LEAD BEADS: THE USE AS THE IRREGULAR FIELD SHIELDING

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ABSTRACT

The use of lead beads in the irregular field shielding to replace the normal custom block is presented. By studying the shielding efficiency of two bead sizes (3.52 ± 0.37 mm and 5.13 ± 0.43 mm in diameter) with two packing methods, pressure and unpressure packing. From the study, it revealed that the small beads with pressure packing method (HVL= 1.6 cm) has a little higher shielding efficiency depending on the dense of the beads. To provide the convenience in a practical use, the two perspex trays were designed to mounted with the collimator beam shaping rails (MURT 37/1) and table mounted beam shaping tray (MURT 37/2) to fit to the treatment couch of the Cobalt-60 machine for the larger field size. Test of accuracy and reproducibility in shielding position were accomplished by radiographic film. Comparison of shielding effect between the shielding blocks made by alloy and lead beads are also presented. Advantages in the use of lead beads are the ease and rapidity construction. Moreover, it is economical and no need of melting in the re-used. The only problem is that much care has to be taken for the correct position of the shielding block. It can be concluded from the study that the lead bead is practical for shielding irregular shaped field, especially in an urgent situation in megavoltage therapy.

INTRODUCTION

The shaping of treatment fields is primarily dictated by tumour volume. Not only the critical organs but also the normal tissue surrounding should be spared. From this reason, the treatment fields sometimes are complex and irregular in shape that required the use of shielding block. Most common the shielding blocks are made of lead. But in 1973, Power et al.[1] suggested the use of alloy (or Lipowitz metal or brand name cerrobend). The alloy is a combination of bismuth 50%, lead 26.7%, tin 13.3% and cadmium 10%. The advantage of alloy to lead is its lower melting point (70°C) than lead's (327°C).[2] Thus it can be easily made into any shape. However, some problems encountered in the use of alloy. Primarily ,in Thailand, alloy was introduced from abroad, so the cost is very high (approx 800 baht/kg). Secondly, in the process of making alloy, without attention, sometimes there are air bubbles inside that they can minimize the shielding efficiency.[2] Finally , it takes 1-2 days before alloy shielding block can be introduced to the patients. Therefore the use of lead beads to replace the alloy in the irregular field shielding has been developed. Since it is economical (20 baht/kg) and no need of melting in the re-used process. This study will investigate the shielding efficiency , the procedure of construction and the convenience in the use of lead beads compared with alloy.

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MATERIALS AND METHODS

1. Cobalt-60 Teletherapy machine
2. Farmer Dosemeter type 2570/A/B
3. Water phantom 30 x 30 x 20 cm3.
4. Styrofoam cutter
5. Densitometer
6. Two lead bead sizes (3.52 ± 0.37 mm and 5.13 ± 0.43 mm diameter)
7. Perspex sheets

The investigation in shielding efficiency between the two sizes of lead beads and the methods of packing them into the styrofoam block mold was done by measuring the transmitted radiation in water phantom compared between the same thickness of lead beads and the two packing methods. In the first packing method, lead beads were packed randomly by filling in the mold cavity. The second method is the same as in the first one but only this time the pressure was added at the bead front surface until they were packed and lied dense firmly together. After this packing processes, the transmitted radiation at various points of lead beads in the block mold will also be measured to find the uniformity of shielding efficiency.

After the first measurement, the size of lead beads and the packing method will be chosen to carry on the HVL findings. Then the two perspex trays were designed to hold the styrofoam block mold with the lead bead inside for at least 5 HVL in depth. The first tray will be fit with the collimator beam shaping rail of the Cobalt-60 machine. Because of the thickness of the styrofoam block, there is no room between the shaping tray and the outer surface of the collimator so the maximum treatment field feasible to this tray was only 26x26 cm². This tray was called MURT 37/1. (Fig 3) To overcome such a problem another tray was designed to fit with the treatment couch for the large treatment field, like Mantle or inverted-Y, the maximum field setting was enlarged to 35x35 cm² as shown in Fig 4.

In order to study the shielding efficiency of leads beads compared to alloy, both materials were constructed at the same thickness (5 HVL). By the shielding tray MURT 37/1 and MURT 37/2 the shielding blocks were made for inverted-Y and mantle field treatment respectivety. Exposed these two different materials shielding blocks with radiographic film and measured the transmitted radiation in term of the optical density by densitometor. Time consuming in each step of construction was also recorded to compare between alloy and lead beads. Test of accuracy and reproducibility in the shielding position was done by port film.

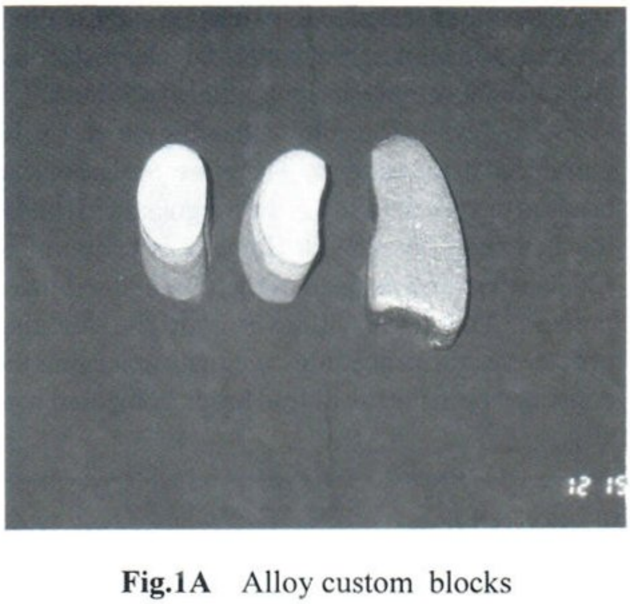
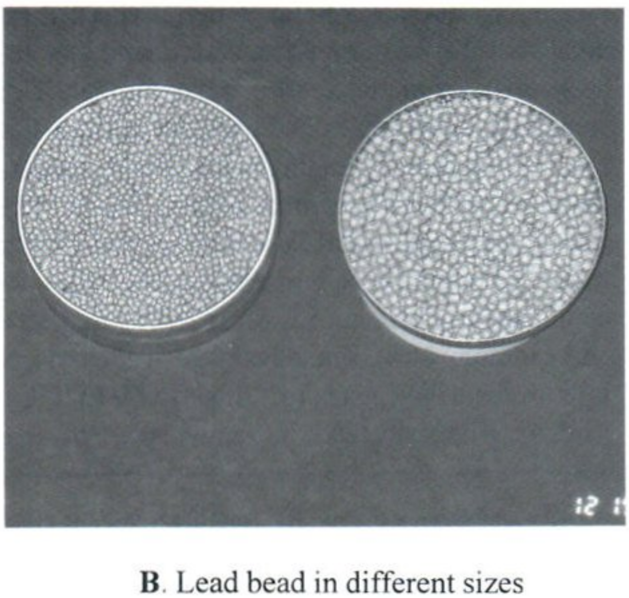
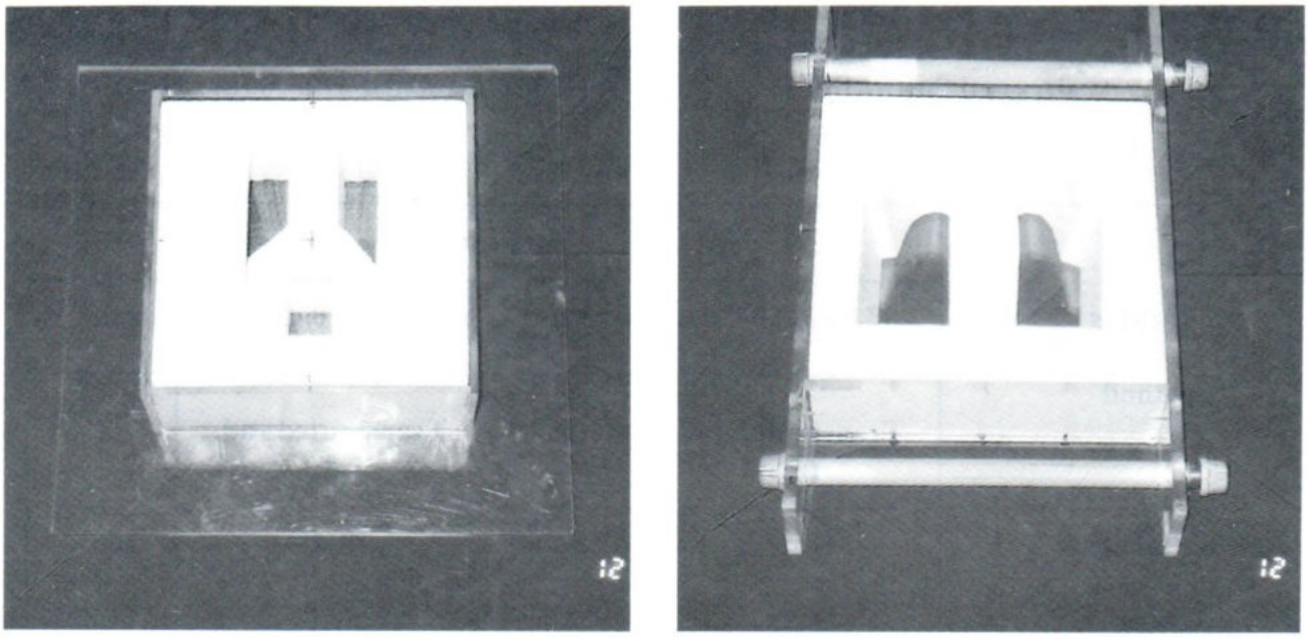


Fig.1A Alloy custom blocks



B. Lead bead in different sizes



MURT 37/1 **MURT 37/2**

Fig.2 The perspex trays MURT (37/1) and MURT (37/2)

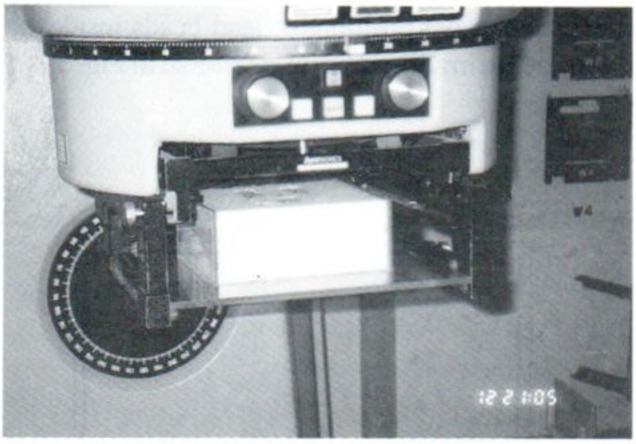


Fig.3 The collimator shielding tray (MURT 37/1) that available for maximum field size 26x26 cm^2

RESULTS

The shielding efficiency was performed by measuring the transmitted radiation in water phantom by NE dosemeter type 2570 A/B to study the shielding efficiency, The data showed that the shielding effect was not significanty difference in both sizes of the bead and packing methods. But it is obviously seen that the small bead size with the pressure packing gives a little higher shielding efficiency than the others as shown in table 1.

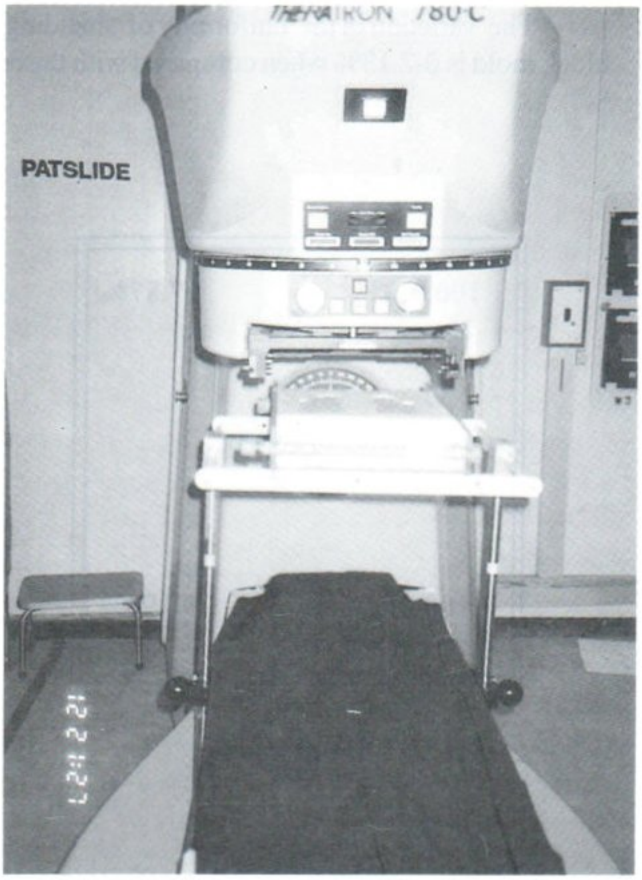


Fig.4 The table mounted beam shaping tray MURT 37/2 available for the maximum field size 35x35 cm^2

TABLE 1 **The transmitted radiation (nanocoulombs, nC) measured between the two bead sizes and the two different packing methods irradiated with 10 cm x 10 cm Cobalt-60 beam.**

Packing method	Lead beads			
	3.52 + 0.37 mm diameter		5.13 + 0.43 mm diameter	
	Transmitted rad. (nC)	%	Transmitted rad. (nC)	%
-No lead bead	44.4	100	44.4	100
-Unpressure	5.35	12.5	5.25	11.82
-Pressure	4.70	10.58	5.10	11.48

The variation in the uniformity of shielding efficiency in various positions of lead beads inside the block mold is 0-2.13% when compared with the central axis of the irradiated beam as shown in Fig. 5

Small beads **Large beads**

Fig.5 The shielding efficiency uniformity of lead beads.

For the shielding efficiency of the small lead beads with the pressure packing method, the HVL measurement was done for three times in the plastic phantom to prove that there is no human error in the packing process. From the measurement, the HVL is 1.6 cm. Then the styrofoam mold with the thickness of 5 HVL were made to fit in the MURT 37/1 and MURT 37/2. The comparison of shielding efficiency between lead bead and alloy was shown in Fig.6 and Fig 7.

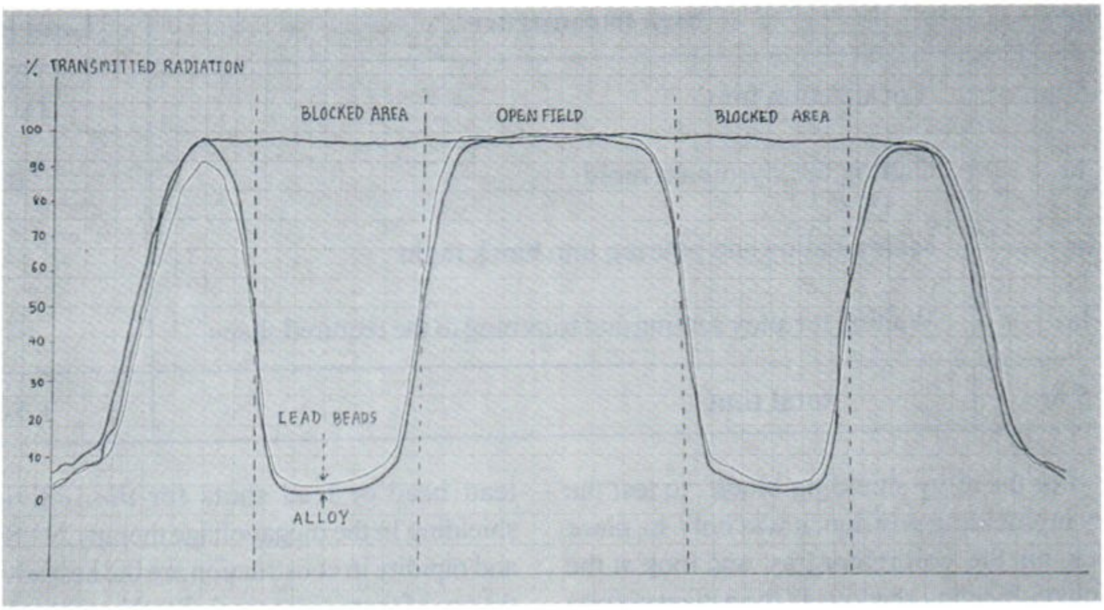


Fig. 6 The comparison of shielding efficiency between alloy and lead beads in inverted-Y treatment field for collimator shielding tray. (MURT 37/1)

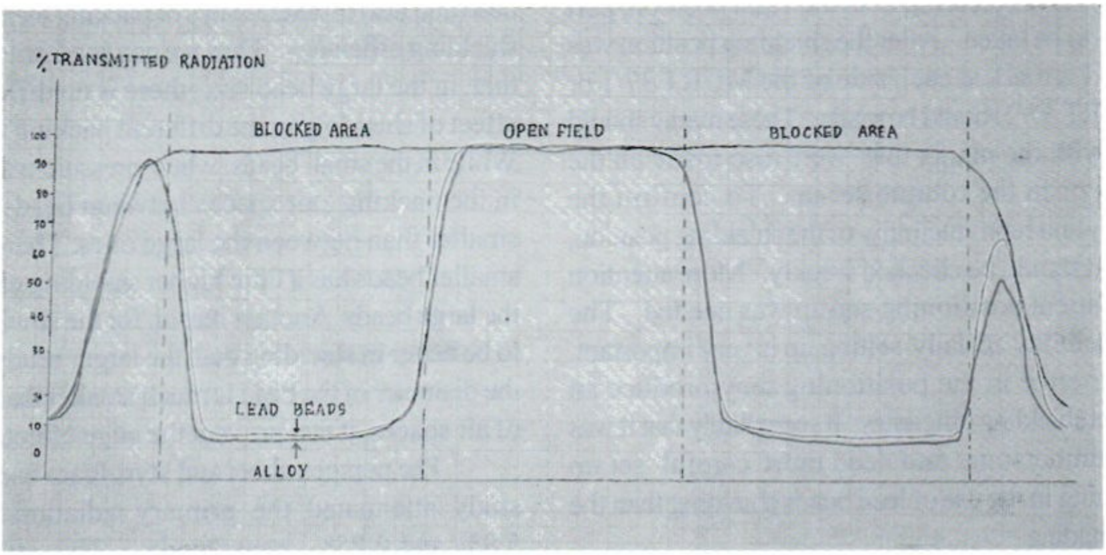


Fig. 7 The comparison of shielding efficiency between alloy and lead beads in mantle treatment field for table mounted beam shaping tray. (MURT 37/2)

The time-consuming in the construction processes of the alloy and the lead beads shielding block were shown in Table II. The data show that it takes only 1.5-2 hours to construct the lead beads shielding block compared with 5.5-7.5 hours in the case of an alloy shield.

TABLE II Time-consuming in each step of construction processes between alloy and lead beads shielding block.

Alloy	Step to construct	Lead beads
0.5-1.5 hr.	Localization film	1-1.5 hr.
0.5 hr.	Cutting the styrofoam mold	0.5 hr.
0.5 hr.	Melting alloy and pouring into block mold	-
4-5 hr.	Waiting for alloy settling and trimming to the required shape	-
5.5-7.5 hr.	**total time**	1.5-2 hr.

For the alloy shielding block , to test the accuracy in shielding position, it was only to place the block on the collimator tray and look at the projection of shielding shadow on the patient surface whether it matched with the area we want to block or not. This procedure cannot be done using the lead beads shield. It is the collimator tray that hold the styrofoam mold and the lead beads inside which blocked the light field. The only way to ensure that the lead beads shielding is in the right position, port film has to be taken. After the shielding position was satisfied, a mark at each side of the MURT 37/1 or the MURT 37/2 should be made. These marks should match with the marks that were also made on the collimator in the routine set-up. To confirm the accuracy and reproducibility of the shielding position, port film should be checked weekly. More attention in the patient positioning set-up was needed. The reproducibility in daily setting up is very important. A small error in the positioning may produce an incorrect shielding efficiency. It seem likely that it was more cumbersome and need more careful set up positioning in the use of lead beads shielding than the alloy shielding.

DISCUSSION

There are some studies in the introduction of lead bead or lead shots for the individaulized shielding In the megavoltage therapy.[4,5,6] Simplicity and rapidity in construction are the best adventage in the use of them. The size of lead beads and the packing method should be determined before bringing them into the routine use. But the study of Abraham W[5] suggested that any size of lead beads with the ideal packing would have the same shielding effect. In this study we have investigated using both sizes of lead bead and also different ways of packing them on their shielding efficiency. Thus we can see from the result that, in the large bead size, there is no difference in effect of shielding in the different packing methods. While in the small beads, when pressure was applied in the packing , air spaces between beads become smaller than between the large ones. Therefore the smaller beads has a little higher shielding effect than the large beads. Another reason for the smaller beads to be better in shielding than the larger beads is that if the diameter of the bead is much smaller than the size of air spaces, it can prevent the edge effect.[5]

The perspex sheet and styrofoam used in this study attenuated the primary radiation beam by 5.9% and 0.85% respectively. This attenuation effect should be accounted for in the dosage calculation.

The limitation in the use of MURT 37/1 and

MURT 37/2 in this study is that it can be used only in the anterior port only. Improvement of shielding tray to provide for any direction of the beam port should be developed.

MURT 37/1 in this study is now put in practical use. Most treatment area of the external beam teletherapy are not greater than 26cmx26cm except for the mantle technique which required the bigger treatment field but the MURT 37/2 can solve this problem.

CONCLUSION

In the study of introducing the lead beads to be used as an irregular field shielding, we found that.

1. The small size of the lead beads (3.52 ± 0.37 mm) and the packing method using pressure packing gave the best shielding efficiency.
2. There is a good uniformity of shielding effect in both sizes of lead beads, the small or the large.
3. The HVL of the small lead beads in this study is 1.6 cm
4. The MURT 37/1 tray designed to use with collimator beam shaping rail was applicable for most treatment techniques with the field not greater than 26 x 26 cm^2. For larger treatment field, MURT 37/2 tray, attached with table mounted beam shaping tray will serve that purpose.
5. MURT 37/1 and MURT 37/2 can be used only for anterior port.
6. The comparison between alloy and lead bead shielding block:

6.1 Considering for the shielding efficiency, alloy and lead beads shield have the same shielding efficiency.

6.2 The time consuming to build the block, lead beads shield can be made easily and rapidly (1.5-2 hr). While for the alloy shield it consume more time to make(5.5-7.5 hr). Moreover, there are some other advantages for the use of lead beads, such as

- no toxicity of evaporation from melting process.
- can be re-used immediately.
- economical price (20 baht/kg) while the alloy cost 800 baht/kg.

6.3 For shielding accuracy, lead beads shield needs more careful and complicated work to setup shielding position than to setup an alloy shield.

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