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CARCINOMA OESOPHAGUS: MODIFIED COMPUTED TOMOGRAPHY CRITERIA IN PRE-OPERATIVE PREDICTION OF RESECTABILITY

Radiodiagnosis

Dr. Sudha Kiran Das* DMRD, MD Associate Professor, Department of Radiodiagnosis, JSS Medical College and Hospital, JSSAHER, Mysuru, Karnataka, India*Corresponding Author

Dr. Vikram Patil DNB Assistant Professor, Department of Radiodiagnosis, JSS Medical College and Hospital, JSSAHER, Mysuru, Karnataka, India

Dr. Mahesh Shetty MS Associate Professor, Department of Surgical Gastroenterology, JSS Medical College and Hospital, JSSAHER, Mysuru, Karnataka, India

Dr. Rudresh Hiremath MD, DNB, EdiR Professor, Department of Radiodiagnosis, JSS Medical College and Hospital, JSSAHER, Mysuru, Karnataka, India

Dr. Sachin P Shetty Md5 Senior Resident, Department of Radiodiagnosis, JSS Medical College and Hospital, JSSAHER, Mysuru, Karnataka, India

ABSTRACT

Background: To assess the sensitivity and specificity of Computed Tomography pertaining to invasion of tracheobronchial tree and aortic invasion using modified imaging criteria and compare the same with the original criteria. **Materials & Methods:** Retrospective and prospective correlative study evaluating the accuracy of CT in determining tumour resectability in patients with histological diagnosis of carcinoma oesophagus over a period of ten years from December 2000 to June 2006 and from June 2014 to October 2019. Histologically confirmed patients who underwent pre-operative imaging with CT for tumour staging and were subjected to curative or palliative surgery were included in the study. **Results:** Overall the sensitivity and specificity in assessing resectability to be 64.28% and 100% respectively using the modified criteria, this would imply that to a large extent, CT would not render any patient who is operable as inoperable. **Conclusion:** Computed tomography as evaluated in this study is a specific but relatively less sensitive modality in evaluating tumour resectability in carcinoma of oesophagus.

KEYWORDS

Carcinoma oesophagus, Computed Tomography, Pre-operative evaluation.

Introduction:
Carcinoma of the oesophagus remains one of the most virulent of all cancers, with an overall 5-year survival rate in patients amenable to definitive therapy ranging from 5% to 30% [1]. Worldwide, it is the 6th leading cause of death among malignancies [2]. Oesophageal carcinoma, in addition to its geographical and racial variation, has a gender bias, and is on an average seven times more common in men than in women. The incidence rate is close to the prevalence rate, indicating a short overall survival time. Staging plays an integral part in guiding stage specific treatment protocols and has a great impact on overall survival. Common imaging modalities used in staging include computed tomography [CT], magnetic resonance imaging, endoscopic ultrasound, and positron emission tomography scans. Current treatment options include multimodality therapy mainstays of current treatment include surgery, radiation, and chemotherapy [3-6].

Over the years, optimistic reports regarding accuracy of CT in assessing resectability has been counterbalanced by notes of caution as documented in the surgical literature. In contrast to the preliminary studies recommending CT as the primary modality in evaluating tumour resectability, to date current recommendations suggests CT to be used in conjunction with EUS for accurate TNM staging. The usage of the latter is limited by cost factor, availability and expertise required for interpretation.

In our study, few modifications were made to the original criteria to improve the specificity of CT in determining tumour resectability pertaining to infiltration of the tracheobronchial tree and aorta. It evaluates the sensitivity and specificity of CT in assessing resectability as compared to surgery, which is the gold standard. The purpose of this study was aimed at improving the accuracy of CT in pre-operative prediction of resectability. Increased accuracy not only reduces the rates of inadvertent surgery but also ensures respectable tumours are not staged as unresectable.

Methodology:
Retrospective and prospective correlative study evaluating the accuracy of CT in determining pre-operative tumour resectability in patients with histological diagnosis of carcinoma oesophagus was done over period of ten years from December 2000 to June 2006 and from June 2014 to October 2019 at two centres, Christian Medical College, Vellore and JSS Medical College and Hospital, Mysuru. All the patients over the age of 18 years who underwent pre-operative imaging with CT for tumour staging and subsequently underwent curative or palliative surgery were included for the study, including those who underwent neoadjuvant therapy, either chemotherapy or radiation therapy or a combination of both. Patients in whom, there was lack of per-operative data documentation or time lag between CT and surgery was more than 45 days were considered as exclusion. Key findings that preclude resectability would be invasion of the tracheobronchial tree or aortic invasion. Retrospective cases were obtained via the operative records in the surgical units and information was obtained from the operative records, as documented in the patient folders, and correlated with the biopsy records. CT scans were available for reviewed on PACS (Picture archiving and communication system). Contrast enhanced contiguous CT was performed on a CT Siemen's Emotions (Helical CT), Phillips MDCT (Brilliance 6slice and Ingenuity 128 slice CT). Single breath hold technique with maximum inspiration, beginning from the thoracic aperture up to the lower margin of the liver, with 50cc of oral contrast to be swallowed on table. Intravenous and oral contrast was used in all patients with exception of a few in the retrospective group.

Criteria used to assess infiltration are as follows:
Imaging criteria used to determine infiltration of contiguous structures are like that which has been used in literature. In evaluation of the tracheobronchial tree or aortic invasion, the original imaging criteria to infer invasion of the tracheobronchial tree and aorta was applied and the same was compared with the accuracy of the modified criteria.

i) Extra oesophageal spread:
1.Tumour present in the mediastinal fat transgressing all the muscular layers of the oesophagus, seen as indistinctness of the periesophageal mediastinal fat.

2.Loss of fat planes between the oesophagus and the contiguous mediastinal structures.

ii) Criteria to infer infiltration of the tracheobronchial tree: [Figure 1]
a) Original criteria in assessing invasion of the tracheobronchial tree:

1. The posterior tracheobronchial wall in the normal cervical trachea is often concave (inwardly bowed), but the intrathoracic trachea is linear or convex (outwardly bowed). Invasion is inferred when there is inward bowing of the posterior tracheobronchial wall or there is displacement away from the spine [7-10].

2. Absent fat plane at the level of the tumour and preserved above and below the tumour is suggestive of invasion.

3. Thickening of the tracheobronchial wall or demonstration of tracheal or bronchial fistula with the oesophagus at the level of tumour or intraluminal extension is definitive of invasion.

b) Modified criteria in assessing invasion of Trachea-bronchial tree:
1. Smooth indentation of the posterior wall of the trachea or tracheal displacement by the tumour mass with no focal indentation was interpreted as no definite infiltration.

2. Focal indentation of the trachea bronchial tree where the tumour contacts the tracheobronchial tree was interpreted as definite sign of infiltration.

3. Other findings of definite infiltration included focal wall thickening or demonstration of tracheal or bronchial fistula with the oesophagus at the level of tumour or intraluminal extension.

iii) Criteria to infer infiltration aortic invasion: [Figure 2, 3]
a) Original criteria to infer aortic invasion by Picus et al: [6,11-15]

This is based on the degree of direct contact between the tumour and the aorta. Based on the total aortic circumference of 360degrees, the extent of contact was evaluated.

1. Arc of contact < 45degrees: No invasion
2. Arc of contact between 45 and 90 degrees: Indeterminate
3. Arc of contact more than 90 degrees: Invasion.

b) Modified criteria in assessing invasion of the Aorta:
1. Preservation of periaortic fat plane between the tumour and the aorta, irrespective of the arc of contact: No infiltration
2. > 90 degrees of contact with loss of intervening fat plane: Infiltration.
3. Loss of periaortic fat plane, the arc of contact was assessed.
4. < 45 degrees: No invasion.
5. 45-90 degrees: Indeterminate. In these subgroup of patients, three criteria were laid. If two or more criteria were present, infiltration was inferred.

- Indistinct aortic wall
- Loss of triangular fat plane between the aorta / spine and the tumour
- Focal contour abnormality of the aortic wall.

iv) Left atrium and pericardium:
1. Obliteration of the fat plane at the level of tumour mass but present above and below this level: Infiltration.
2. Focal pericardial thickening or presence of pericardial effusion: Infiltration.

v) Crural infiltration:
1. Loss of crural definition with a contact of more than 1cm with the tumour mass: Infiltration.

Results:
Of the 198 patients who underwent surgery, 133 patients were included and 65 were excluded owing to the time lapse between the CT and surgery, for lack of per-operative documentation, 8 patients had CT done elsewhere, three patients had oesophageal perforation, of these one had metallic stenting. Of the 133 patients included, 93 were male (69.92%) and 40 female (30.8%). Mean age was 49 years, with a range of 28 year to 82years. Anatomically, the occurrence of carcinoma oesophagus predominated in the mid and distal third oesophagus comprising of 60% of the cases, followed by those with involvement of esophagogastric junction, two patients had carcinoma involving the upper third of oesophagus. Histologically, squamous cell carcinoma was noted in 66% of patients and adenocarcinoma in 34%. Adenocarcinoma's were encountered in those with distal third carcinoma with involvement of the esophagogastric junction. 28 patients were operated post neoadjuvant chemotherapy. Of the 22 patients found inoperable per-operatively, 18 were predicted on CT.
In evaluation of the tracheobronchial tree, the original criteria had a positive predictive value of 44% and negative predictive value of 82%, the modified criteria had a 100% and negative predictive value of 89%, with a specificity of 100%. Sensitivity and specificity with the original criteria were 60% and 75% respectively vs. 75% and 100% with the modified criteria in evaluation of the tracheobronchial tree. In assessment for aortic invasion, based on the original criteria, the sensitivity was 100%, however the specificity was only 29.8%, whereas the modified criteria had sensitivity of 60% and specificity of 100% and negative predictive value of 89.2%, with a specificity of 100%. CT was accurate in assessing involvement of the gastroesophageal junction in all patients with esophagogastric tumours and the same was confirmed both at surgery and pathologically. However, in evaluation for crural infiltration, the sensitivity was 83% and specificity was 90%. One patient had pericardial infiltration, which was inferred as post RT fibrosis on CT. Three patients had infiltration of the azygous vein which was missed on CT.

Discussion:
Pre-operative assessment and subsequent selection for various treatment arms depends on accurate clinical and radiographic staging with CT. Curative resection of the oesophageal tumour requires both thoracotomy and laparotomy. Exploratory thoracotomy per se, to determine resectability of oesophageal carcinoma is by itself associated with post-operative mortality in the range of 10%-22% [14-18]. Higher accuracy in pre-operative staging may decrease pre-operative mortality to less than 15% and increase resectability to a rate higher than 50%.

Tracheobronchial tree infiltration, based on the modified criteria used in this study, i.e. focal indentation or irregularity and not mere extrinsic impression on or inward bowing of the posterior tracheal wall is to be used to infer infiltration. This criterion is not only sensitive but also specific with an accuracy rate of 100%. Vascular invasion precludes surgical resection. The pioneering study by Picus et al was based on the arc of contact between the oesophagus and the aorta had low accuracy rates owing the indeterminate group. Modification to the criteria described by Picus et al pertains to the indeterminate group (range of 45 degrees to 90 degrees). In our study, intravenous contrast was administered with resultant distinct depiction of the aortic wall. Distinct depiction of the aortic wall and contour abnormality was used in addition to the triangular fat plane to determine infiltration in the indeterminate group. The CT's were evaluated for aortic invasion using the original criteria by Picus et al and the modified criteria. Sensitivity and specificity with the original criteria were 100% and 30% respectively vs. 60% and 100% with the modified criteria [19,20].

Conclusion: As much as it is imperative to reduce the incidence of inadvertent surgery, high sensivity and low specificity as observed previously laid our criteria would render some operable patients inoperable, which is undesirable as surgery is the cornerstone is curative therapy for carcinoma oesophagus. Based on the results gleaned from this study, modified criteria in evaluation of pre-operative resectability has significantly higher specificity in comparison to the original criteria. Future directives in this area for validation of the modified criteria would require another study with a subset of patients who undergo surgery without pre-operative neoadjuvant therapy.

Figure 1: Infiltration of the tracheobronchial tree [Original vs Modified Criteria].

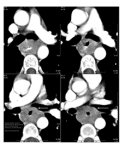


Fig 1: Inward bowing of the posterior tracheobronchial wall s/o infiltration [original criteria]

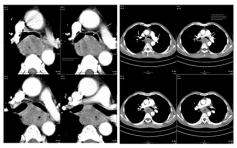


Fig 2/3: Focal indentation [modified criteria] s/o infiltration.

Figure 2: Modified criteria in assessment of aortic invasion of the Aorta

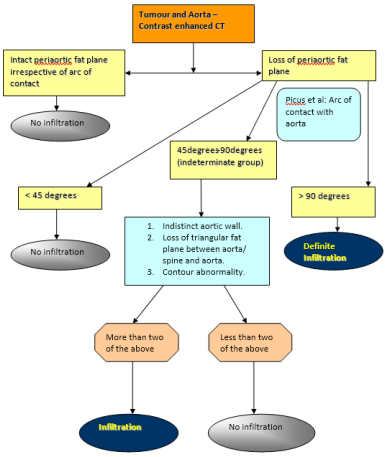
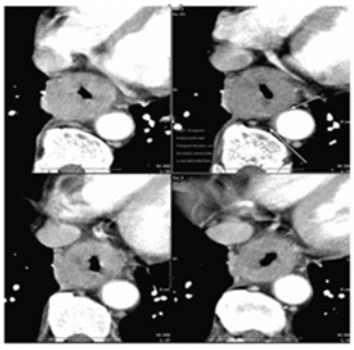


Figure 3: Modified criteria in assessment of aortic invasion of the Aorta demonstrated.

3a: Distinct aortic wall, focal contour abnormality and the triangular fat plane,
3b: Definite infiltration – indistinct aortic wall and focal contour abnormality.



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