A NEW CLINICAL EXTRAPOLATION CHAMBER DOSIMETER

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ABSTRACT

In recent years the extrapolation chamber has been developed a clinical dosimeter for electron beams and X-rays from medical linac. It consists of a new type extrapolation chamber, a water phantom and an intelligent portable instrument. The chamber is fitted a thin entrance window and has a collecting electrode made of polystyrene 20 mm in diameter. The electrode spacing can be varied by stepping motor drive achieving high precision of electrode setting. The variable gap is as small as 0.20 mm to 6 mm. The dosimeter can automatically finish the measuring process, and has error self-test and dose self-recording function. The total uncertainty is 2.7 %.

Keywords: Extrapolation chamber Medical linac Radiation therapy

1 INTRODUCTION

The extrapolation chamber is a plane-parallel ionization chamber with a variable gap. The first called "extrapolation chamber" was designed by Failla[1] in 1937. It was used for measuring of alpha or beta beams[2] and low energy X-rays.[3] Mason *et al.*[4] measured surface dose in megavoltage photon radiation and Jarvinen[5] measured electron depth dose distribution with an extrapolation chamber. Jin Tao[6] discribed an universally autogirative absorbed dose system of extrapolation chamber for determination of relative dose distribution in various materials. The treatment planning in radiation therapy is based on the depth dose which distribute the isodoses in tissue-equivalent material of irradiation. In order to get more reliable clinical information on depth dose distributions especially on dose rate at the surface and in the build-up region, a new type of clinical extrapolation chamber dosimeter for electron beams and X-rays from medical linac is developed. The paper presents these dosimeters' structure and reveals the result of measuring clinical irradiation dose.

2 DESCRIPTION OF THE APPARATUS

The clinical extrapolation chamber dosimeter consists of an autogirative extrapolation chamber, a water phantom and a portable instrument.

The autogirative extrapolation chamber is shaped like a 14 cm high cylinder. The housing outside diameter is 6 cm, and the air volume diameter is 4 cm. The chamber is fitted with a thin entrance window and has a collecting electrode. The electrode spacing can be varied by means of a computer–controlled stepping motor achieving high precision electrode into step. The cross section of chamber is illustrated schematically in Fig.1. The chamber parts are made of polystyrene film and carbon, all of which are soft–tissue equivalent with respect to transmission and back–scatter of electron beams striking the entrance window (1). The aluminium–coated foil is 0.07 mm in thickness. The foil is stretched by a ring (2) on the polystyrene electrode housing (3). The entrance foil (1) is connected with bias voltage via the high voltage jack (6). The other electrode is the graphite–coated surface (4) of the polystyrene block (5), 45 mm deep × 45 mm dia. The surface (4) is divided into a circular collecting electrode (20 mm dia.) and a guard ring by a groove which is 0.2 mm in width and depth.

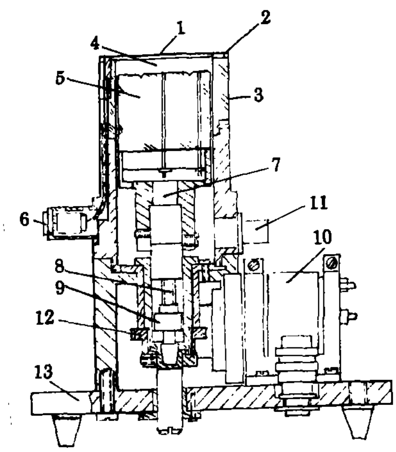

Fig.1 Medical extrapolation chamber

(11) Collecting electrode socket
(12) Clamp (13) Stand

The effective volume of the extrapolation chamber can be changed by varying distance between the electrode (4) and entrance window (1). The chamber is designed to allow adjustment of the distance between electrodes over a range 0.5 to 5.5 mm with electrode parallelism maintained to an accuracy of 0.05 mm and such is obtained by mounting the polystyrene block on a sliding–fit rod (7) and a bolt (8) which travels within a 86 mm long cylindrical guide (9). The chamber depth can be varied by the stepping motor (10) coupled to a bolt (8) screwed into the rod. The stepping motor is controlled by computer which is set in the instrument.

When the chamber was used to measure the depth dose or X–ray dose, it could be used in a water phantom. The phantom is 30 mm long × 30 mm wide × 35 mm high. The cylinder housing is in center of the phantom, with a diameter of 62 mm and a hight of 14 cm. The top of cylinder is 0.5 mm in thickness. Its wall is 4 mm thick.

The portable intelligent instrument consists of an 8–bit MCS–48 computer–on–slice, high voltage power, electrometer, controlling board by a stepping motor, data collecting and processing system and micro printer. The hardware system has seven pieces of board and two devices. The main program of software was designed as well. The overall dimensions of chamber measures are 50 cm thick, 42 cm wide and 12 cm high. The basic principles of the underlying method and extrapolation chember measurement were presented by ICRU[7] and IAEA[8].

The intellect dosimeter can automatically finish all the process of measuring doses, and it has error self-test and dose self-recording function.

3 MEASUREMENT

As a single example of the clinical extrapolation chamber, since 1987 several

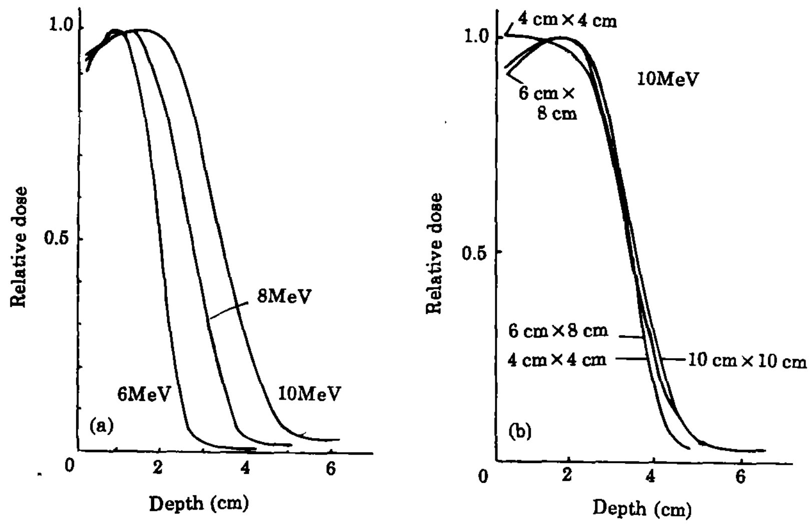

Fig.2 The depth dose curves of electron beams in polystyrene

Table 1

Estimated uncertainty of determination of absorbed dose in material with 99 % confidence limit

Source	Uncertainty (%)	Source	Uncertainty (%)
Measurement of volume		Correction factor for lack of	
Measurement of area	0.4	saturation voltage	0.2
Measurement of distance	0.8	Correction factor for humidity	
Correction factor of pot	0.08	of the air	0.05
Correction factor of field	0.1	W/e	0.5
Measurement of ionic charge		Stopping power ratio	1.5
Capacitance for charge measurement	1.5	Perturbation correction factor	0.8
Voltage measurement	1	Total	2.7

electron depth dose curves in polystyrene had been measured with the chamber (see Fig.2), which is particularly applicable to measuring the surface dose and the build-up region distribution. Electron beam and X-ray depth dose curves in water are analysed in Fig.3 and 4. The linac ZJ-10 is made in China.

The maximum uncertainty in absolute dose measurement with the described dosimeter is within 2.7 per cent (see Table 1). However, in relative measurement, only good reproducibility is important and using this device it is less than 1 per cent.

In addition, this dosimeter was compared with a Farmer 2570 dosimeter in absorbed dose measurement of high energy electron beams at Xinjiang People's Hospital in 1988. The measuring results are 0.458 cGy per monitor unit and 0.462 cGy per monitor unit for Farmer chamber and extrapolation chamber respectively, and these results are agreeable within 1 %.[9]

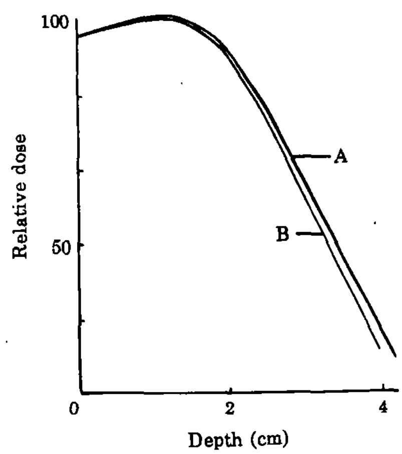

Fig.3 The depth dose curves of 7.5 MeV electron beams in water

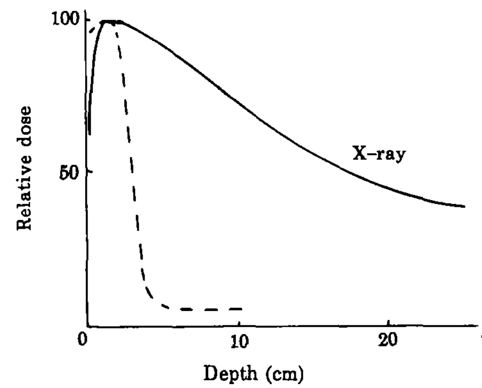

Fig.4 The depth dose curves of electron beams and X−rays of 7.5 MeV in water

4 CONCLUSION

The dosimeter can be used for clinic measuring of surface dose and build-up region distribution in radiation therapy.

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