Chapter-10

Summary

The main intention of this thesis is that it should be like a guide for the physicists, radiation oncologists and to the management who are going for high end linear accelerators with IMRT, IGRT features. Starting from the selection of the linear accelerator and its site to the some of the important and latest Quality assurances are explained thoroughly. In introduction part all important radiotherapy (teletherapy) machines are described briefly and also the function of the Linear accelerator is explained in detail. In the second chapter, the Selection of the machine is discussed which is very important for the management and the new physicists. The problems in Room Planning, Precautions to take before installation of the machines and Installation of the machines are discussed and explained with our experience. Installation, commissioning and its results are shown. In photon beam characteristics measurement of back-scattered radiation from micro multileaf collimator into the beam monitor chamber from a dual energy linear accelerator is measured. This is the first study on mMLC in India. General procedures like Head scatter factor, phantom scatter factor and Total Scatter correction factors for the Elekta synergy machine, which is the first of its kind in India, are derived. It is having MLC (80 leaves replaced X-Jaws), Y-jaws (asymmetric jaws) and back up diaphragms,

Commissioning and quality assurance of the CMS XIO radiotherapy treatment Planning system for external beam photons for Elekta synergy machine and primus plus linear accelerators are explained.

A Comparative Study of Convolution, Superposition and Fast Superposition Algorithms in Conventional Radiotherapy, Three-Dimensional Conformal Radiotherapy and Intensity
Modulated Radiotherapy Techniques for various Sites done on CMS XIO system. The purpose of this study is to compare the results from three different algorithms for four different sites representing varied heterogeneity conditions and using Conventional, 3DCRT and IMRT Techniques. In the present study Convolution, Superposition and Fast superposition Algorithms are used for all plans. This also allowed us to know the suitability of algorithm for respective diagnosis and treatment techniques.

Commissioning and Quality Assurance of the X-ray Volume Imaging System of an Image-Guided Radiotherapy capable Linear Accelerator (Elekta Synergy) is discussed in detail and gave all the important information like safety and functionality QA, Geometric accuracy QA and Imaging test procedures. Results and Images are shown in detail. This data is useful for the future generation physicists who are going for IGRT machines.

Quality assurances in Active breath control, which is useful for gating in IGRT treatment are explained in the "Measurement of Magnitude of shift of tumor position as a function of deep inspiration breath hold: an analysis of pooled data of lung patients with active breath control in image guided radiotherapy". According to this some recommendations are given to the physicists and oncologist who are going for ABC system.

Conclusions:

Installation and commissioning of linear accelerators is the challenging job for the physicists. Precautions in selecting the site and room construction and installing the machine are most important thing. According to our experience proper plan saves lot of time and money. Proper plan also useful to generate good dose distributions and associated calculations for external beam radiotherapy accurately and reliably. A good preplan saves
lot of time and better output.

In the measurement of backscattered radiation from mMLC it can be concluded that the maximum reduction of 0.5% in dose delivery is observed for 6 MV photons with constant secondary collimator field size and with various field sizes of mMLC. This is due to backscattered radiation originating mainly from the mMLC reaching the beam monitor chamber. Monitor unit rate is almost constant for all field sizes. The maximum variation in monitor unit rate between open and closed feedback control circuits is 2.5%. There is no difference in pulse width and negligible difference in pulse frequency. Collimator backscatter radiation can be taken into account in dose calculation by a simple multiplicative factor. Hence we should take beam measurements very carefully while using detachable mMLC because of the contribution of its radiation backscatter effect into beam monitor chambers delivered.

The Commissioning and quality assurance of the CMS XIO radiotherapy treatment planning system involves many steps, beginning from beam data acquisition and entry into the computerized TPS, through patient data acquisition, to treatment plan generation and the final transfer of data to the treatment machine and quality assurance of TPS. Medical physicist is responsible for the overall integrity of the computerized TPS to accurately and reliably produce dose distributions and associated calculations for external beam radiotherapy. The entire treatment planning process involves many steps.

Convolution, Superposition and Fast superposition algorithms (CMS, XiO Planning system) are compared using Conventional, 3DCRT and IMRT techniques for Esophagus, Lung, Prostate and Hypopharynx cases. Within the target structures the deviations of mean dose to the prescribed dose and maximum percentage of variation between all algorithms
are recorded for all techniques. Maximum percentage of variation between algorithms is 3.7% recorded in case of Ca Lung with IMRT technique. Statistical analyses are performed by comparison of mean relative differences with prescribed dose, Conformity Index and Homogeneity Index for target structures. Fast superposition algorithm showed excellent results for lung and Esophagus cases. Superposition algorithm showed excellent results for prostate and Convolution algorithm showed excellent results for hypopharynx. In case of ca. lung, prostate, esophagus and hypopharynx, OARs are getting more doses with superposition algorithm, convolution algorithm, fast superposition algorithm and convolution algorithms respectively. According to this study as the results from these algorithms differed significantly care should be taken when evaluating treatment plans as the choice of dose calculation algorithm may influence treatment planning as well as clinical results.

The safety, geometric accuracy and image tests have been useful in detecting performance of the XVI system that needed recalibration. Use of these tests over an extended period shows that the XVI system has good mechanical reliability and stable image quality. The system is capable of producing images with excellent spatial resolution and resolution in high-precision geometry. However, it is important that all tests should be performed on a regular basis within a suggested period to establish guidelines and confidence. These tests also proved that a flat panel detector is very much suitable for image-guided high-precision radiation therapy.

Even though we are using very sophisticated instruments like active breathe control
systems for to control the moving targets there is still some intrafraction variations in the position of the tumor. Daily tumor targeting of lung cancers are feasible with the help of DRR's from planning system when compared with DRR'S from iView-GT. Much accuracy needed when we go for hypo fractionation. Due to these reasons we studied the intrafraction variations by using mDIBH in a single fraction for 5 times on eight patients. In our study we have taken the DRR’S of the bony anatomy as reference. We compared the DRR’s from the TPS to the DRR’s from the iViewGT in selected gating phase. Our data demonstrate good intrafraction reproducibility of lung tumor position using ABC with same value of threshold limit.

Patient cannot inhale same amount of air every time even though the threshold value is kept the same. As the volume of inhalation is different for each duration the maximum shift observed is less than 4mm. For maximum difference of inhaling volume there is a need for observing the shift. The results that are obtained are closer with other author’s results that compared TPS Data to the iViewGT data by using soft tissues, external markers and internal permanent markers. If this shift is less than permissible level we can continue treatment other wise new session of mDIBH should start. Also 5mm margin has to give while contouring itself for compensating the magnitude of the shift of tumor position with respect to mDIBH .This procedure is going to give us better and more accurate treatment.

Finally we can conclude that, the moderated deep inspiration breath-hold method with a spirometer is feasible, with relatively good reproducibility of the tumor position for Image guided radiotherapy in lung cancers.

Scope of the future work:

More Quality assurance procedures should come in XVI. As of now there are no proper protocols for Quality assurances on XVI. Some of the Quality assurances belongs to CT
can also be included. We should derive some basic values in imaging tests, geometric accuracy tests, which should be applicable to all IGRT machines. There is a lot of scope for research in Active breath control. In active breath control, lot of analysis is done. But still there are number of unsolved problems. Until today there is no protocol for threshold limit, phase (inhale or exhale) and standard method for gating. As organ movement varies in each and every breath, it is very difficult to predict the position of all the organs at a time. In such case dose to normal structure and tumor will vary for each and every breath hold. We have to account all these factors. In the installation and commissioning of linac and TPS so many other fast methods and accurate methods has to be found to make the procedures faster and more accurate.