(i) COMPARISON OF DOSES MEASURED & CALCULATED:

In the experimental study, the brachytherapy treatment-plan was made and approved in the TPS to find out dwell positions for Ir-192 HDR source in the phantom. The EBBT treatment plan verification was carried out in the locally fabricated tissue equivalent phantom material with the EBT3 Gaf-chromic film dosimeter. The EBT3 film analysis was done in the film dosimetry system. The dose measured at the different locations in the phantom for OARs present around the tumor compared with the doses calculated in the TPS at the same location in the phantom. DVH tool was used to assess the data for the analysis. It was observed from the TPS calculated and phantom measured dose values that the dose values measured in the phantom with Gafchromic EBT3 film dosimeter were having less variation at lesser distance and more variation was found at far distances from the source catheter position. The dose values measured at a location in the phantom represent more variation from the TPS calculated dose values. It was due to the air inhomogeneity present in between the film and the source. In the external beam radiotherapy, the advance treatment techniques i.e. VMAT, IGRT, IMRT plans generated in the TPS and a patient specific plan verification quality assurance is carried out where a plan is said to be pass and acceptable for treatment if it follow the gamma index passing criteria which accept less than 5 % variation between TPS calculated dose and measure dose value in Electronic portal imaging device or in the quality assurance phantom. Here in the brachytherapy, dose variation occurs because inverse square law affects the doses around the source.

The dose value measured at the 1cm away from the tip of the source position is higher due to the air gap of 1cm in between the film and the tip of the source. The dose value measured at 2cm away from the source loading position located inside the Ipsilateral Lung was found high from the TPS calculated dose value due to the lung tissue inhomogeneity. The dose value measured at the sternum bone location was lower than the TPS calculated dose due to low doses at far distances from source and film response at the low dose exposure[64].

The TPS commercially available employ some technique for dose-distribution clinically for calculation[16]. The film measured dose values were vary at some points in phantom from the TPS calculated dose values which might be because of the calculation algorithm in TPS which was not considered the inhomogeneity of tissue present in the phantom. The dose value about the source was affected by the distance of measurement points from the source and to tissue absorption and scattering[65, 66]. Geometric function in the formalism of dose calculation had ignored attenuation and scattering and on the basis of source modeling for activity spatial distribution a correction for inverse-square-law was provided[16]. Dose distribution around the source was calculated by assuming homogeneous medium in the TPS which effects to dose values around the source at least up to 5cm distance whereas the dose calculated by TPS was higher contrast to the dose measured at Contraletral lung, Ipsiletral lung (surface), Ipsiletral lung (2cm depth), spinal cord and descending aorta location in phantoms. The result of the experimental study was found similar to the study performed by the Nikoofar et. al. [47] who demonstrated that by raising the gap among positions of the source and point of measurement lead to fast fall-off in dose. The dose to the Ipsiletral Lung was differing due to the dose gradient region and film placement position. The measured doses to the position of pulmonary trunk, coronary artery, Contraletral lung organs which were at large distances having difference due to radiation scattering and attenuation. At the positions nearby the source the doses may be decreased because of to inverse-square-law effect and at distances more the dose reduced due to tissue absorption and it increased by scattering. The distribution of dose was affected with the absorption and scattering at more distances and deviation of about 20% in absorbed dose might caused which depends upon the energy of the source[65, 66]. The dose measured at the 2cm depth in the Ipsiletral lung position was found higher then calculated in the TPS. This might be due to the affect of lung density and TPS dose calculation algorithm and assumption of homogeneous medium.

The phantom was fabricated for the thoracic site where OARs and target volume was transformed to the cubical form from the actual oval or spherical shape. The film dosimeter positioning in the phantom for each OARs was made with very accuracy. To verify the doses measured in phantom and calculated in TPS at film for OARs, the dose was find out at five positions in each film. The dose measured for each organ at risk was compared with doses calculated in TPS at same position. It was observed that the doses were having some variation on the same plane dose points. This variation was due to the distance between the source and the point of dose measurement.

Marinello et. al. [67] demonstrated that hyperdose sleeve always has to be taken into account. In the Intraluminal brachytherapy an unavoidable issue was steep dose-gradient between radiation source and mucosa of lumen. In this study 6F lumen care catheter was used so no problem with the hyperdose sleeve.

The phantom studies on dosimetric analysis are useful and applicable for guiding brachytherapy system and it can be adopted for QA program an important tool also for TPS verification for non-standard conditions. EBT series film is accurate and easy measurement tool for in-vivo dosimetry in brachytherapy system among all dosimeters. The in-vivo dosimetry measurement result showed, absorbed dose at remote points was because of scattered radiation whereas in closer points there was an effect of primary radiation for the targets.

Uniyal et al[58] study found the dose values measured by EBT3 film and dose calculated by TPS for distances up to 3cm from radiation source were in good-agreement with each other, which cover almost relevant clinical distances. The distance more than 3cm, showed higher variation among the measured and calculated doses this is due to the extremely low dose at more depth.

The results are comparable to study by Raina et al.[68], where he explained the variation among the doses measured and TPS planned is because of the lack of scatter. The dose was found with up to 15 % difference in absence of a scattering medium from TPS calculated dose. In our study the dose measured at the sternum is 15.8% lower than the TPS calculated dose.

The absorbed dose to Esophagus, Spinalcord, Ipsiletral Lung, Descending Aorta, Heart, Coronary Artery, Ascending Aorta, Pulmonary Trunk, Sternum and Contralateral Lung was measured by EBT3 Gafchromic films in the locally fabricated tissue equivalent phantom. The results illustrate that doses to the OARs measured in the phantom with radiochromic films are differ from the dose calculated in the TPS[69]. As the result showed there was a variation in the planned and the delivered doses so this phantom dosimetry can be adopted as a quality assurance tool to validate the treatment plan, it can be performed weekly as a part of brachytherapy Intraluminal plan verification tool in radiation oncology.

Hence the phantom fabricated locally is very helpful in the Intraluminal brachytherapy treatment plan verification in HDR machine.

(ii) UNCERTAINTY IN AN EBT3 FILM DOSIMETRY SYSTEM:

Gafchromic films are used in the dose distribution verification in radiotherapy. EBT3 film from the family of Radiochromic films are latest model now in use with added a matte polyester layer. In this model the films is symmetrical in structure which eliminate the dependency on the film side orientation. The film dosimetry system consist the film and the flat bed scanner. There are some uncertainties with the dosimetry system and these uncertainties are determined by Marroquin EY et. al. He analyzed the response of the film and fitting of the experimental data to a potential function gives uncertainties of 2.6%, 4.3%, and 4.1% for the red, green, and blue channels, respectively. In his work the dosimetry system presents an uncertainty in the dose analysis of 1.8% for the doses greater than 0.8Gy and less than 6Gy for red channel. The irradiated films show difference in the response by scanning in portrait or landscape mode. He found less uncertainty while using portrait mode. The film response depends on the position of the film on the scanner bed, an uncertainty of 2% for the red, 3% for the green and 4.5% for the blue channel. The Uniformity and reproducibility Radiochromic film and reproducibility of the response of the scanner contribute less than 1% to the overall uncertainty in dose. As per their analysis the total uncertainty was found 3.2%, 4.9% and 5.2% for red, green and blue channel respectively. These uncertainties contribute in the total dose measurement uncertainty[70].

(iii) DOSIMETRIC AND VOLUMETRIC ANALYSIS:

Ninety EBBT sessions of thirty carcinoma lung patients were assessed for dosimetric as well as volumetric evaluation after the completion of treatment. The dose and volume parameters in first session of brachytherapy were made the reference or base values for assessment of effects after second and third session of brachytherapy in each patient.

The affect of tumor site or its occurrence in the left lung and right lung of the patients on the organ at risk doses was analyzed in the lung carcinoma patients who were divided in left lung and right lung two groups. The doses obtained from the TPS and entered in Excel worksheet and imported into the SPSS software.

The dosimetric and volumetric analysis in the EBBT treatment patients, the doses were obtained from the 1st EBBT Session to 3rd EBBT treatment session and sum the doses for all the OARs. The doses were found in their tolerance limit.

The esophagus mean dose, Heart Maximum doses, spinal cord maximum doses, Trachea maximum doses, descending aorta maximum doses, Kidney maximum doses were decreased and esophagus maximum dose, Heart mean doses, contraleteral lung maximum doses, Left Coronary Artery maximum doses, Liver maximum doses were increased in third session compared to first EBBT treatment plans.

Entered the data into Microsoft Excel Worksheet for all the included patients and import this data sheet into SPSS software to perform the statistical analysis in thirty patients.

The literature search results on the dosimetric study in the endobronchial brachytherapy area and found some studies with the clinical perspective and its outcome like relief in symptoms and patient quality of life improvement after treatment. The research carried in this thesis work is not found any data available on internet therefore the comparison of the study findings is unable to explain here. [27]

Sneha et. al. found that the 50% reduction in endobronchial component and 84% endoscopic response post treatment at one month in 15 patients. [71]

In the bronchus airway path blockage condition it is taken on immediate priority to remove it in the patient. [72, 73, 27]

As per Gustafson et. al. study around 50% or more reduction in the degree of obstruction was reported in 64 % of the included study patients[74, 27].

This reduction in the obstruction found in the studies performed earlier might be correlated with tumor volume and directly influence the organs at risk doses in three endobronchial brachytherapy sessions consecutively in the included patients. The organs at risk doses analyzed in carcinoma cervix and esophagus sites by the authors while there is no study available on the dosimetric and volumetric analysis in the endobronchial brachytherapy.

Deepinder et. al. study used the dose prescription distance 0.8cm in place of 1.0cm from the catheter center which was taken by measuring the separation between the catheter and lumen mucosa layer of the patient in the CT scan with adequate dose coverage to the endobronchial lesion.[75]

The transfer tube used in endobronchial brachytherapy is positioned eccentrically in the lumen of bronchus to help in delivering high dose to the mucosa layer during irradiation. Omori K et.al study designed two wings applicator which open at the location of radiation delivery and keep the source in the lumen center to reduce dose to the bronchial mucosa. The author result showed the hemoptysis and bronchial stenosis were lower in EBBT with this two-wing applicator use[76].

Sur R et.al study showed, there was a reasonable enhancement in the symptoms relief by joining the EBBT and EBRT treatment modalities but the enhancement was not significant statistically[77].

In carcinoma lung treatment brachytherapy can be chosen as per the location of the tumor. The tumor volume with large size affects the organs at risk doses and coverage of the tumor volume. The study has the strength to reveal the factors affecting the organs at risk doses in lung carcinoma brachytherapy. The clinical implication and future recommendation of the study are helpful in the patient selection for brachytherapy treatment. The EBBT provides effective palliative treatment and should be recommend to patients with endobronchial tumor lesion[27]

The target volume variation after the treatment with EBBT in thirty patients was analyzed and found that the TV decreased from 1st session to 3rd session of EBBT. This showed that the EBBT is effective treatment of lung carcinoma patients while the tumor is in bronchial region. The Conformity index (CI) of the EBBT plans was calculated with the TV, V95% and TV in cc for thirty patients. It was found that the CI is better in 3rd EBBT plan compared to first EBBT plan in thirty patients.

In the EBBT technique the dose is prescribed at 1cm distance from the center of the catheter and sometimes there is a possibility that the prescription point may fall inside the region or outside this region[78]. If the wall of the lumen fall inside the dose to the OARs will be increased and if it falls outside then the tumor gets inadequate dose and OARs gets low dose. Therefore, it is very important to decide the dose prescription point while planning the EBBT patients.