Pergamon

Radiation Measurements Vol. 29, No. 6, pp. 605–609, 1998

Printed in Great Britain
PII: S1350-4487(98)00072-9
1350-4487/98/$ - see front matter

INCIDENT CONTAMINATION LEPTON DOSES MEASURED USING RADIOCHROMIC FILM IN RADIOTHERAPY

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(*Received* 4 *April* 1998; *accepted* 21 *May* 1998)

Abstract—Measurement of lepton contamination is achieved across a radiotherapy photon beam and peripheral doses using radiochromic film. An extrapolation technique is used where several layers are suspended in air to measure incident contamination without the effects of phantom scatter. Surface dose was measured as 11% of D_{max} for 6 MV beams at central axis and 9% for 10 MV photons for a 10×10 cm field size. Peripheral lepton doses were found to decrease compared to central, however, were still measurable. Peripheral lepton dose was found to increase with field size and was 12% and 15%, 2 cm outside the geometric field edge of a 30×30 cm field size at 6 and 10 MV respectively. Radiochromic film is a suitable dosimeter for measurement of lepton contamination absorbed dose to surface layers of skin. © 1998 Elsevier Science Ltd. All rights reserved

1. INTRODUCTION

Radiochromic film due to its relatively energy independent active layer (Muench *et al*., 1991) has become an effective dosimeter for assessment of absorbed dose especially in areas of high dose gradient (Butson *et al*., 1996a,b,c). Examples of previous measurements of lepton contamination have been with extrapolation TLDs suspended in air (Butson *et al*., 1996a,b,c) and using a half-blocked method (Sixel and Podgovsak, 1994). Removal of lepton contamination using magnetic fields has also produced an indirect measurement of lepton contamination (Biggs and Russell, 1983). However, all these techniques require extensive measurements to produce measurement for peripheral doses and off axis as they are point dosimeters. MD-55-2 Gafchromic film has the ability to quantitatively measure dose over a two-dimensional (2-D) surface. In this note it has been used to study off-axis and peripheral lepton contamination doses.

2. MATERIALS AND METHODS

Measurements were performed with two Varian 2100C accelerators at photon energies of 6 and 10 MV. The film used was Gafchromic MD-55-2 with batch number 970116. The film results were corrected for non-uniformity with a double exposure technique. The film was analyzed with a 660 nm Red GaAlAs ultra bright LED on a converted Scanditronix RFA300 densitometer (Carolan *et al*., 1997). The film was suspended in air using a string brace thus no scatter material except the film itself was present. Three layers of Gafchromic film were stacked on top of each other, to extrapolate to zero thickness, to remove the incident dose due to phantom photon scatter. The contamination lepton spectrum was evaluated using a neodymium iron boron magnetic deflector (Butson *et al*., 1996a,b,c) and helium bag system which would eliminate lepton contamination at a 10×10 cm field size.

3. RESULTS

Figure 1 shows the percentage dose results recorded in the first two layers of Gafchromic film and the extrapolated lepton contamination dose derived by an extrapolation to zero film thickness. A linear extrapolation curve is used to derive the incidence lepton contamination dose.

Figure 2(a) and (b) shows the extrapolated incident lepton dose measured for various field sizes at 6 and 10 MV energy. Lepton doses within the geometric field edge are relatively uniform for all field sizes with an increasing fluence with field size. A distinctive reduction in lepton dose is seen in the

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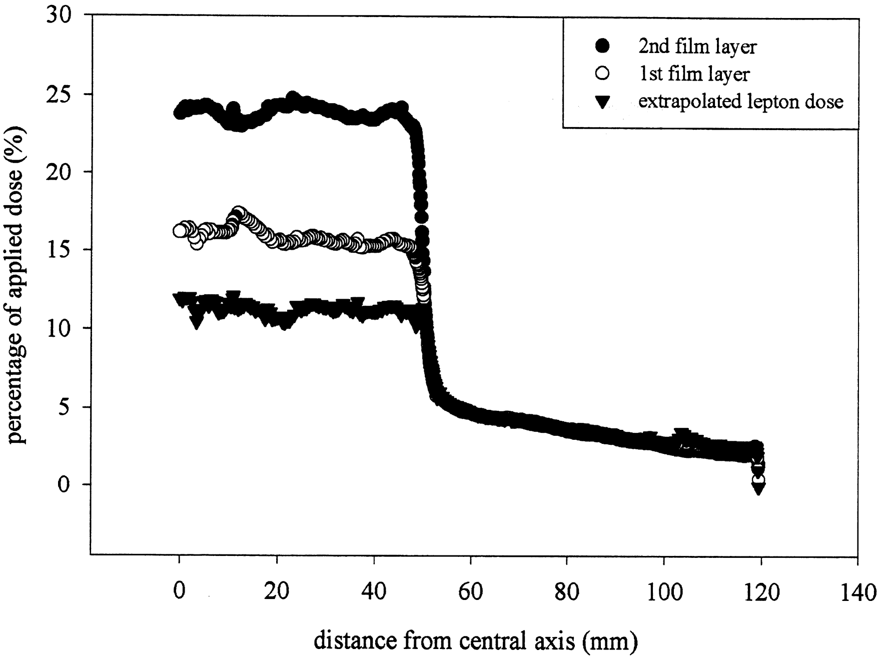

Fig. 1. The extrapolation technique used to measure incident lepton dose. Layers of Gafchromic film are suspended in air and dose is extrapolated to zero thickness to eliminate photon phantom scatter.

penumbral region with a measurable dose recorded in the peripheral regions. Peripheral lepton dose increases with field size. At 30×30 cm field size, lepton contamination levels of 10% of applied dose are still measured up to 8 cm outside the treatment field.

Figure 3 shows the depth dose curve produced by lepton contamination for a 10×10 cm field at 6 MV measured by Gafchromic film. Results were derived by comparing build up curves measured with and without a magnetic field and helium bag system to remove lepton contamination. Results quoted are the differences seen in the two measured build up curves.

Figure 4 shows the derived lepton spectrum achieved by comparing Fig. 3 depth dose results to Monte Carlo simulated mono energetic electron beams. A Marquardt (1963) algorithm is used to produce the spectrum of best fit. A larger percentage of lepton contamination is low energy, i.e. less than 0.75 MeV.

4. DISCUSSION

Lepton contamination of photon beams in megavoltage radiotherapy can produce unwanted skin reactions when treating deep tumors, due to the leptons short range in matter. Their sites of production are well known and include the treatment head of the accelerator and the air column directly above the patient. Measurements performed with Gafchromic film have shown that the lepton contamination produced in open fields is uniformly distributed across the entire treatment field. The extrapolation data shows that 60–70% of total incident surface dose is due to lepton contamination at a 10×10 cm field size. As field size is increased this proportion increases. Peripheral dose due to lepton contamination is also significant especially at larger field sizes. 10–15% of applied dose is delivered to the skin surface outside the treatment field due to lepton contamination. This is due to the lateral scatter of lepton produced in the treatment head and air column.

By comparison of the build up curves measured with and without a magnetic deflector and helium bag system an indirect measure of lepton contamination depth dose is achieved as shown in Fig. 4. The electron contamination is in general low energy due to the short ranges measured. An energy spectrum was de-convolved using this data compared to Monte Carlo generated mono energetic beams. The largest proportion of lepton dose was due to low energy 0–0.75 MeV leptons. These are expected to mainly be generated in the air column directly above the patient (Nilsson, 1983) and the treatment head is expected to produce the majority of the higher energy electrons.

5. CONCLUSIONS

Gafchromic film has been shown to be an appropriate dosimeter for measurement of lepton contamination in profiles across a treatment beam and

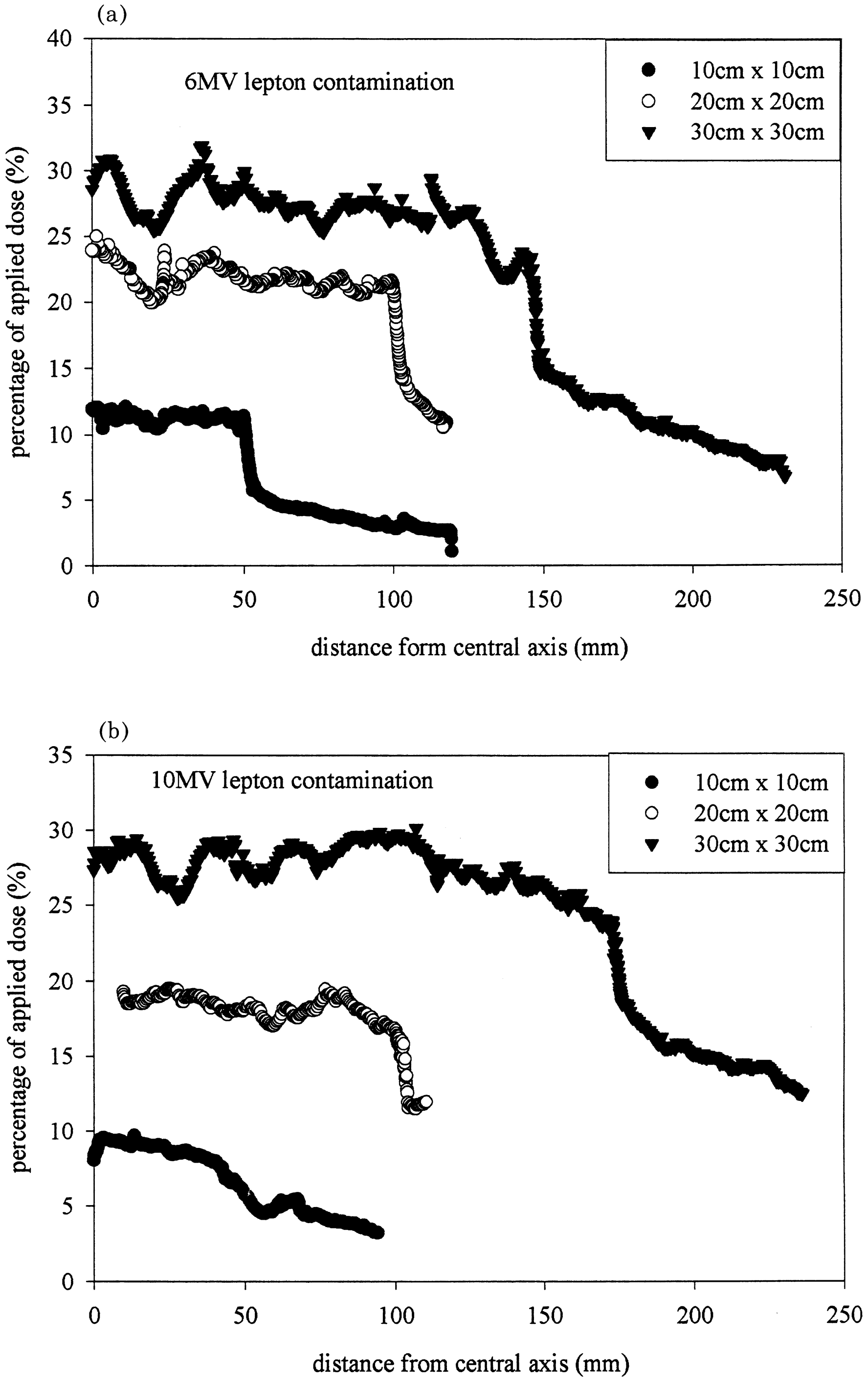

Fig. 2. Shows the extrapolated lepton contamination measured at: (a) 6 MV; and (b) 10 MV photon energy.

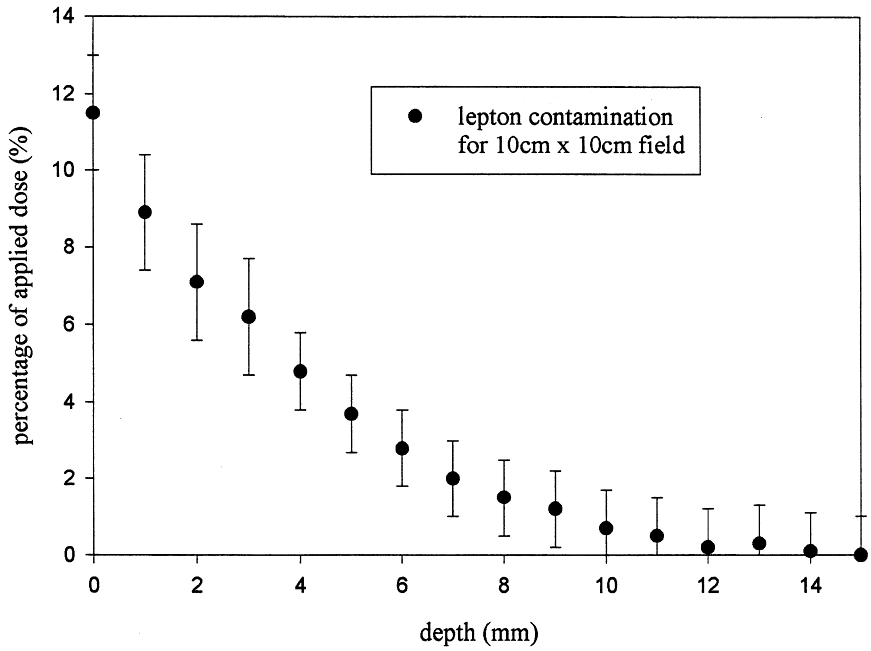

Fig. 3. Shows the lepton contamination depth dose measured for a 10×10 cm field at 6 MV energy, 100 cm source to surface distance.

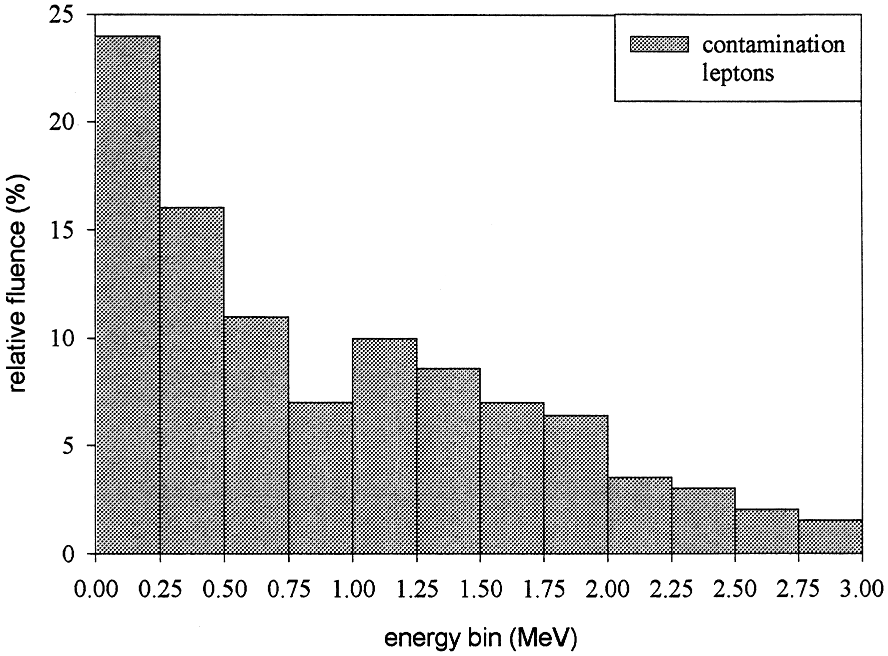

Fig. 4. Shows the energy spectral components of lepton contamination from the depth dose shown in Fig. 3.

for assessment of lepton contamination spectral components.

REFERENCES

Biggs, P. J. and Russell, M. D. (1983) An investigation into the presence of secondary electrons in megavoltage photon beams. *Phys. Med. Biol.* **28**(9), 1033–1043.

Butson, M., Mathur, J. and Metcalfe, P. (1996a) Radiochromic film as a radiotherapy surface dose detector. *Phys. Med. Biol.* **41**(6), 1073–1078.

Butson, M., Mathur, J., Perez, M. and Metcalfe, P. (1996b) 6 MV X-ray dose in the build up region: empirical model and the incident angle effect. *Aust. Phys. Eng. Sci. Med.* **19,** 74–82.

Butson, M., Wong, T., Law, A., Law, M., Mathur, J. and Metcalfe, P. (1996c) Magetic repulsion of linear accelerator contaminates. *Med. Phys.* **23,** 953–955.

Carolan, M., Butson, M., Herrmann, K., Mathur, J. and Metcalfe, P. (1997) Conversion of an infrared densitometer for radiochromic film analysis. *Aust. Phys. Eng. Sci. Med.* **20**(3), 183–185.

Marquardt, D. (1963) An algorithm for least squares estimation for non-linear parameters. *J. Soc. Ind. Appl. Math.* **11,** 431–441.

Muench, P., Meigooni, A., Nath, R. and McLaughlin, W. (1991) Photo energy dependence of the sensitivity of radiochromic film and comparison with silver halide film and LiF TLD's used for brachytherapy dosimetry. *Med. Phys.* **18,** 769–775.

Nilsson, B. (1985) Electron contamination from different materials in high energy photon beams. *Phys. Med. Biol.* **30**(2), 139–151.

Sixel, K. and Podgorsak, E. (1994) Build up region and depth of dose maximum of megavoltage X-ray beams. *Med. Phys.* **21**(3), 411–416.