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Editorial

New AMPI Executive Committee

Association of Medical Physicists of India (AMPI) is the only representative association of Indian Medical Physicists who are working with radiation in hospitals, research institutes, medical colleges, industrial units etc. The recent growth of corporate sector hospitals in various parts of India has not only caused the boom in the number of young members of AMPI but has also contributed in their spread all over India as these hospitals have sprung up in so called tier II and tier III cities as well. The recent election of new Executive Committee (EC) reflects the same trend which has as many as three-fourth members being first time elected. In that ways it is an enthusiastic young EC which is a welcome change. However, a few seniors in EC along with the young blood have greater responsibility to channelize the youthful energy in a constructive and cooperative manner. The recent efforts of EC to form committees for various tasks incorporating the experienced members from even outside EC is a laudable step which may bring the desired combination of experience and energy. Medical Physics profession and subject is at the cross-road today mainly due to rising aspiration of younger lot, searing employment opportunities, changing job profile and impending new governmental policies for health sector. The new EC has to pursue the agendas pro-actively. It is imperative that AMPI implements policy of one-person-one-post for its various arms so that more and more members may be able to contribute their mite to the association. The complexities of problems medical physicists are facing especially with respect to governmental rules demand long-term sincere efforts on the part of AMPI. If a larger group of people are involved in efforts of AMPI it would ensure the continuity of the process and its related knowledge even after periodic election of EC. Due to wider geographical location of the EC members it is essential to exploit newer communication technologies to arrange virtual meetings more frequently. It is only the energetic constructive cohesive cooperation among EC members which would bring the desired results in the long run.

Pratik Kumar

SMALL FIELD DOSIMETRY OF FF & FFF: DISCUSSION ON VARIOUS PARAMETERS

Ganeshkumar Patel, Medical Physicist &
RSO, Park cancer Hospital, Delhi

With the advances in technology, different treatment techniques like IMRT, SRS, SRT, RAPID ARC & SBRT proved to be boon for patients but these advanced techniques demands more stringent quality assurance. In SRS & SRT treatment usually targets have small volume hence planning system creates segments of small field size, also in these techniques high dose of the order of 3-5 Gy dose per fraction is delivered in less number of fractions so accuracy of dose delivery play the major role. Now a day's many institutes preferring to do SRT planning in FFF mode instead of conventional FF mode because in FFF mode dose rate increased by factor 2-4 times which provides the advantage of short treatment time which ease in the patient immobilization. As we know that procedure, protocol & detectors used in large field dosimetry could not bring out the same result in small field dosimetry. Small field dosimetry needs special considerations as there are various parameters like charge particle disequilibrium, source occlusion, and penumbra overlapping and volume effects of detector affecting the actual measurements.

In this article I am going to discuss in detail of the said parameters in small field dosimetry of FF & FFF beam. The field size in the range 0.3x0.3cm2 to 4x4 cm2 is said to be small field or precise definition is "for the selected energy & medium, the field size is not large enough to ensure lateral charge particle equilibrium (CPE). In narrow photon field there is loss of lateral charge particle equilibrium because field size is smaller than lateral range of charge particle hence it introduces dosimetric challenge to Physicist. Second parameter is source occlusion as shown in fig (1), because of partial view of extended direct beam source from the point of measurement there is error prone measurement takes place. Third parameter is penumbra overlapping as shown in fig (1), penumbra overlapping creates deviation from true beam profile which results drop in beam output and dose underestimation.

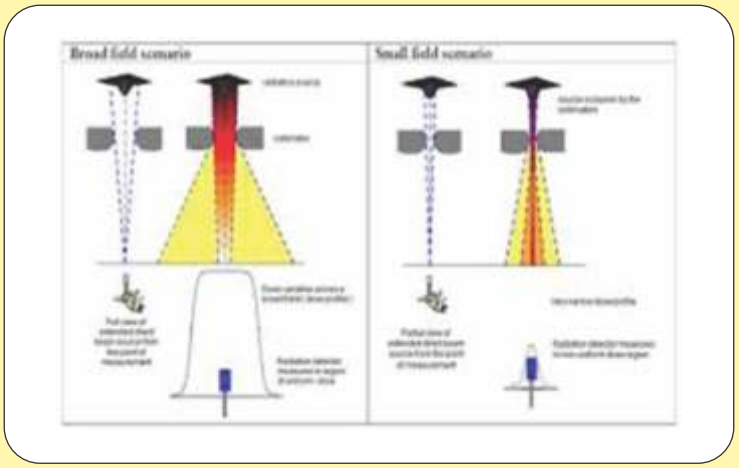

Figure 1: Source occlusion & penumbra overlapping

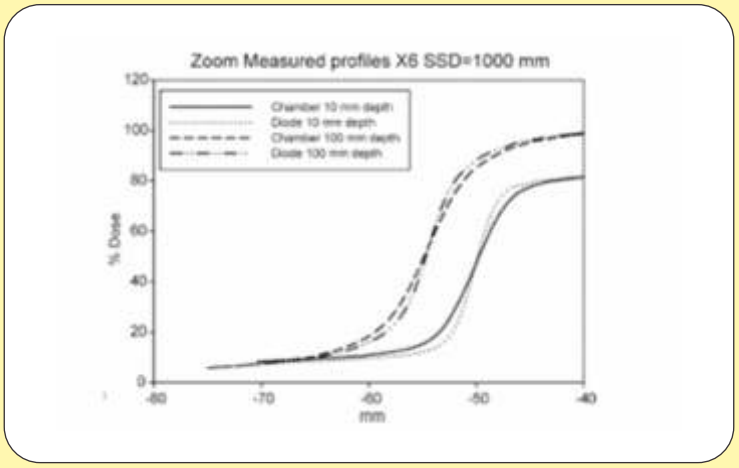

Figure 2: Broadening of measured steep dose in penumbra region

The forth and most important parameter that has great impact on small field dosimetry is volume effect of detector. Volume effect of detector has two disadvantages i) large detectors tend to underestimate the central axis dose. ii) Broadening of measured steep dose gradient in penumbra region as shown in fig (2) above. CAX normalization combined with the volume effect in a small field leads to, the dose in out of field region will be overestimated, PDD at large depths will be overestimated and the 50% isodose line will appear slightly larger than it is. As we know that output factor reduces in smaller field sizes because of backscattering into monitor chamber from beam defining jaws, reduced scattering, electronic disequilibrium & obscuration of source. Because of partial volume effect of chambers large volume detectors are not suitable for output factor measurement of small fields. The graph (3) shows the variation in relative output factor versus size of detector for 6 & 15 MV photon beam in FF mode.

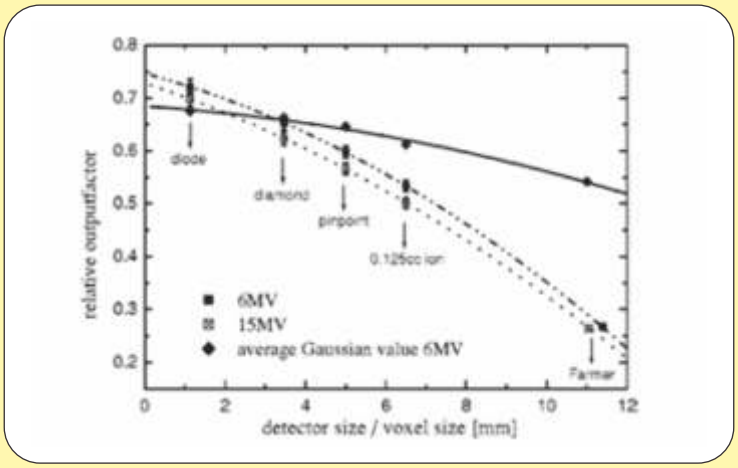

Figure 3: Relative output factor versus size of detector for 6 & 15 MV photon beam in FF mode

Choice of detector matters in small field dosimetry as there are number of alternatives available in small volume chambers e.g. pin-point chamber,semi-flex ion chamber, diode detector, diamond detector all these active detectors have very small volume but they need to satisfy the special requirements like high spatial resolution, high sensitivity, near water equivalence, negligible energy, dose rate & directional dependence.

Output factor measurements: There are challenges in the determination of Scp(total scatter factor) because of energy dependence, volume averging & fluence perturbation of detectors, more than 14% variation reported in various studies. CPE in a detector requires that in scattering must be equal to out scattering, this depends on electron range &density of medium. Density of diode detector is more than water & over respond on on CAX dose in small field.The response of diode detector affected by temperature,dose rate, energy & angular dependence, unshielded diode detectors for small field dosimetry has found to be suitable but there is always uncertainty about the accuracy even if correction is applied. If measured with ionization chambers, the reason for an underestimation of output factors is the increase of lateral electron disequilibrium with an increase of the detectors measuring volume. Pin point chambers somewhat good to measure output factor for small field because of very small volume & water equivalence. A microdiamond detector is found to be suitable for output factor measurement of small field because of water equivalence, high sensitivity, Direction independence & high spatial resolution [1, 4].

All the above parameters discussed for conventional FF beam in small field sizes but in case of FFF beam where beam characteristics changes abruptly what kind of changes we expect in small field dosimetry. Dosimetry subdivided in two categories absolute & relative dosimetry. In most of studies it is found that there is no marginal difference in absolute dose measured on central axis in small fields for FF & FFF beam. Relative dosimetry comprises PDD, dose profile & total scatter factor measurement where significant changes reported which we will discuss. The PDD measured in FFF mode is found to be shallower because of photon energy spectra are softer, unless the PDD has been restored through increasing the electron energy [2].For Varian LINAC skin dose for FFF beams higher compared to FF beams as measured with parallel plate chamber, for example the dose at 1mm depth relative to Dmax was found to be 53% for flattened 6 MV but 61% for a FFF beam. For smaller field sizes skin dose is very less, skin dose varies field size because there is less low energy photon contamination from head scatter. FFF beam have sharper penumbra even though there is a penumbra overlapping takes place which result in dose under estimation. Outside treatment field, FFF beams generally produce lower dose, leakage radiation & collimator scatter are subsequently reduced. For output factor measurements, the field size is defined by using jaws. Head scatter factor of FFF beam is different from FF beam due to the absence of flattening filter. A significant difference of more than 3% is seen in output factor of larger field 4x4 cm2 to 40x40cm2 in FF & FFF mode [3]. In FFF reduced head scattering contribution reduces output factor for small field but in comparison with FF output factor for small field size, many papers on this topic has given less than 2% variation [4]. In FFF mode choice of detector is same as that in FF mode, small volume detector should be used that has minimum energy & dose rate dependence, micro chambers or diamond detector are best suited for small field. If field size is small compared to detector, measurements should perform at greater SSD with proper correction Dose verification of smaller fields should be carried out with at least other independent passive detectors like radiochromic film, TLD etc.

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OUR MEDICAL PHYSICS FACILITY

RADIATION PHYSICS DIVISION, REGIONAL CANCER CENTRE, THIRUVANANTHAPURAM, KERALA

Dr P. Raghukumar, Additional Professor & Dr Saju B, Additional Professor Radiation Physics Division, RCC

Regional Cancer Centre

Regional Cancer Centre (RCC), Thiruvana nthapuram established in 1981, is an autonomous institution sponsored jointly by the Government of Kerala and the Government of India. It provides world-class state-of-the-art facilities in cancer prevention, diagnosis, treatment, rehabilitation and palliation to the population of the state of Kerala and adjoining parts of Tamil Nadu. This is one among 26 centres in India operating under the NCCP of the M o H and F W. Every year the centre registers nearly 14000 new cases and provides follow up services to nearly 1.8 lakhs patients. Of these, nearly 8000 patients undergo radiotherapy.

The Centre has the following major Divisions: Radiation Oncology, Surgical Oncology, Medical Oncology, Paediatric Oncology, Pathology, Imageology, Nuclear Medicine, Anaesthesiology, Radiation Physics, Cancer Research, Clinical Services, Palliative Medicine, Community Oncology, Cancer Epidemiology, Transfusion Medicine, Laboratory Medicine, Microbiology, Library, Information Systems. The Imageology Division has the following facilities: 1.5 Tesla MRI, MR Spectroscopy,16 Slice Multidetector CT, State of the art PACS, Digital Mammography, Prone biopsy table & mammotome, Three Ultrasound machines & X-ray units, CR system for digital X-rays. The Nuclear Medicine Division has a Dual head SPECT Gamma camera. Radio iodine therapy for hyperthyroidism and thyroid cancer are being routinely done. A PET CT scanner is being installed.

Radiation Physics Division

Dr. T.P. Ramachandran was the Head of the Division when the division started functioning in 1980. Dr.V.Padmanabhan took charge of the division in 1995. Dr. Raghu Ram K Nair is the present Head of the Division from 2002 to till date.

Staff

Dr. Raghu Ram K.Nair	Professor & Head
Dr. Raghukumar P.	Additional Professor
Dr. Saju B.	Additional Professor
Dr. Thayal Singh Elias	Associate Professor
Smt. Zhenia Gopalakrishnan	Assistant Professor
Smt. Divya K.T.	Assistant Professor (on leave)
Sri.Giri Purushothaman	Assistant Professor
Smt. Debjani Phani	Assistant Professor
Sri. Shaiju V.S.	Assitant Professor
Smt. Sharika V.Menon	Assistant Professor
Sri. Sarin B.	Lecturer
Sri. Sreelish K.	Medical Physicist (Temp)

Equipment

At present our division is equipped with a total of five linear accelerators and one cobalt machine for teletherapy treatment. Of these, two Clinac 600Cs (80 Leaves MLCs, MV Imaging capabilities) and one dual energy Clnac iX (120 Leaves MLC, with on board imaging facilities like kV-kV or MV-kV matching, CBCT, capable of performing RapidArc and high dose rate photon for SRS) are from Varian Medical Systems, One Precise (dual energy, 80 leaves MLC) and One Synergy (dual energy, Agility 160 leaves MLC, portal imaging) are from Elekta. A Blood Irradiator (BI2000) was installed in 2009 for irradiating donor blood. Our brachytherapy setup consists of a Microselectron HDR machine and Oncentra MasterPlan planning system.

We have a dedicated isocentric C-arm for taking orthogonal films for planning. CT/MR based planning is also performed on a few Ca Cx patients (15-20 patients per week) after US guided applicator placements. An average of 35 Ca Cx patients are treated in a week. Nearly 10-15 patients per year are treated by interstitial implantations or surface moulds using MUPIT or flexible implants. Treatment Planning is performed with Eclipse planning system with 4 workstations and 4 contouring workstations. Elekta's PrecisePLAN is also in use for external beam treatment planning. For simulation we use a Simulator from Elekta (Simulix Evolution) and a 16 slice Light Speed 4D CT from Wipro GE (Optima 580). We do all type of treatment planning ranging from 2D planning, 3D CRT, IMRT, IGRT, VMAT, Gated treatments, TBI, SRS, SRT and SBRT. The SRS treatment is performed in Clinac iX machine with BrainLAB's M3 micro MLC with the help of Monte Carlo based iPLAN Planning System. All Varian related equipment are linked to a central server which works on ARIA environment. We also have a MOSAIC R&V which connects and stores the data of patients treated in Elekta machines.

We have all the required dosimetric tools for modern radiotherapy department. Radiation Field Analyzers (RFA-300 and Blue Phantom), iMATRIX, Portal Dosimetry, ArcCHECK, BEAMCHECK, X-lite, number of ionization chambers of various volumes, Diode detectors and OSLDs for in-vivo dose measurements, diagnostic X-ray QA Kits, Wilson-Lutz test tool, Survey meters etc are being used routinely to perform the machine/patient specific quality assurance tests as well as to assure radiation safety.

Training Programs and Courses

Recently we started a Post MSc Diploma in Radiation Physics (two years duration) which has a maximum capacity of 4 seats per year. We provide training to both undergraduate and post graduate students from various medical colleges within and outside Kerala and also from abroad in addition to the in house MD students of various disciplines like Radiotherapy, Radio diagnosis, Medical Oncology etc. We conduct orientation classes and training programs for Radiation Technology students and Nursing students from different institutions in Kerala. Our Radiation Physics Division has 11 Physicists and 40 Radiotherapy Technologists.

Research

Six candidates took Ph.D. from this Division and eight candidates are currently pursuing their Ph. D. in Medical Physics. The Centre is engaged in research activities in the field of radiotherapy and natural background radiation. An extensive work on natural background radiation was performed by this centre in collaboration with Health Research Foundation, Japan and Environmental Assessment Division,BARC in the high natural background radiation area of Karunagappally in Kollam district. This division developed a rectal-bladder spacer balloon device for reducing the rectal and bladder dose in cancer of Uterine Cervix patients undergoing brachytherapy. Two type of manual dose calculation software independently developed by two department members, treatment aiding devices like Styrofoam cutter, contour plotter, brachytherapy machine etc were developed at our centre and some of them are currently in clinical use. The division is engaged in a number of projects both clinical as well as non-clinical with support from various organizations.

The center has participated in many national and international TLD/OSLD inter-comparisons (Equal-Estro, RPC, BARC) and the output found to match with international standards.

The Division is responsible for the QA and radiation safety of Imageology and Nuclear Medicine Divisions.

MOVERS AND SHAKERS

Prof. Arun Chougule, Dean, RUHS & Head, Deptt. of Radiological Physics and President, AMPI was awarded by SMS Medical College on 26th January 2015 for his special contribution in education & research. Congrats !!!

Dr. B. Ravi Kumar, Physicist & RSO, Deptt. of Radiotherapy, Govt. General Hospital, Kakinada, Andhra Pradesh has been awarded Ph.D. degree in Nuclear Physics by Andhra University, Visakhapatnam in May 2014. The title of his thesis was “Experimental investigation of inhomogeneities due to different tissues and applicators in the high dose rate brachytherapy”. Congrtas !!!

Mr. R. Venkatraja has joined as Sr. Medical Physicist & RSO, Shankar Cancer Hospital, Dr.Sheela Sharma Memorial Charitable Trust, Mathura in June 2015.

BACK TO BASICS

CTDI: FOOD FOR THOUGHT

MPS Mann, Consultant Medical Physicist &
RSO-III, Pan Max Healthcare

As many may believe, CT Dose Index is not a patient dose. It is simply a CT dose out-put descriptor. The word "index" was specifically included in CTDI's name to distinguish the quantity from the radiation dose absorbed by a patient. Equipment typically used to measure CTDI100 includes an integrating electrometer, a 100-mm-long CTDI ionization chamber, and a CTDI phantom made of polymethyl methacrylate. The phantom is placed with its long axis perpendicular to the plane of the transverse CT scan and the ion chamber placed in one of the holes through the phantom. CTDI100 is obtained by integrating the dose over 100 mm from a single transverse scan and dividing it by the nominal beam width. This has ensured consistent radiation output measurements.

In US, American College of Radiology (ACR) maintains Dose Index Registry. It is a data registry that allows facilities to compare their CT dose indices to regional and national values. Information related to dose indices for all CT exams is collected, anonymized, transmitted to the ACR, and stored in a database. Institutions are then provided with periodic feedback reports comparing their results by body part and exam type to aggregate results.

The American Board of Radiology has qualified the registry as meeting the criteria for practice quality improvement (PQI), toward the purpose of fulfilling requirements in the ABR Maintenance of Certification Program.

AAPM POSITION STATEMENT ON THE USE OF BISMUTH SHIELDING FOR THE PURPOSE OF DOSE REDUCTION IN CT SCANNING

(Taken from https://www.aapm.org/publicgeneral/BismuthShielding.pdf)

Policy Text:

Bismuth shields are easy to use and have been shown to reduce dose to anterior organs in CT scanning. However, there are several disadvantages associated with the use of bismuth shields, especially when used with automatic exposure control or tube current modulation. Other techniques exist that can provide the same level of anterior dose reduction at equivalent or superior image quality that do not have these disadvantages. The AAPM recommends that these alternatives to bismuth shielding be carefully considered, and implemented when possible.

Rationale for policy:

Bismuth shielding has been used to reduce the dose from CT to anterior radiosensitive organs, such as the breast, lens of the eye, and thyroid [1]. These bismuth-impregnated latex shields are placed over the organ of interest to attenuate the x-ray beam entering the patient. While bismuth shielding appears easy to use and studies confirm a reduction in anterior surface dose [2-5], there are several disadvantages associated with their use that could result in increased patient dose and/or degraded image quality [6]. Other methods for reducing anterior dose exist that do not suffer from these drawbacks. These methods may additionally offer improved image quality and/or additional dose reduction relative to the use of bismuth shielding, and

should be carefully considered by users seeking to reduce dose to the lens of the eye, thyroid and breast.

Disadvantages associated with the use of bismuth shields:

1) Applying bismuth shielding together with automatic exposure controls (AEC) systems, such as tube current modulation (TCM), leads to unpredictable and potentially undesirable levels of dose and image quality.

AEC systems adjust scanner output based on patient attenuation to deliver a user-specified level of image noise. They take into account system characteristics, patient anatomy and user-specified requirements for image quality [7]. Localizer CT radiographs (e.g. anterior-posterior and/or lateral) are used to estimate patient attenuation, and system behavior is programmed according to the measured attenuation. However, when bismuth shielding is used, the dose delivered to the patient and the image quality achieved depends on whether the shield was placed before or after acquisition of the CT radiograph.

Placing a bismuth shield on the patient prior to acquiring the CT radiograph will lead to measuring higher "patient" attenuation and the tube current will be increased accordingly [4, 8]. The effect of dose reduction to the anterior surface by bismuth shielding will be countered, and dose to other surfaces will be increased, which is clearly undesirable.

Placing a bismuth shield on the patient after the CT radiograph has been acquired avoids having the AEC algorithm increase the tube current [4, 8] on some systems. However, the image quality delivered will not be what the user prescribed due to the additional attenuation of the shield, which the system did not anticipate (as it was placed after the CT radiograph was acquired).

On other systems, the AEC algorithm responds to increases in patient attenuation that occur after the CT radiograph has been acquired, resulting in differences in both image quality and dose relative to what was planned using the CT radiograph.

2) The shields can degrade image quality and accuracy.

The shields can cause streak and beam hardening artifacts. They artifactually increase CT numbers below the shield [9] and adversely affect the accuracy of CT numbers. Because these would affect the accuracy of coronary calcification measurements, the Society of Cardiac CT clearly states that breast shields are not recommended in cardiovascular CT [10]. Additionally, if the inferior aspect of the shield lies over the upper portion of the liver, unacceptable image quality in the liver can occur.

3) The shields waste some of the patient's radiation exposure.

In CT scanning, the x-ray tube rotates 360 degrees around the patient and irradiates the patient from all directions. When the x-ray tube is above the patient, the shield absorbs x-rays before they strike the patient and reduces the dose to peripheral organs. However, when the x-ray tube is beneath the patient, the shield does not reduce dose to the patient, but rather absorbs many of the photons exiting the patient before they can reach the CT detector. Those photons would have contributed to forming the CT image. Similarly, photons from lateral directions are partially attenuated by the shield upon exiting the patient. Therefore, during more than half of each 360-degree rotation of the x-ray tube, the shield attenuates useful photons, thus wasting radiation dose. This leads to a noise increase across the entire image, not just in the region near the shield [4, 9, 11, 12].

Alternative methods for reducing dose to peripheral organs in CT scanning:

For equivalent levels of image noise, the percent dose reduction to the anterior surface from bismuth shielding can be achieved by reducing the x-ray tube current by that same percentage [11-14]. This has the added benefit of reducing dose to the lateral and posterior surfaces. No additional materials (i.e. the shields) or special scanner features are required, and technologists do not need to spend additional time positioning the shields on patients or disinfecting the shields between patients. Furthermore, streak and beam hardening artifacts are avoided and CT number accuracy is maintained. Other methods for reducing dose to specific peripheral organs include adjusting AEC parameters to more aggressively decrease the tube current in regions of lower attenuation (e.g. in the thorax) and use of organ-based tube current modulation techniques. Since AEC systems on CT scanners can be complex and involve adjustments of several parameters, users are urged to consult with a medical physicist and/or applications specialist when making changes to the AEC parameters.

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