Original Article

Comparison of Lead and Cerrobend Blocks for Incident Photon Flux of 6 and 15 MV X-rays

Iftikhar A[1], Wazir M[2], Kakakhail MB[3], Sbilal A[3], Amjad H[2], Khwaja A[1], Khushnaseeb A[1]

Abstract

Background: During radiotherapy treatment, critical organs are shielded using lead and cerrobend blocks. The objective of this study is to compare the effects of lead and cerrobend shielding blocks on incident photon beam.

Methods: Collimator scatter factors were measured for open square fields (3 x 3 cm to 40 x 40 cm) defined by collimator jaws and for fields blocked down to smaller asymmetric fields by using five different Lead and Cerrobend blocks for 6 and 15 MV photon beams from a Varian Clinac 2100C accelerator. The measurements in air were performed using Farmer type ionization chamber fitted with acrylic build up caps.

Results: The Block Tray Factor (BTF) increased with field size for both 6 and 15 MV photon beams. In case of Lead blocks, the extreme variations in BTF for 6 MV photon beam are 0.70 %, 0.84 %, 0.56%, 0.80 % and 1.15 %. Similarly, for 15 MV the maximum variations for Lead blocks are 0.46 %, 0.60 %, 0.83 %, 0.88 % and 1.10 % respectively. No significant difference has been observed in the BTF of Cerrobend blocks for 6 and 15 MV photon beams.

Discussion: The dose received by a point in air apparently shielded by lead blocks has three main contributions: 1. Due to primary photon beam transmitted through the block, 2. Due to scattered photons, 3. Due to contamination electrons. These three factors collectively cause the increase in BTF with increasing field size, energy, and decreasing block size.

Conclusions: The effect of shielding on the beam output increases with field size, beam energy and shield size. This increase follows almost the same pattern for both lead and cerrobend shielding blocks. Therefore shield factors for all field sizes, beam energies and shield sizes should be determined separately for precise patient dose delivery.

Keywords: Cerrobend shielding blocks; Output factor; Build up caps

Please cite this article as: Iftikhar A, Wazir M, Kakakhail MB, Sbilal A, Amjad H, Khwaja A, Khushnaseeb A. Comparison of Lead and Cerrobend Blocks for Incident Photon Flux of 6 and 15 MV X-rays. Iran J Cancer Prev.2011; Vol4, No1, P10-14.

1. Center for Nuclear Medicine And Radiotherapy (CENAR), BMC Complex, Quetta, Pakistan
2. Institute of Nuclear Medicine, Oncology and Radiotherapy, Abbotabad, Pakistan
3. Pakistan Institute of Engineering and Applied Sciences (PIEAS) Islamabad, Pakistan

Corresponding Author:
Iftikhar Ahmad; MS of Medical Physics
Tel: (+92) 081 92 13 224
Email: iahmadmp@gmail.com

Received: 1 Sep. 2010
Accepted: 4 Dec. 2010
Iran J Cancer Prev 2011; 1:10-14

Introduction

The goal of radiotherapy is to deliver accurate dose to the cancerous tissues and simultaneously avoiding the unnecessary dose to the healthy tissues. Therefore it is essential that field shaping be as perfectly individualized to the patient as possible. Standard lead shields for critical organs such as lungs, kidney etc were used initially. However, these standard blocks cannot be used for patients of every age and anatomy. Moreover custom field shaping for other critical structures was not possible too. Nowadays the most common system for customized beam shaping consists in a low melting point alloy, called cerrobend. This system finds a wide spectrum of applications for almost all energies and field sizes in radiotherapy. For example, customized shields for critical organs such as lungs, kidneys etc. are made for individual patients treated with large fields (Mantle field for Hodgkin's disease or total body irradiation for hematological malignancies) [1-3]. Similarly, a testicle shield locally fabricated in mould room has been used for the treatment of Seminoma Testis by Inverted Y portals [4]. Also relatively small shielding blocks used in the treatment of head and neck cancers can be fabricated easily.

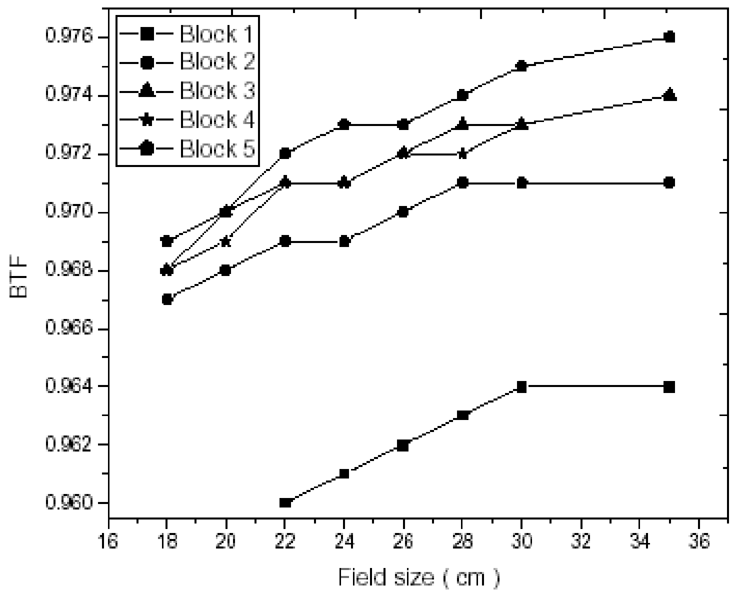

Figure 1. Block Tray Factor (BTF) of lead blocks as a function of field size for 6 MV photon beam

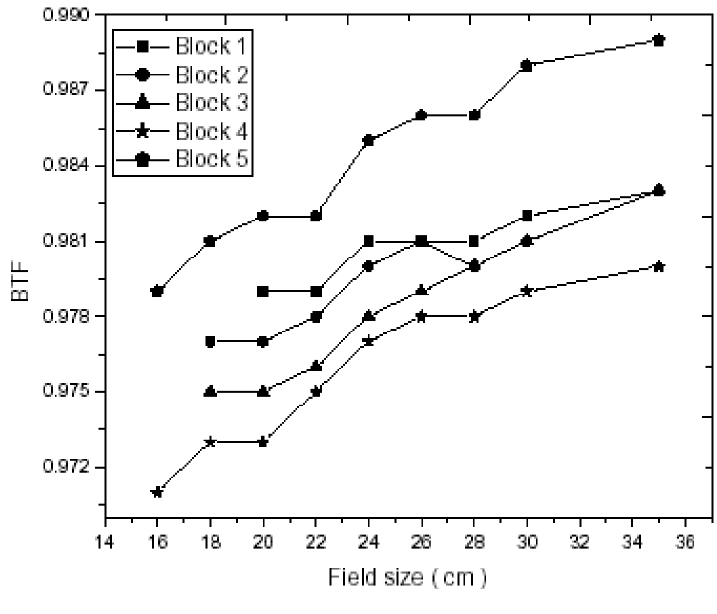

Figure 2. TBF of lead blocks as a function of field size for 15MV photon beams

Thickness of shielding block is determined by the energy of the treatment beam. But, usually standard lead blocks of same thickness are used for each energy of the treatment beam. Similarly, cerrobend blocks normally fabricated in the mould room using styrofoam cutting system did not consider the beam energy [5].

Most dosimetry calculation systems ignore the effect of shield block size, field size and beam energy on the incident photon flounce based on the belief that it is small and difficult to model for different block and field sizes and energies. Instead, a single-value tray transmission factor is usually measured with a 10 cm x 10 cm field and used for all field and block sizes [6]. The purpose of the present study is to investigate the variation in collimator scatter factor in the presence of shielding

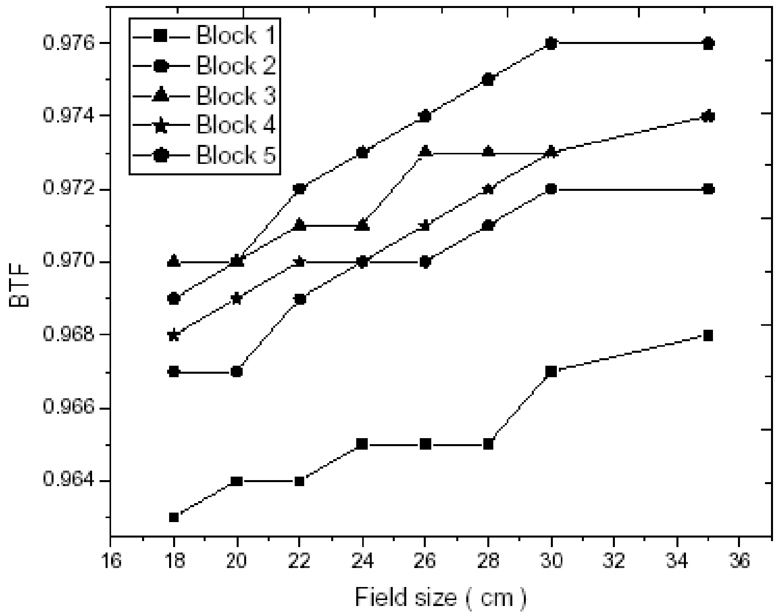

Figure 3. BTF of cerrobend blocks as a function of field size for 6 MV photon beam

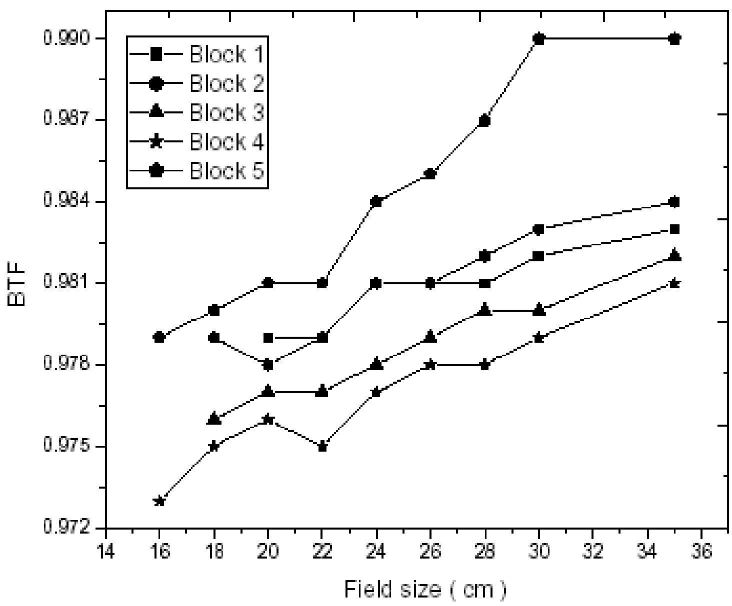

Figure 4. BTF of cerrobend blocks as a function of field size for 15 MV photon beam

blocks in the path of radiation beam and its field size and beam energy dependence.

Materials and Methods

The photon beams used in this study had energies 6 and 15 MV generated by a Varian linear accelerator (Clinac 2100C) installed at the Institute of Nuclear Medicine, Oncology and Radiotherapy (INOR) Abbottabad, Pakistan. Scanditronicx-Wellhofer Farmer type ionization chamber (FC65-G) with inner diameter of 6.2 mm and having an active volume is 0.65 cm3 has been used. All measurements were taken with the detector set with its central axis perpendicular to the beam axis and isocentrically positioned at the reference depth in empty water phantom (set at 100 cm). Acrylic build up caps with diameters of 30 cm and 50 cm has been used for 6 and 15 MV photon beams respectively. The field size was larger than the buildup cap in each case. Square fields with side length ranging from 3 cm to 40 cm were studied. A 6 mm thick Lexan Block tray with 86 standard holes at different positions was used. Lead and Cerrobend shielding blocks has been used in this study for comparison. The five different blocks of each type included one square block (5 cm x 5 cm), two rectangular blocks (2.2 cm x 7.5 cm and 1.3 cm x 7.5 cm), one semi-circular block (5 cm diameter) and one circular block (1.3 cm diameter). These blocks were named as 1, 2, 3, 4, and 5 respectively. The thickness (or height) of each block was 7.5 cm. These blocks were mounted on Lexan tray one by one and inserted in the accessory mount of treatment head. The source to tray distance was 56.7 cm.

Results

The X-ray beam used for the investigation of Block Tray Factor had energies of 6 and 15 MV generated by a Varian Clinac 2100C linear accelerator. The measurements were performed in air using Farmer type ionization chambers placed on the beam central axis at the reference depth of d_{max} in acrylic build up caps. The reference depths for 6 and 15 MV photon beams are 1.6 and 2.9 cm respectively.

Standard Lead Blocks

The field size dependence of Block Tray Factor (BTF) for five standard Lead shielding blocks of different shapes and dimensions using 6 MV photon beam has been measured with Farmer type chamber placed in acrylic build up cap. The BTF data obtained is plotted as a function of field size in figure 1. There is a gradual increase in BTF for all five standard shielding blocks. The BTF increases with increasing field size and decreasing block dimensions. The maximum variations in BTF with field size for block 1, 2, 3, 4 and 5(This nomenclature for these blocks was introduced before) are 0.40 %, 0.45 %, 0.63 %, 0.63 % and 0.75 % respectively. This story repeats itself for BTF measured with 15 MV photon beams under same experimental setup. Figure 2 shows the corresponding plot of BTF against field size. The variations in BTF for 15 MV photon beams are prominent than the corresponding 6 MV photon beam. These variations for standard blocks 1, 2, 3, 4 and 5 are 0.46 %, 0.60 %, 0.83 %, 0.88 % and 1.10 % respectively.

Cerrobend blocks

To compare the effects of lead and cerrobend shielding blocks, five cerrobend blocks of same size as that of lead blocks has been used. The BTF of these cerrobend blocks as a function of field size has been measured with Farmer type ionization chamber fitted with acrylic build up caps for 6 & 15 MV photon beams. The variations of BTF for 6 MV photon beams as a function of field size are presented in figure 3. The BTF variation follows a gradual and undefined increase with field size. These variations in BTF for block 1, 2, 3, 4 and 5 are 0.50 %, 0.56 %, 0.42 %, 0.57 % and 0.75 % respectively. The BTF plot as a function of field size for 15 MV photon beams is displayed in figure 4. The same gradual increase in BTF with field size for all five cerrobend blocks has been observed.

Discussion

The objective of this study was to compare the effects of lead and cerrobend shielding blocks on incident photon beams of 6 and 15 MV energies. The effect of shielding on the beam output increases with field size, beam energy and shield size. This increase follows almost the same pattern for both lead and cerrobend shielding blocks.

The dose received by a point in air apparently shielded by lead blocks has three main contributions: First, due to primary photon beam transmitted through the block which is obviously higher for 15 MV than 6 MV photon beams (since all blocks are of same thickness). Also for blocks of larger size (length and width) this component will be smaller. Second, due to scattered photons which are primarily originated from the face of the shielding block. This component will increase with increasing field size, energy, and block size. Third, due to contamination electrons that is enhanced by increasing field size and energy. The blocks absorb the contamination electrons from the accelerator head and replace them by its own. These three factors collectively cause the increase in BTF with increasing field size, energy, and decreasing block size.

For same thickness of blocks and energy of photon beam, the measured BTF depend on the attenuation and scattering of the photon beam by the shielding blocks. Both these processes depend on atomic number of the material. The atomic number of Lead is 82 while the effective atomic number of Cerrobend is 76.84. Therefore both attenuation and scattering of the photon beam by the Lead blocks will be prominent as compared with Cerrobend blocks. Therefore almost similar results have been obtained.

Conclusion

The effect of shielding on the beam output increases with field size, beam energy and shield size. This increase follows almost the same pattern for both lead and cerrobend shielding blocks. Therefore shield factors for all field sizes, beam energies and shield sizes should be determined separately for precise patient dose delivery. Moreover, the perturbation of the incident beam by both lead and cerrobend blocks are almost equivalent.

Acknowledgment

None

Conflict of Interest

The authors have no conflict of interest in this article. No funding had been received from any organization.

Authors' Contribution

This study was designed by MW and AH while literature review was done by MBK and SBA. The corresponding author analyzed the data and wrote the paper. KhA and KA contributed to the data entry process.

References

1. Li FM, Luo W, He ZC. Dosimetric analysis of radiotherapy with middle shielding blocks of different widths at the lower cervical supraclavicular field for stage N2-3 nasopharyngeal carcinoma. Ai Zheng. 2007; 10:1127-32.
2. Ravichandran R, Binukumar JP, Davis CA. Simple technique for fabrication of shielding blocks for total body irradiation at extended treatment distances. Indian J of Med Phy. 2009; 34 (4): 223-5.
3. Ravichandran R, Krishnamurthy K, Sivakumar SS, Davis CA, Mohanti BK, Ghamrawy KE. Dosimetry of large field photon irradiations at extended treatment distances with linear accelerators. J Med Phys. 2006; 31:126-7.
4. Ravichandran R, Binukumar JP, Kannadhasan S. Testicular shield for para-aortic radiotherapy and estimation of gonad doses. Med Phys. 2008; 33(4): 158-61.
5. Khan FM. Treatment Planning III; Field Shaping, Skin Dose, and Field Separation: Pine J. Standen M, Kairis LR. Physics of Radiotherapy 3rd Edition, New York. Lippincott Williams and Willeins, USA. 2003, 274-5.
6. Paul A. J. Changes in incident photon fluence of 6 and 18 MV X-ray caused by blocks and block trays. Med. Phys. 1999; 26(10). 2092-8.