

# Imaging Characteristics of Esophageal Cancer on Multidetector Computed Tomography

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## Abstract

**Purpose:** The study aimed to describe imaging characteristics of esophageal cancer on multidetector computed tomography (MDCT) and to evaluate the agreement in the diagnosis between MDCT and endoscopic ultrasound (EUS).

**Materials and methods:** Data of consecutive patients with esophageal cancer were collected from April 2017 to July 2018 at a single institution. Inclusion criteria for analysis were patients who were pathologically confirmed esophageal cancer and underwent MDCT and EUS. Exclusion criteria were past history of esophageal surgery, chemotherapy and radiotherapy for esophageal cancer. Tumor characteristics such as location, length, wall thickening, contrast enhancement, local invasion, lymphadenopathy and distant metastases were analyzed. Cohen's Kappa measure was used to examine the concordance in the diagnosis between MDCT and EUS.

**Results:** Thirty three patients (male/female: 93.9%/6.1%) met the inclusion criteria. The mean age was  $59.6 \pm 7.8$  years (range, 48-74 years). Distribution of esophageal cancer was 6.1%, 45.5% and 48.4% in the upper, middle and lower third, respectively. The mean length of tumor was  $75.3 \pm 34.6$  mm (range, 20 – 207 mm). Wall thickening was observed in all cases. Most of the patients were at stage T3 (69.6%) and N1 (66.7%) with regional lymphadenopathy (87.9%). Two modalities had good and moderate levels of agreement in tumor location ( $\kappa=0.742$ ) and tumor staging ( $\kappa=0.582$  for T-stage and  $\kappa=0.424$  for N stage), respectively.

**Conclusion:** MDCT is a useful and reliable diagnostic technique for the diagnosis and staging of esophageal cancer. It should be combined with EUS to provide a panoramic and accurate baseline information for clinicians to select the appropriate treatment.

**Key words:** Esophageal cancer, multidetector computed tomography, endoscopic ultrasound, wall thickening, local invasion, lymphadenopathy

## INTRODUCTION

Esophageal cancer is one of the common gastrointestinal malignancies and is the fifth most common cause of cancer – related deaths in men and the eighth leading cause of cancer mortality in women worldwide [2]. Accurate preoperative staging is crucial in determining the most suitable treatment and avoiding inappropriate attempts at curative surgery [3]. Multidetector computed tomography (MDCT) and endoscopic ultrasound (EUS), two of imaging modalities, have been widely used in the diagnosis and staging of esophageal cancer according to the society of thoracic surgeons guidelines [10]. Various studies have validated the accuracy of these two modalities in preoperative staging of esophageal cancer [4][12]. However, few studies have addressed the concordance of diagnosis between these two methods. Therefore, the purpose of the present study was (i) to describe the imaging characteristics of esophageal cancer on MDCT with respect to staging according to the TNM staging system of the American Joint Committee on Cancer (AJCC 2010), and (ii) to evaluate the concordance in diagnosing between MDCT and EUS.

## MATERIALS AND METHODS

### Study sample

Data of consecutive patients with esophageal cancer were collected from April 2017 to July 2018 at a single institution. Patients who had suspected clinical manifestations, MDCT, EUS findings and histopathological confirmation of esophageal cancer were included in the analysis. Patients with past history of esophageal surgery, chemotherapy and radiotherapy for esophageal cancer were excluded.

### Imaging protocol

Baseline MDCT images were obtained according to standard institutional protocols using a 64-slice MDCT (Philips Brilliance 64, Philips Healthcare, Best, The Netherlands). All patients were subjected to a whole body spiral scan in supine position within a single breath-hold. The following parameters were used: a detector coverage of 40mm, a gantry rotation time of 0.6s, a slice thickness of 3 mm, a pitch 1-2 and an effective tube current-time product of 150-250 mAs and 140 kV, collimation 64 x 0,625 mm. Non-ionic contrast medium (Ultravist® 300mg, Bayer Healthcare, Germany) was administered in all patients with an average dose of 1.5ml/kg of body weight. The contrast medium was

injected intravenously through a mechanical power injector (Stellant, Medrad, Pittsburgh, PA, USA) at a rate of 5ml/s. Images were acquired with a triphasic scan including non contrast phase, arterial phase acquired at 35-40s and portal venous phase at 70-80s after injection. The computer-assisted bolus-tracking software was used to determine the optimal scan delay for the arterial phase in each patient. Multiplanar and 3D reconstruction images were generated by designated Philips software (Planar mode and Volume Rendering). All the CT images were interpreted by 2 radiologists with over 20 years of experience (TKL, PHD).

### Research parameters

MDCT images were analyzed based on tumor location and length, pattern of wall thickening, contrast enhancement, local invasion, lymphadenopathy and distant metastases. The TNM staging system of AJCC 2010 was used for tumor staging. We grouped T1 and T2 categories because they were indistinguishable on MDCT due to the impossibility to differentiate individual layers of esophagus wall [7][9][11]. T1-T2 classification is usually seen as a smooth outer border of the thickened esophageal wall and a clear fat plane around the lesion [2][6]. T3 category was defined as irregularities of the outer border, stranding of the paraesophageal fat or ill-defined abnormal soft tissue density around the tumor. Invasion of adjacent structures through the obliteration of fat planes between esophagus and adjacent organs indicated T4 [7]. Mediastinal and abdominal lymph nodes greater than 10mm and supraclavicular lymph

nodes greater than 5mm in short axis diameter were considered etastatic regional lymph nodes [9][11]. Findings of MDCT and EUS were compared to evaluate concordance.

### Statistical analysis

Continuous data are presented as means  $\pm$  standard deviation, while categorical data are given as counts and percentages. Cohen's Kappa measure was used to analyze the concordance in diagnosing esophageal cancer between MDCT and EUS. All analyses were performed using SPSS 20 version (IBM, IL, USA).

## III. RESULTS

A total of 33 patients (male/female: 93.9%/6.1%) met the inclusion criteria. The mean age was  $59.6 \pm 7.8$  years (range, 48-74 years). Dysphagia was the most common chief complaint (93.9%). Distribution of esophageal cancer was 6.1%, 45.5% and 48.4% in the upper, middle and lower third, respectively. The mean length of tumor was  $75.3 \pm 34.6$  mm (range, 20 – 207 mm). Wall thickening and tumor contrast enhancement were observed in all cases (Fig. 1). Imaging characteristics and TNM staging of esophageal cancer on MDCT were summarized in Table 1. Invasion of adjacent tissues were seen 15.2% of patients (Fig. 2, 3). Most of the patients were at stage T3 (69.6%) and N1 (66.7%) with regional lymphadenopathy (87.9%). Concordance of MDCT and EUS in T and N classification was described in Table 2.

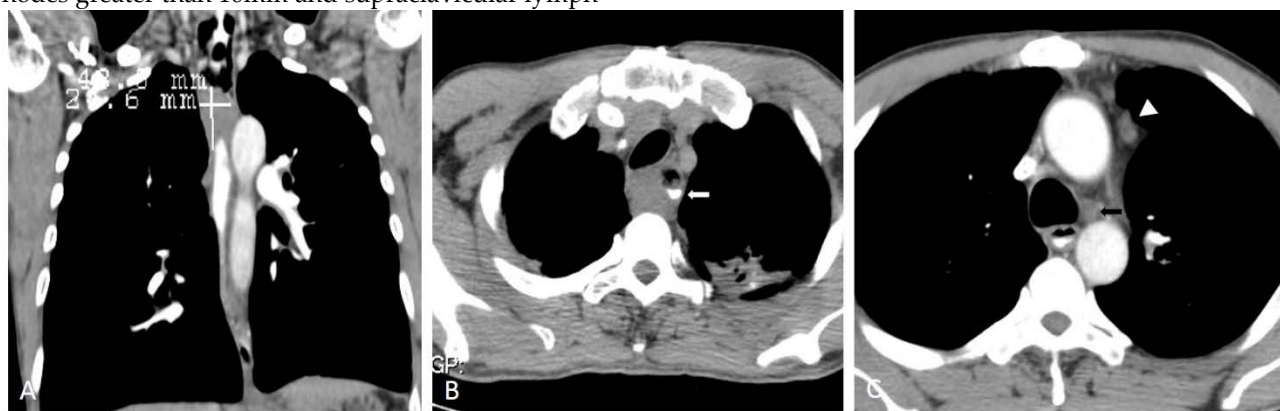


Figure 1. A 53 year old male presented with dysphagia (A) Coronal MDCT image demonstrated an 4.2x2.4 cm contrast-enhanced esophageal mass in the upper third. (B) Asymmetrical wall thickening was evident which was suggestive of malignancy. Note the presence of oral contrast (white arrow) indicating a narrowed lumen and a consolidation of the left upper lung. (C) Lymphadenopathy was seen at the left lower para-aortic level (arrowhead) and aorto-pulmonary window (black arrow).

Table 1: Imaging characteristics of esophageal cancer on MDCT

Imaging characteristics on MDCT	N = 33	Percentage
<b>Wall thickening</b>		
< 10 mm	1	3.0
10 – 20 mm	22	66.7
> 20 mm	10	30.3
Asymmetrical	21	63.6
Circumferential	12	36.4
<b>Contrast enhancement</b>	33	100
<b>Stranding of the periesophageal fat</b>	28	84.8
<b>Invasion of adjacent structures</b>	5	15.2
<b>Regional lymph nodes involvement</b>	29	87.9
<b>TNM classification</b>		
T1 - T2	5	15.2
T3	23	69.6
T4b	5	15.2
N0	4	12.1
N1	22	66.7
N2	7	21.2
M0	27	81.8
M1	6	18.2



Figure 2. Axial MDCT image showed an effacement of the triangular fat space between esophagus, vertebral body and aorta (arrow) with Picus angle  $> 90^\circ$ . The fat plane between the mass and the aorta was also obliterated (arrowhead). These findings were consistent with aortic invasion.

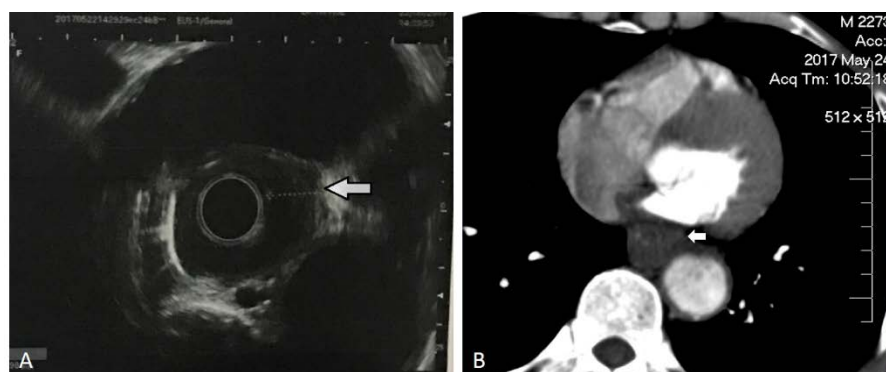


Figure 3. EUS image (A) revealed an eccentric mass with obliteration of the hyperechoic fifth layer (adventitia) in the lower esophagus (arrow) corresponding to a diffuse wall thickening and periesophageal fat infiltration on MDCT (B) (arrow).

Table 2. Concordance of T and N staging between MDCT and EUS

Modality	Stage	EUS			Total
		T1,T2	T3	T4	
MDCT	T1,T2	4 (80%)	1 (20%)	0 (0%)	5 (100%)
	T3	1 (4.3%)	21 (91.3%)	1 (4.3%)	23 (100%)
	T4	0 (0%)	3 (60%)	2 (40%)	5 (100%)
	Total	5	25	3	33
Kappa = 0.582					
Modality	Stage	EUS			Total
		N0	N1	N2	
MDCT	N0	2 (50%)	2 (50%)	0 (0%)	4 (100%)
	N1	3 (13.6%)	16 (72.7%)	3 (13.6%)	22 (100%)
	N2	0 (0%)	2 (28.6%)	5 (71.4%)	7 (100%)
	Total	5	20	8	33
Kappa = 0.424					

## DISCUSSION

Esophageal wall thickness is a focus of investigation when assessing the esophagus on MDCT. Normal esophageal wall thickness at MDCT measures less than 3mm in distended status, thus any wall thickness greater than 5mm is deemed abnormal [9][10]. Wall thickness in our study was  $18.7 \pm 7.8$ mm on average. The average wall thickness of esophageal cancer corresponding to T1-T2 stage, T3 stage and T4 stage were  $10.6 \pm 1.1$  mm;  $18.0 \pm 5.0$ mm and  $30.0 \pm 9.9$ mm, respectively. Wall thickness could be useful for predicting T stage because the greater the wall thickness, the deeper the tumor invades the esophagus wall, resulting in

advanced T category, as similar in the study of Li H and coworkers [5].

An accurate determination of tumor depth is important for treatment planning. The 64-slice MDCT and multiplanar reformation (MPR) techniques, which optimize the visualized esophagus and adjacent anatomic structures and discover the extension of tumor, are helpful in identifying an invasive point and the degree of invasion. Our study had 69.6% T3; 15.2% T1-T2 stage and 15.2% T4, as similar in the study of Chandna P, 56% of patients were T3 stage [1]. The adjacent organ invasion was reported including aortic invasion and tracheobronchial invasion.

EUS is considered the most accurate imaging modality for T categorization of esophageal cancer because it can be used to define the layers of esophageal wall and thereby differentiate T1, T2 and T3 [8]. Results of EUS were reported 9.1% T1; 6% T2, 75.8% T3 and 9.1% T4 in our study. It had a moderate level of agreement in diagnosis T – classification between MDCT and EUS with Kappa Coefficient of 0.582. According to table 2, EUS and MDCT correctly diagnosed 4 cases (80%) at T1-T2 stage. At T3 stage, consensus was reached in 21/23 cases (91.3%). At T4 stage, these two modalities agreed on 2 cases (40%). For cases where unconsensus exists, it was due probably to the limitations of EUS in cases of advanced tumor. In this setting, esophageal obstruction may hinder the passage of the EUS probe. As similar to the study of Vollweiler J [11], the accuracy rates for prediction of T stage were different for non-transversible strictures, tight strictures that were difficult to pass and easily transversible strictures.

EUS also has advantages over other imaging modalities in the evaluation of regional lymph nodes. Results of EUS were reported 15,2% N0; 60,6% N1 and 24,2% N2. It had a moderate level of agreement in diagnosis N – classification between MDCT and EUS with Kappa Coefficient of 0.424. As similar to T stage, the difference in diagnosis between two modalities was due to the limitations of EUS in cases of advanced tumor. In addition, EUS can visualize lymph nodes close to the esophageal wall [11].

## CONCLUSION

MDCT is a useful and reliable imaging modality for the diagnosis of esophageal cancer. EUS is considered the best in determining the depth of tumor invasion, especially at early stage. Therefore, MDCT and EUS should be considered complementary modalities in staging of esophageal cancer and to assist clinicians in selecting an appropriate treatment.

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