed.

Table 2 lists the doses in various sections of the Rando phantom. From the data, it can be seen that the uniformity of dose throughout the whole body of phantom is within ± 7.05% of the dose at the reference point.

Table. 2 The measuring doses as the percentage of dose at reference point in various sections of rando phantom

Sites	Numbers of measuring points	Measuring doses (%)
Brain (Section # 3, 4)	5	90.4-100.00
Neck (Section # 8)	4	99.4-111.5
Chest (Section #15,16,17)	4	80.6-84.6
Abdomen and pelvis (Sec # 23,24,26,29,33)	26	91.3-103.4
Averaged dose	39	96.02±7.05

General agreement with prescribed dose can be seen for most region of the phantom. It is noted there are four measuring points having lower dose comparing to the others

Since the organ dose at the prescribed point from this experiment is set to 200 cGy, therefore, the total organ dose given to reference point can be calculated to 1200 cGy. The dose measured at each organ are summarized in Table 3.

Table 3 The radiation dose to various organs from irradiating 1200 cGy on the prescription point of the Rando phantom

Organs	Radiation dose (cGy)
Lens	901.5-945.4
Lungs	723.8-840.8
Kidneys	1131.2-1154.8
Livers	1144.7-1186.4
Small intestine	1135.3-1181.4
Large intestine	1199.8-1212.5
Rectum	1161.9
Skin (thigh, legs)	1090.6-1146.1

DISCUSSION

Most of the measuring points (35 from 39 points) have a good agreement with the prescribed dose. Except the four points at mediastinum that the dose are quite low (80.4-84.6 % of prescribed dose) when compared to the others. It is found that these four low dose points are the positions of TLD under the perspex shielding tray designed for lung shielding block . Because of the length of this shielding tray is only 1/3 of the treatment field length , the correction factor for tray attenuation (about 7% of primary dose) and PDD for irregular field were not taken into account for dose calculation.

For large-field radiotherapy , the delivery of a uniform dose of radiation over the entire target volume is not a simple task. This report is an attempt to verify the uniformity of the dose delivered to the patients under the unusual geometric condition with the conventional facility. It is found that the thinner perspex sheet or net shielding tray should be replaced the old one and Clarkson' method should be provided in dose calculation for large area blocked treatment field. However, it can be concluded that for the TBI technique, multiple field (halfbody,adjacent direct field) would be given a satisfactorily uniform dose.

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Foot Note: PDD = Percentage Depth Dose, TAR = Tissue Air Ratio, TMR = Tissue Maximum Ratio, TPR = Tissue Phantom Ratio.