QUALITY ASSURANCE IN RADIOTHERAPY BY IN VIVO DOSIMETRY ; ENTRANCE DOSE MEASUREMENT

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ABSTRACT

Quality assurance in radiotherapy by in vivo dosimetry was performed at the Division of Radiation Oncology, Department of Radiology,Siriraj Hospital during August 1996 to January 1997. The entrance doses of a total number of 467 treatment set-ups (182 cancer patients)undergoing radiation therapy with Cobalt-60 Teletherapy unit were measured with semiconductor detectors. From the study , the global results of the percentage ratios of the measured dose and calculated dose showed a Gaussian frequency distribution which a mean and one standard deviation value were 99.2+3.34 %. This meaned that the uncertainty caused by a systematic and random errors in the treatment delivery were 0.8% and 3.34% respectively. Eighty-seven percents of all treatment set-ups are reliable due to the dose delivered fitted in ±5% of the prescribed dose while the treatments with a large error (2SD) were found in 2.99%. Source of the uncertainties in this study arised from incorrect dose calculation , contour irregularities, human mistakes in treatment setting-up , insufficient immobilization and erroneous in the entrance dose measurements themselves.

INTRODUCTION

The outcome of radiation therapy ,local control and complication, is closely related to the dose delivered to the clinical target volume and surrounding normal tissue. A small change in the absorbed dose can give rise in failure of tumour control and complication probabilities[1]. Especially, when the prescribed total dose are closed to the tolerance of the surrounding normal tissues, it is critical to deliver the accurate prescribed dose to the target volume. ICRU in its report No.24 recommended the actual dose delivered to the clinical target volume should be within ±5% of the prescribed dose[2]. WHO in 1988 also published the guidebook of the quality assurance programme in radiation therapy to urge the radiotherapy centers all over the world to control thier treatment quality[3]. In this study ,we aim to investigate the dose accuracy delivered to the patients undergoing radiation therapy with Cobalt-60 Teletherapy unit at the Division of Radiation Oncology,Siriraj Hospital, Mahidol University by in vivo dosimetry.

MATERIAL AND METHOD

The semiconductor detector Rainbow type 30-490-80 (suitable for photon in the energy range of Cobalt-60 to 4 MV x-rays) connected with electrometer was selected in this study due to its main advantage of no time delay between measurements and results. First, it was calibrated with 0.6 cm^3 NE Farmer Dosemeter type 2570/1 . The calibra-

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tion was performed with the four diodes in calibration disk positioned on the surface of a solid water phantom (30cmx30cmx30cm) at the center of 15cm x15 cm field at 80 cm SSD with Cobalt-60 Teletherapy unit. (Fig 1)

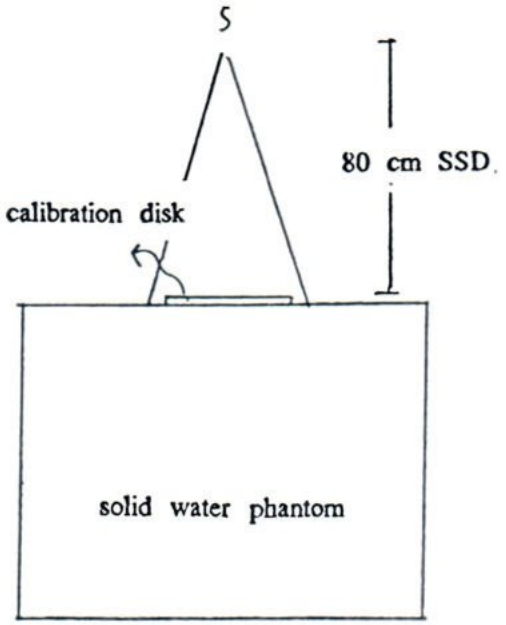

Fig. 1 The calibration geometry of semiconductor diodes

Since four diodes were used in this study, so the calibration factor (F_{cal}) was determined for each individual . The entrance dose calibration will be determined as the ratio of the absorbed dose measured with ionization chamber (D_{IC}) at depth of maximum dose (0.5 cm) and the reading gained by semiconductor(R_{SC}). Therefore, the calibration factor of each diode was

$$F_{CAL} = \frac{D_{IC}}{R_{SC}}$$

MEASUREMENT ON PATIENTS

Having been calibrated completely, the diode will be positioned in the center of the treatment field on the skin of the patient after the treatment set-up was performed as usual from the radiological technologist. The signal from the electrometer will be evaluated at the end of an irradiation and was converted to the measured entrance dose. Correction factors due to irradiation geometry differed from the reference geometry such as collimator openning, tray, source-skin distance (SSD) also have to be determined and applied to the following equation.[4]

$$\text{MEASURED ENTRANCE DOSE} = SC\ SIGNAL\ X\ F_{CAL}\ X\ C.F_{FIELDSIZE}\ X\ C.F_{TRAY}\ X\ C.F_{SSD}$$

Then the data of measured entrance dose will be evaluated as percentage of the ratios of measured and expected (or calculated) entrance dose(% MD/ED). Expected entrance dose is manually calculated from the dose at depth of maximum of the prescribed dose. Because of the importance of having sufficient data for statistical analysis, in this study the data will be received from making a few measurements on many patients as suggested from Dobbs HJ,et al.[5]

MD = Measured entrance dose

ED = Expected (or calculated) entrance dose

RESULTS

From the entrance dose measurements on the total number of 182 cancer patients undergoing radiation therapy at the Division of Radiation Oncology, Siriraj Hospital, the distribution of the patients receiving measurement are classified as in Table 1.

Table1. Distribution of the patients receiving entrance dose measurements

Group of patients	No. of patients	No.of measurements	No.of measurements/patient
Head & Neck	96	261	2.72
Mediastinal	23	36	1.56
Breast	32	118	3.69
Spine	6	16	2.66
Pelvic	25	36	1.44
Total	182	467	2.56

The data of the entrance dose measurements were plotted as the frequency distribution of the ratios of measured dose and expected dose in percentage (%MD/ED). N was the number of treatment set-ups measured, the mean value (X) and one standard deviation (SD) were also calculated from the data.

GLOBAL RESULTS OF ENTRANCE DOSE MEASUREMENT

The overall results of the total number of 467 treatment set-ups showed a distribution of % MD/ED with a mean value of 99.20% and one relative standard deviation of 3.34% as presented in Fig. 2 The discrepancy between the measured and the expected mean value was 0.8%.

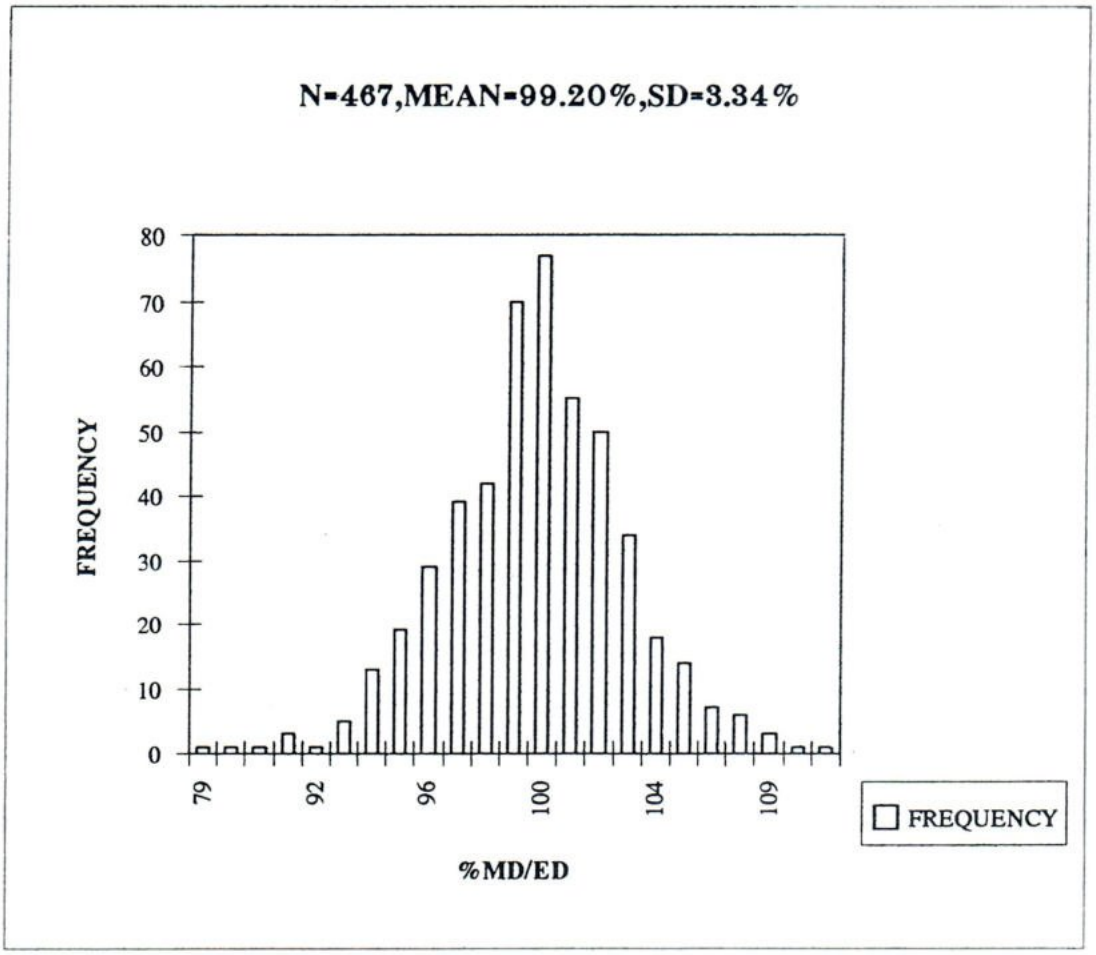

Fig.2 Frequency distribution of overall results of entrance dose measurement

RESULTS OF ENTRANCE DOSE MEASUREMENT ON PATIENTS TREATED FOR HEAD AND NECK MALIGNANCY

Radiation treatment technique in head and neck malignancy are two -paralleled opposing fields and one anterior cervical split field. The entrance dose measurement was performed on lateral field only because it cannot be measured correctly on central-blocked field such as anterior split field. Total number of 261 lateral field treatment set-ups (96 patients) were measured and the mean value of %MD/ED in this group of patients was 98.84% and one standard deviation of 2.98% as shown in Fig 3.

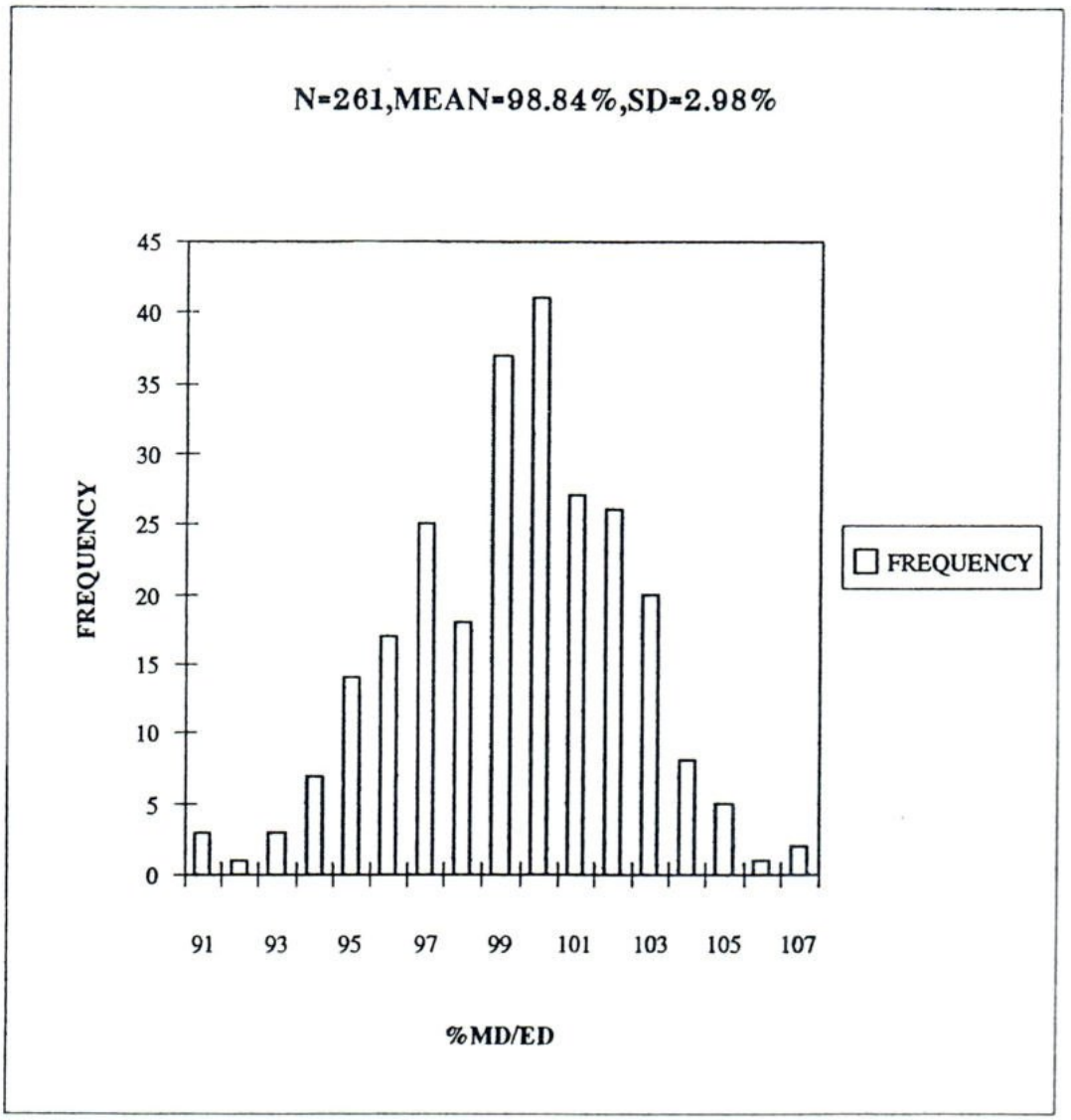

Fig. 3 The histogram showed frequency distribution of % MD/ED in head and neck malignancy patients

RESULTS OF ENTRANCE DOSE MEASUREMENT ON BREAST CANCER PATIENTS

Most of patients received radiation therapy with the Quadrate Technique. Entrance dose measurement was performed on all treatment fields (Internal mammary chain, Supraclavicular-axillary and Tangential fields) and the ratios of % MD/ED were plotted in Fig 4. The total number of measurements performed was 118 measurements on 32 patients. The mean and one relative standard deviation value of % MD/ED was 100.43±3.86. It can be seen that the frequency spread of the results in breast cancer was broader than the head and neck malignancies.

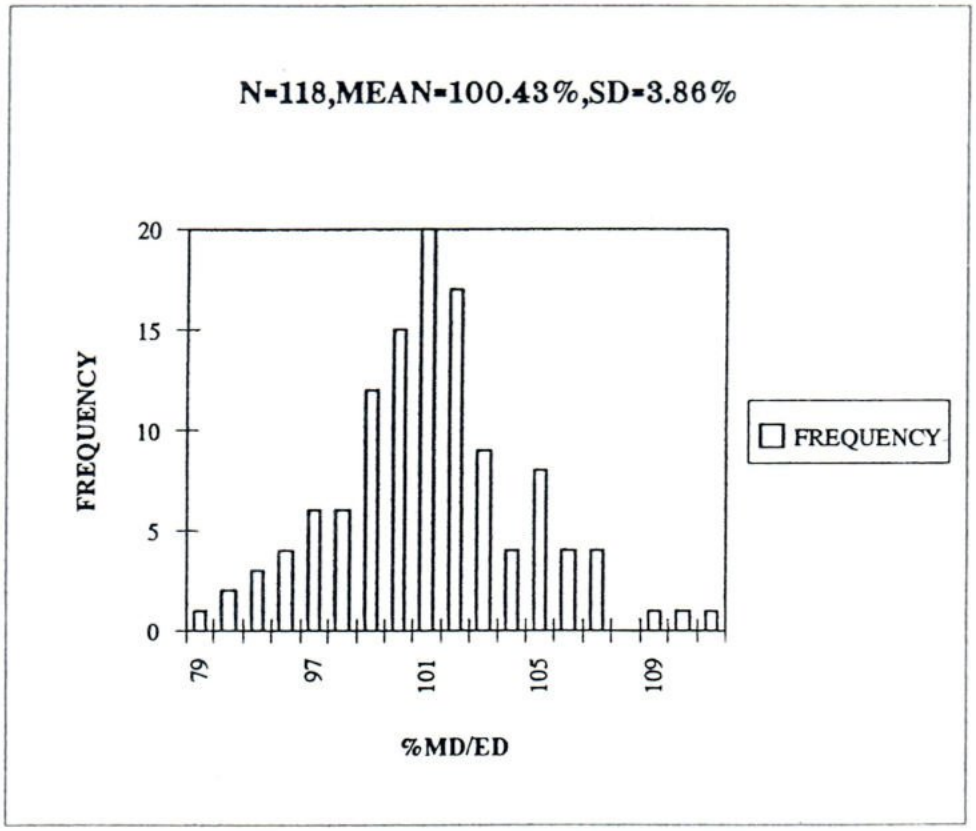

Fig 4. The histogram showed frequency distribution of % MD/ED in breast cancer patients

Results of entrance dose measurement on other treatment sites such as mediastinum, pelvic and spines, were not plotted in histogram due to a small number of data in each site. The results of the mean and one standard deviation of % MD/ED in all treatment sites are summarized in Table 2.

Table 2 Mean (X) and one relative standard deviation (%SD) of %MD/ED in all treatment sites

Treatment Sites	No. of Measurements (N)	Mean	% SD
Head & Neck	261	99.84	2.98
Breast	118	100.43	3.86
Medistinum	36	97.33	3.00
Pelvic	36	98.90	2.15
Spines	16	100.68	4.35

DISCUSSION

From the global results of entrance dose measurement , the percentage ratios of measured and calculated dose (%MD/ED) have a mean and one standard deviation equal to 99.2 ± 3.34 %.

The discrapancy between measured and calculated dose 0.8% implied to the systematic error found in our treatment delivery. This kind of error arised from poor measurement and calibration process including poor initial adjustment. As well as the standard deviation value 3.34% indicated to the random error caused by human mistakes in patient setting-up such as setting up of the machine parameters, patient positioning and patient immobilization.[6]

In this study, both of the systematic and the random error founded were reasonably acceptable because they were in good agreement with the studys of Leunens G[4] and Mijnheer et al[7] that concluded the uncertainty associated with dose delivery should be less than ± 3.5% ,expressed as one relative standard deviation. And from the calculations of Goitein[8] the 5% accuracy requirement as proposed by the ICRU should be considered as 1.5 SD. In our investigation 86.94% of all treatment set-ups are fitted in this requirement. Large error that defined as a discrapancy between measured and calculated dose in + 2SD have also been detected in 2.99% of all meaurements. Source of errors came from incorrect dose calculation, contour irregularities, insufficient immobilization and also an errorneous in entrance dose measurement themselves due to the measurement geometry differing from the calibration geometry such as the measurement on Tangential breast irradiation.

For breast cancer dose measurement, the results showed a broader of standard deviation in %MD/ED than in head and neck malignancy. When 118 data of entrance dose were analyzed, we found that 83 measurements performed on Internal mamary chain and Supraclavicular-axillary field has a mean + SD of % MD/ED equal to 99.32+2.7%, while the other 35 measurements performed on Tangential field was 100.26±5.03%. These data coincided with the study of Leunens G, et al[9] that reported the treatment error was found 15% in Tangential breast irradiation in Cobalt-60 Machine without automatic verification system compared to treatment error of 2.3% in Mevatran Siemen linear accelerator when this system was available.

Results of entrance dose measurement on spinal irradiation also has a large standard deviation (4.35%). However, having a small number of data therefore we cannot make any discussion here.

CONCLUSION

It could be concluded from the study that the quality of whole treatment chain, that means dosimetry, dose calculation ,treatment techniques using in our treatment delivery, would be in a satisfactory level as well as improvement in treatment techniques such as effective immobilization and reproducibility, machine with auto-verification system, should be provided to minimize the incidence of random error.

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