Dosimetric Reporting of CT based Intraluminal Brachytherapy in Carcinoma Oesophagus: A Single Institutional Study

***Abstract:* Background: Intraluminal brachytherapy results in, high therapeutic ratio and remains an important part of the multimodality treatment of oesophageal cancer. But there is a lack of established dosimetric evaluation and guidance for the same. The aim of this study is to evaluate and report the dosimetric characteristics in ILBT patients.**

***Materials and Methods:* From January 2014 to December 2021, data of oesophageal cancer patients treated with radical external beam radiotherapy followed by ILBT was retrospectively collected and these patient's dosimetric parameters were also retrieved from planning systems and documents. The volume of target, dose to target and dose to lungs, heart and spinal cord was recorded.**

***Results:* Twenty patients were taken for this study. The mean treatment length was 5.65+2.09 cm. Mean HRCTV V100 was 21.9% and HRCTV V200 was 7.9% and this corresponds to 75% and 25% of the target volume, respectively. The mean D2cc received by the B/L lung, heart and spinal cord was 63%, 61% and 15% of the prescription dose respectively. The median disease free survival observed was 13.05+9.88 months.**

***Conclusion:* The treatment regimens and techniques used in ILBT are vast and varied. Our study emphasises on consistent, safe treatment policies for the use of CT based HDR ILBT in oesophageal cancer.**

***Key Words:* Oesophageal Cancers, Brachytherapy, Dosimetry.**

Introduction:

Oesophagus cancer forms 3.1% of cancers in the world and most commonly occurs in Eastern Asian countries. In India it accounts for 63,180 new cancer cases and 58,342 deaths. [1] The treatment of oesophageal cancer has come a long way from radical surgery to radical chemoradiotherapy (CRT) and presently with neoadjuvant CRT followed by surgery being the standard for inoperable cases. [2] Treatment of choice is dictated by multiple factors such as the site of involvement (upper, middle, lower 1/3rd), the length of disease (more than or less than 10cms), and also on the patient's general condition.

Intraluminal Brachytherapy (ILBT) plays a major role in the treatment of oesophagus cancer. [3] ILBT is a method of inserting the radioactive source through the applicator into the oesophagus to achieve the dose to the tumour. It can be done using many applicators such as Bonvoisin-Gerard tube, Ryle's tube, Balloon centring applicator. [4] Presently high dose rate (HDR) brachytherapy with remote after loading system is the type of brachytherapy used widely. With the advancement in imaging technology, the simulation method has moved from X-ray radiography to computed tomography (CT)/magnetic resonance imaging and this has helped in better calculation and documentation of dose received by the structures. In spite of all these advances in ILBT, the guidelines for dosimetric parameters to be achieved in CT based planning are sparsely found in literature, hence the need for this study.

This study aims to evaluate dosimetric aspects of CT based HDR ILBT.

Methods and Materials:

With a primary objective to analyse the dosimetric parameters obtained during CT based HDR ILBT, this study was conducted. After the institutional ethical committee approval, data of histo pathological proven oesophageal cancer patients treated with radical external beam radiotherapy (EBRT) followed by ILBT between January 2014 to December 2021, was collected. Following EBRT of 45-50 Gy in 1.8 -2 Gy per fraction with concurrent chemotherapy, the patients underwent brachytherapy procedure on an outpatient basis with an interval of two to four weeks between EBRT and ILBT. At our centre, in view of patient comfort and compliance, the Ryle's tube is used for ILBT treatments. The Ryle's tube (14-16 fringes) was inserted through the nostrils with the help of anaesthetizing agent and held with the use of plasters. The universal applicator (LLA1200-20) with X-ray marker was inserted into the Ryle's tube and a plain simulation scan (CT scan) was taken (Asteion VP, Toshiba) with 3 mm slice thickness.

The images were then transferred to HDR Plus treatment planning software for structure delineation, planning and optimization. The high-risk clinical target volume (HRCTV) and the organs at risk (OAR) such as bilateral lungs, heart, and spinal cord were contoured by radiation oncologists and the applicator digitization was done by physicists. After digitization the dwell position of 3mm activated in the applicator and the dose of 6.5Gy X 2 fractions was prescribed to HRCTV surface control points and optimization was done to achieve the maximum therapeutic ratio. Treatment was executed using Bebig Multisource 18 channels HDR Brachytherapy system with Cobalt 60 radioactive source and the source details are as follows: source dimension is 3.5mm x 1mm with half-life of 5.26 years. Following which the plans were evaluated by the oncologist and delivered with a 24 hours inter fraction gap using Bebig multisource HDR brachytherapy.

The dosimetric parameters were collected such as dose received by 0.1cc (D0.1cc), 2cc (D2cc) and 5cc (D5cc) of OARs and dose received by 90% (D90),98% (D98) and 100% of HRCTV volume (D100), Volume of HRCTV receiving 90% (V90),100% (V100),150% (V150) and 200% (V200) of prescription dose respectively.
The post treatment follow-up data was also noted from the records with respect to toxicities and survival. The disease free survival (DFS) was calculated from the completion of treatment to histopathological diagnosis of disease recurrence.

Statistical analysis:
The values were tabulated in Microsoft excel sheet and analysed using SPSS (Statistical Package for the Social Sciences) software 20.0 version. The descriptive data was analysed using mean or median.

Results:

Characteristics of the accrued 20 patients are listed in Table 1. Median age is 60 years (range: 45 - 77 years) with 11 male and 9 female patients. Mean treatment length of oesophageal disease was 5.65+2.09cm. The dosimetric parameters of HRCTV and OARs such as bilateral lungs, heart and spinal cord are explained in table 2.
Figure1 shows the axial section of isodose distribution with bilateral lungs being represented by yellow, heart by orange, spinal cord by teal, HRCTV by pink, 200% isodose line by yellow, 100% isodose line by red and 50% isodose line by blue. The mean D2cc received by the B/L lung, heart and spinal cord was 63%, 61% and 15% of the prescription dose respectively. In our study, the dose to lungs and heart was < 65% of the prescription dose and spinal cord received < 25% of the prescription dose.
All the patients were followed up and the median disease free survival observed was 13.05+9.88 months. It was observed that 10% of these patients developed stricture at treated site and had to undergo dilatation for the same.

Discussion:

Oesophageal cancer treatment has changed drastically over the decade with multimodality approach being the basis. Role of radiation varies from neoadjuvant to definitive CRT and also in palliative setting. [5] In-spite of all the advances in radiotherapy this cancer poses difficulty in treatment due to its location near critical structures such as heart, lungs and spinal cord. To overcome this hurdle, ILBT has been employed to administer tumoricidal doses. Brachytherapy because of its rapid dose fall off leads to higher therapeutic index, that is, maximum dose to the tumour and lesser dose to the surrounding tissues. It is either us ed to deliver higher dose as boost in radical setting or as a sole modality in palliative settings. [3]

According to American Brachytherapy Society (ABS) recommendation, for unifocal thoracic adenocarcinoma or squamous cell carcinoma, less than 10 cm in length of disease, with no evidence of extra oesophageal or regional nodal or metastatic disease, ILBT is employed as a boost in radical setting, post 2-3 weeks of completion of concurrent CRT. [6]

Dose and fractionation of ILBT varies and multiple fractionation regimens have been tried in the past, such as 5 Gy x 2 fractions, 6 Gy x 3 fractions, 6 Gy x 2 fractions, 7 Gy x 2 fractions and 8 Gy x 2 fractions [6,8,9,10] and they all have shown equivalent results.

Marinello et al in his study has dealt with reference isodose and treated thickness in ILBT based on Paris system. [11] Another study by Supe et al in 2007 deals with reference volume, treated planning volume and hyperdose sleeves in different applicator size and various optimization. [12] There is lack of literature on CT volume based dosimetric evaluation of treated target and OAR in ILBT.

In our study, with a wide range of HRCTV treated (7-67cc), the lungs and heart received higher dose than spinal cord due to the large radius of the thoracic vertebral body; the spinal cord is further away from the oesophageal growth and hence receives 40% less dose than the heart and lungs. These doses translated into none of the patients having any recorded pulmonary, cardiac or spinal toxicities and there were no deaths due to toxicities. We observed the median DFS is in comparison to the median DFS in literature (range 6 - 16 months) with the achieved dosimetric parameters. [13]

Conclusion:

To the best of our knowledge, this is the first study to report on the dosimetric parameters in CT based planning of ILBT in oesophagus. With the achieved dose constraints and coverage, we observed a DFS similar to the available literature and minimal toxicities. This study is a preliminary effort in analysing the characteristics of oesophageal cancers we come across and encourages dosimetrically consistent, safe treatment CT based HDR ILBT planning which will improve not only the DFS, but also reduce toxicities.

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Table 1: Explains the characteristics of the accrued 20 patients.

Characteristics		Number (percentage)
Gender	Male	11(55%)
	Female	9(45%)
Age	41-50	3(15%)
	51-60	7(35%)
	61-70	5(25%)
	71-80	5(25%)
Histology	Squamous cell carcinoma	18(90%)
	Adenocarcinoma	2(10%)
Histology grade	Well	5(25%)
	Moderately	11(55%)
	Poor	4(20%)
Site of oesophagus	Upper thoracic	1(5%)
	Mid thoracic	8(40%)
	Lower thoracic	11(55%)
Length of disease	Less than or equal to 5 cm	9(45%)
	6-10 cm	11(55%)

Table 2: Dosimetric parameters obtained.

Dosimetric parameters	**Median (range)**
HRCTV volume	28.5(7.1-67.6)cc

HRCTV V90	23.95(2.9-57.8)cc
HRCTV V100	21.9(2.5-52.9)cc
HRCTV V150	14.65(1.3-31.3)cc
HRCTV V200	7.1(0.7-16.5)cc
HRCTV D90	4.7(1.6-6.7)Gy
HRCTV D98	3.65(1-5.7)Gy
HRCTV D100	2.7(0.8-4.8)Gy
Bilateral Lung volume	2406.1(1771.6-3998.5)cc
Bilateral Lung D0.1cm^3	4.35(0.7-6.6)Gy
Bilateral Lung D1 cm^3	4.35(0.7-6.6)Gy
Bilateral Lung D2 cm^3	3.85(0.7-6.4)Gy
Bilateral Lung D5 cm^3	3.05(0.6-5.3)Gy
Heart volume	401.25(300.2-608.8)cc
Heart D0.1 cm^3	5.25(0.2-8.5)Gy
Heart D1 cm^3	4.2(0.2-6.9) Gy
Heart D2 cm^3	3.7(0.2-6.4) Gy
Heart D5 cm^3	2.95(0.2-5.5) Gy
Spinal cord volume	14.35(6.1-50)cc
Spinal cord D0.1 cm^3	1.05(0.1-1.6) Gy
Spinal cord D1 cm^3	0.95(0.1-1.4) Gy
Spinal cord D2 cm^3	0.9(0.1-1.3) Gy
Spinal cord D5 cm^3	0.8(0.1-1.1) Gy

Dose received by 90% (D90), 98% (D98) and 100%(D100) of the high risk clinical target volume (HRCTV); Volume of HRCTV receiving 90% (V90), 100% (V100), 150%(150), 200%(200) of prescription dose; Dose received by the 0.1 cm^3 (D0.1 cm^3), 1 cm^3(D1 cm^3), 2 cm^3(D2cm^3) and 5 cm^3 (D5cm^3) of organs at risk (spinal cord, heart and lungs).

Figure:

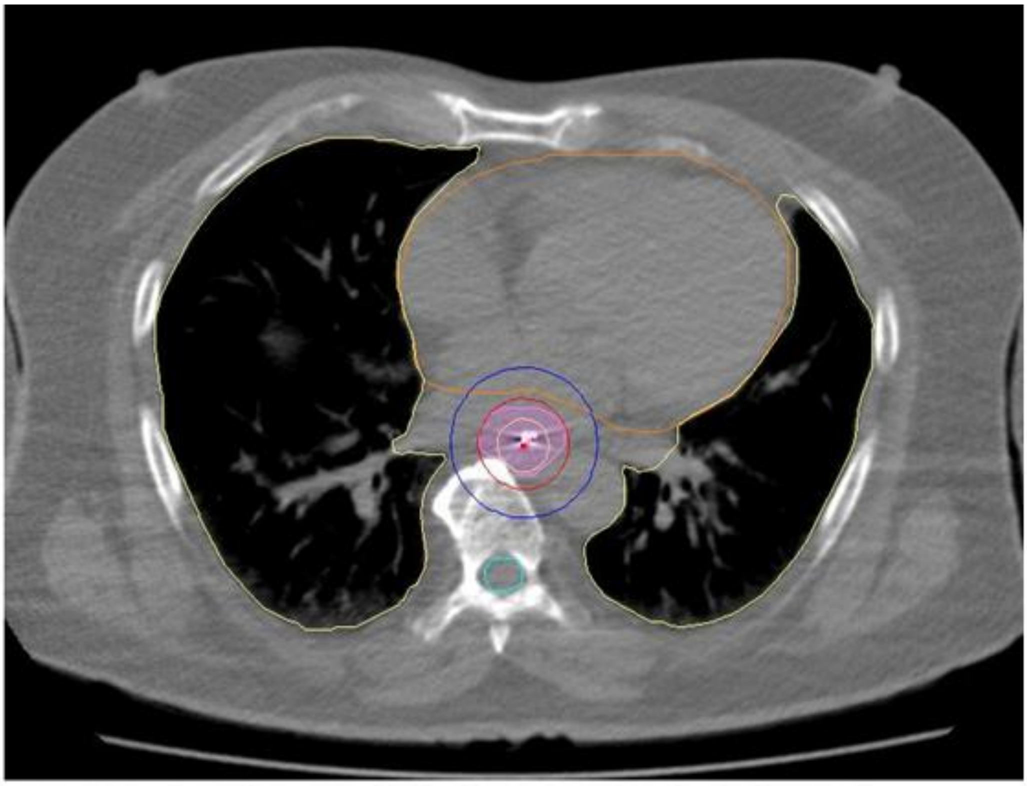

Figure shows the axial view dose distribution. bilateral lungs -yellow, heart-orange, spinal cord-teal, CTVHR- pink.
200% isodose line-yellow, 100% isodose line-red, 50 % isodose line-blue