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Role of multidetector CT esophagography in patients with esophageal carcinoma

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Abstract
Multi-detector computed tomography (CT) is a new prospect in the imaging of the gastrointestinal tract. It allows the imaging of the entire esophagus with high-quality multiplanar reformation and 3D reconstruction. Most precisely the preoperative staging of esophageal carcinoma appears to be the main indication for MDCT. So here in our study our objective is to evaluate the feasibility, comfortability and diagnostic ability of MDCTE in esophageal carcinoma and to compare the findings of MDCTE with barium swallow and upper gastrointestinal endoscopy. For that we included 70 patients, who were endoscopically diagnosed as carcinoma. MDCT Esophagography was performed on 40-slice CT scanner after overnight fast along with all the necessary processing and evaluation were carried out. The endoscopic biopsy results revealed about squamous cell carcinoma in 55 patients (79%) and adenocarcinoma in 15 patients (21%). Most common location of the lesion was middle third of thoracic esophagus, seen in 28 patients (40%). On imaging, we found T4 disease was present in 28 (40%), T3 disease in 33 (47%) and T1/T2 disease in 9 (13%) patients. Overall quality of MDCTE was diagnostic in 63 (90%) patients. The volume rendered images were equal or superior to barium esophagogram in defining the longitudinal extent of the disease in 90% (63/70) of patients. Kappa correlation between MDCTE and barium esophagogram for length of the lesion was found 91.3% and between MDCTE and conventional endoscopy for morphology was 63%. This results which we obtained are better than barium esophagogram in most patients. So it can be a one-stop modality for accurate definition of longitudinal extent of the disease as well as staging in patients of esophageal carcinoma.

Keywords: Esophageal carcinoma, MDCTE, esophagogram, CT scanner

Introduction
Carcinoma of oesophagus is one of the common cancers of the alimentary tract with an annual incidence of 7.5 to 10.3 per 100,000 population In India [1]. The cancer is aggressive with a 5-year survival of dismal 18% at 5 years [2]. With increasing use of chemo-radiotherapy (CRT), the survival rates have increased favourably to 42% with reduced local recurrence rate [2, 3]. Accurate staging of the disease is important for prognostication and planning appropriate treatment [4]. Further, neoadjuvant CRT changes the histological picture at surgery and thus accurate definition of extent of the disease prior to treatment is of utmost importance [5].

Currently, barium esophagogram and multi-detector Computed Tomography (MDCT) scan are the investigations performed for staging esophageal carcinoma. The limitations of these techniques include inadequate definition of tumor margins, inaccurate assessment of T-stage and N-stage of the disease and poor assessment of response to CRT [6, 7]. These shortcomings may result in inappropriate treatment.

Accurate definition of the longitudinal extent of the tumor margins is important for various reasons [8, 9]. These include classification of involved lymph nodes (as regional or metastatic), planning the field for radiotherapy, planning the approach to surgery and for defining the length and positon of palliative stents. A recent study by Sillah *et al*, [10] suggested that esophageal tumor length defined by routine MDCT did not correlate with pathological extent of the tumor. Collapsed esophagus overestimates tumor length (Fig.1). In routine MDCT, esophagus is distended by ingestion of iodinated contrast agent just prior to scanning. The distension here is passive and inconsistent due to rapid contrast transit and depends on the density of contrast swallowed [11].

MDCT esophagography (MDCTE) produces good distension of the esophagus with air for better estimation of wall thickness, disease extent and distensibility [12]. Only few studies are available in the literature evaluating esophageal carcinoma with MDCT esophagography (MDCTE) and only one study has compared MDCTE with barium esophagogram [4, 11, 13, 18]. With this background, we aim to evaluate the feasibility, comfortability and diagnostic ability of MDCTE in esophageal carcinoma and to compare the findings of MDCTE with barium swallow and upper gastrointestinal endoscopy. The average esophageal wall thickness at tumor location was 8 mm (range 3–40 mm) and the average tumour length was 71 mm (range 28–120 mm).

Materials and Methods

Patients

The study as approved by Institute Ethics Committee. All consecutive endoscopically diagnosed cases of carcinoma of esophagus who presented to the Gastroenterology or Gastrointestinal Surgical Clinic between January 2015 and July 2016 were included in the study after obtaining informed written consent. The inclusion criteria were confirmed esophageal carcinoma on biopsy and having not received any previous treatment. The patients with renal failure (where intravenous iodinated contrast could not be given), allergy to iodinated contrast agent and un-cooperative patients were excluded from the study.

Methods

Initial clinical evaluation for symptoms of dysphagia, vomiting, hematemesis, weight loss, anorexia and duration of symptoms was done. The upper gastrointestinal endoscopy (UGIE) pictures of the mass and the biopsy results of all patients were noted. Subsequently evaluation was done with MDCTE and barium esophagogram within a week of performing endoscopy.

MDCT Esophagography

MDCTE was performed on 40-slice CT scanner (Somatom Sensation, Siemens, Erlangen, Germany) after overnight fast. After explaining the procedure to the patient, a nasogastric tube (NGT, 8F) was inserted through the nose for about 15 – 18 cm, so that its tip was below the cricopharyngeal sphincter. Once the patient was on the CT scan table, the proximal end of NGT was connected to a long connector tubing and to a 50 ml syringe through a three-way stop cock. The patient was instructed not to belch during the scan. Just prior to the scan, 10 mg of hyoscine butyl bromide was given intravenously to relax the esophagus and reduce its peristalsis. Room air injection through the NGT into the esophagus was started 10 seconds prior to the scan (at a rate of 25-30 ml/sec) and continued till the end of the scan. MDCT scan was performed in venous phase, 70 seconds after intravenous injection of iodinated contrast agent. Following the scan, the patient was observed for 30 minutes for any complications. Barium esophagogram (single contrast) was done on the same day using 95% w/v barium suspension and spots were taken depending on the site of the lesion.

Processing: The thin section (0.6 mm) CT images were then transferred to the workstation (Syngovia, Siemens). The images were loaded to the "CT colon" preset for obtaining virtual endoscopy (VE) and flythrough images. Volume rendered (VR) images were generated in solid and transparent modes. The time needed for processing of the images was noted. The images were evaluated by two experienced abdominal radiologists with 20 years and 7 years-experience, respectively. The base images, virtual endoscopy and volume rendered images were evaluated by both and compared with barium esophagogram and conventional endoscopy.

Evaluation

The amount of air injected during the procedure was noted. Patient comfort during the procedure was defined using a three-point scale: 1. No pain / discomfort; 2 – Tolerable pain / discomfort; 3 – intolerable pain. Degree of esophageal distension was defined as, *Good*, when the esophagus was well distended with thin esophageal wall proximal and distal to the lesion; *Fair*, when esophagus was adequately distended without loss of diagnostic information; and *Poor*, when there was inadequate distension of the esophagus with loss of diagnostic details. The mucosal abnormality as seen on conventional endoscopy and VE were classified as ulcerative, polypoidal and stricturing. The volume rendered images were compared with barium esophagograms for longitudinal extent of the disease. The overall diagnostic quality of MDCTE was finally graded as diagnostic or non-diagnostic.

Descriptive statistics was used for demographic data and other parameters. Kappa weighted analysis was done to correlate concordance between MDCTE and conventional endoscopy and barium esophagogram. A p-value of 0.05 was considered significant. SPSS 17 (IBM, Chicago) was used for statistical evaluation.

Results

Seventy patients (44 males; 26 females) of confirmed esophageal carcinoma with mean age of 55.1 years (range: 35-80 years) were included in the study. Dysphagia was the most common symptom, seen in all patients. The mean duration of symptoms was 2.5 months (range: 1 – 12 months). The histology on endoscopic biopsy was squamous cell carcinoma in 55 patients (79%) and adenocarcinoma in 15 patients (21%). Most common location of the lesion was middle third of thoracic esophagus, seen in 28 patients (40%). Frequency of tumor in other locations were 11% in upper third (n=8), 23% in lower third (n=16) and 26% in gastroesophageal junction (n=18). On imaging, T4 disease was present in 28 (40%), T3 disease in 33 (47%) and T1/T2 disease in 9 (13%) patients.

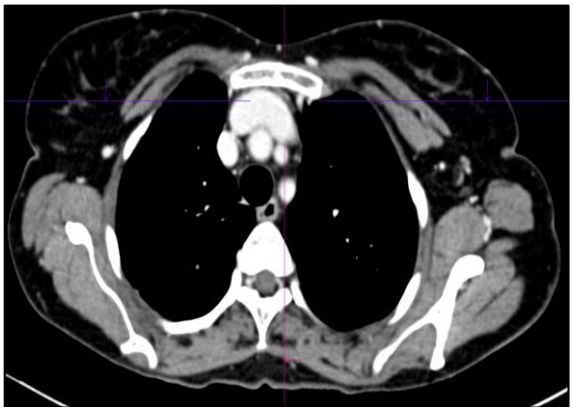

Fig 1: Schematic diagram showing the importance of distended esophagus for accurate definition of lesion extent. In collapsed esophagus, normal wall thickness obscures the mass (arrow).

MDCTE was comfortable and tolerable in 68 patients (97%). In two patients the procedure was intolerable due to coiling of NGT in trachea causing respiratory distress (n=1) and abdominal distension due to excessive air insufflation (n=1). However, the procedure was completed in both cases. There were no procedure-related complications, radiocontrast related allergy or nephropathy in the study population. The mean amount of air injected during the procedure was 656 ml (range: 400 – 900 ml). Esophageal distension was good in 71.5% (n=50), fair in 18.5% (n=13) and poor in 10% (n=7) of patients (Fig. 2). In patients with good, fair and poor esophageal distension, the average amount of air injected were 658 ml, 657 ml and 655 ml, respectively without any significant difference between the groups (p = 0.63). In the patients with poor distension, 5 tumors were in mid third of esophagus, one in upper third of esophagus and one in gastroesophageal junction. The reasons for poor distension were misplaced NGT (n=4), fluid residue proximal to the obstruction (n=2) and un-cooperative patient (n=1).

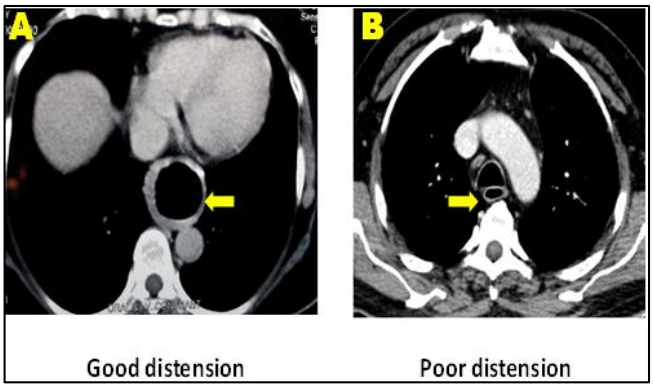

Fig 2: Axial MDCTE images showing good, fair and poor distension of the normal segment of esophagus (arrow).

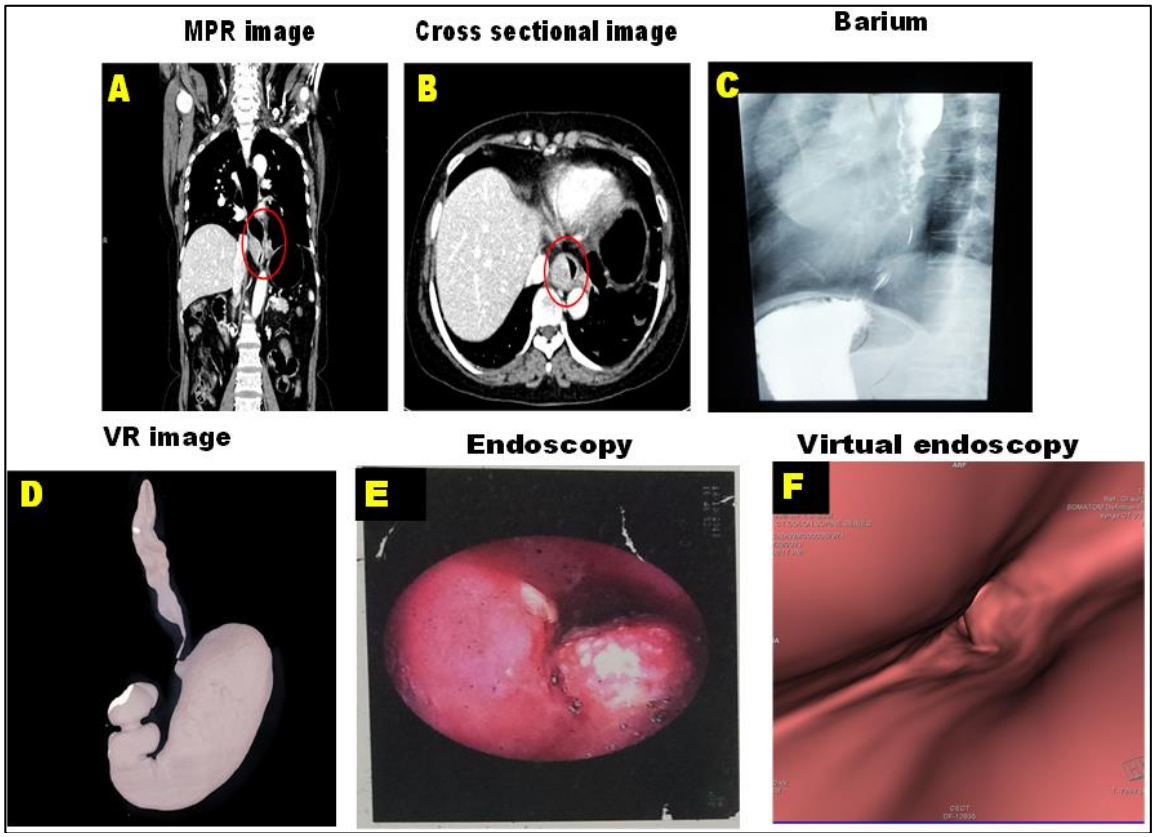

Fig 3: MDCTE of a 51-year-old male patient, presenting with dysphagia for 3 months. Axial (A) and Sagittal (B) base images, Barium (C)3D volume rendered images in s (D) modes and Conventional endoscopy(E)Virtual endoscopy picture (F) showing short segment stricture in distal esophagus (arrows).

The biopsy was adenocarcinoma.

The average time taken for post-processing of the CT images initially was about 30 minutes which reduced to 15 minutes with experience during latter half of the study. The average esophageal wall thickness at tumor location was 8 mm (range 3–40 mm) and the average tumour length was 71 mm (range 28–120 mm). Morphology on virtual and conventional endoscopy are shown in Table 1.

Table 1: Morphological appearance on endoscopy (conventional and virtual)

Morphology	Virtual Endoscopy	Conventional Endoscopy
Ulcerated	23 (33%)	47 (67%)
Polypoidal	18 (26%)	9 (13%)
Stricture	29 (41%)	14 (20%)

Overall quality of MDCTE was diagnostic in 63 (90%) patients (Fig. 3). The volume rendered images were equal or superior to barium esophagogram in defining the longitudinal extent of the disease in 90% (63/70) of patients (Fig. 4).

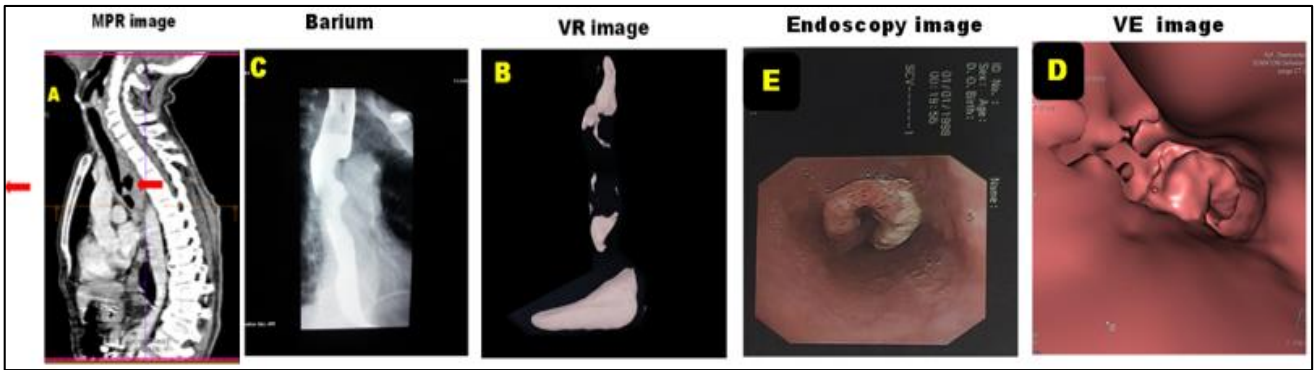

Fig 4: Comparison of MDCTE with conventional techniques in a 67-year-old male patient presenting with dysphagia for 7 months and histology showing adenocarcinoma. Distension was good. Coronal base image (A) showing thickening in upper thoracic esophagus (arrow). Volume rendered image (B) is better than barium swallow (C) for tumor definition (arrow). Virtual endoscopy (D) picture is similar to conventional endoscopy (E).

Discussion

Patients with esophageal carcinoma have a poor prognosis because most patients have advanced disease at the time of presentation [19]. As resection is the only curative treatment option available, early diagnosis and accurate staging are very important for planning the management. On routine CT scan, the esophageal carcinoma is diagnosed based on abnormal wall thickening which primarily depends on extent of distension of the esophagus. This problem can be partly overcome by techniques like endoscopy, barium esophagogram, endoscopic ultrasonography (EUS), CT with oral contrast, Magnetic resonance imaging with diffusion weighted imaging and Positron emission tomography (PET)- CT [20]. Most of these methods are complementary.

Barium esophagogram is highly sensitive, with lesion detection rate of 98% and positive predictive value of 42% [21]. Although conventional endoscopy and barium studies can better demonstrate the mucosal extent of the lesion, they have limitations like inaccurate assessment of the depth of tumour infiltration, and inability to contribute to disease staging [22, 23]. In addition endoscopy is invasive and evaluation beyond a stricturing growth is often not possible as it may not be possible to pass the endoscope distal to the malignant stricture [22]. Endoscopic ultrasonography (EUS) better defines the longitudinal extent of the disease and is useful in local staging [24]. The sensitivity of EUS in the preoperative determination of T and N stages in esophageal carcinoma are 92% and 85%, respectively [25]. However, EUS cannot detect distant metastatic disease either in regional lymph nodes or solid organs due to smaller field of view, is often limited by the inability of current probes to cross the stricture and is associated with risk of perforation [20, 22]. MRI with T2-weighted and diffusion weighted sequences has accuracies of 75 – 87% in staging esophageal carcinoma [23]. However, routine use is difficult due to artefacts, cost and long scan times [26]. PET-CT is often used in the staging of esophageal carcinoma and is useful in detecting un-suspected distant metastasis [27]. It may have role in assessing response to neoadjuvant CRT and in evaluation for recurrent disease [28]. However, due to high cost and limited availability, its routine use is restricted. Further, absence of esophageal distension may not accurately define the extent of the tumor [12].

MDCT and virtual endoscopy (VE) may become a single modality providing all the information needed preoperatively. It has been investigated by many authors for the evaluation of both benign and malignant oesophageal conditions (Table 2) [18]. Good gaseous distension of esophageal lumen is the most critical factor in this technique. Optimal and consistent oesophageal distension can be achieved by either actively insufflating air or carbon-dioxide into the esophagus or passively by using effervescent granules. Active distension requires insertion of a tube, which increases procedure time and patient discomfort. Passively distending the esophagus requires much more patient co-operation. However, studies have shown good results with both techniques (Table 2). There are only eight studies of MDCTE in English literature, most with less than 50 patients (Table 2). Six of these studies used effervescent powder for esophageal distension and obtained good or fair distension in more than 90% of patients. Jin *et al*, [17] suggested ingestion of effervescent powder twice for better distension although this may need more patient co-operation. Only two studies used tube for insufflation and air was used in one study and CO_2 in the other [11,16]. The results in these studies were also similar to studies using effervescent powder. Only one study by Kim *et al*, [16] compared MDCTE with conventional modalities and showed that MDCTE is better than or equal to barium esophagogram in 80% cases and better than or equal to endoscopy in 74% cases. Our study was also similar with similar results. However, our study included 70 patients, which is more than other studies.

Table 2: Comparison of our study with studies in literature

Author	Year (reference)	No of patients	Technique	Results (distensibility)	Remarks
Mazzeo *et al*	2004 [13]	n=33	Effervescent powder	93% - good / fair	Sensitivity - 84% Specificity - 87% Accuracy - 85%
Kim *et al*	2006 [16]	n=23	Tube insufflation (Foley's) with mechanical inflator	91% - good / fair	80% =/> Barium 74% =/> Endoscopy
Panebianco *et al*	2006 [15]	n=39	Effervescent powder	93% - good / diagnostic	92% - Sensitivity 88% - accuracy
Jin *et al*	2009 [17]	n=38	Effervescent powder	91% - Up / Mid 81.6% - Lower	Ingestion twice
Onbas *et al*	2006 [14]	n=44	Effervescent powder	Good – 61%	81% = Endoscopy
Carascasa *et al*	2009 [18]	n=28	Effervescent powder	Not evaluated	None
Ulla *et al*	2010 [11]	n=50	Tube insufflation (Foley's), CO_2 pump	Adequate distension in all	Better definition of tumors in GE junction
Ringe *et al*	2015 [4]	n=52 n=84	Effervescent powder (EP) vs no powder	Distension better with EP	Improves cancer detection
Our study	--	n=70	Tube insufflation (NG tube), Manual injection	Good / fair – 90%	90% =/> Barium 63% =/> Endoscopy

We achieved good or fair esophageal distension in 90% of patients using manual insufflation of room-air. Ulla *et al*, [11] in their study of 50 cases used mechanical insufflators and approximately 1000-1200 ml of CO_2 gas under sustained pressure to achieve optimal distension in all cases. Although CO_2 is inert and causes less patient discomfort, maintaining a CO_2 cylinder and mechanical insufflator in a radiological suite may be expensive. We successfully used lesser amount of room air without causing much patient discomfort. The average amount of air injected was not significantly different between patients with good and poor oesophageal distension (655 ml vs 658 ml). Patient cooperation is necessary to get good oesophageal distension. Spraying of the posterior wall of the pharynx with a local anaesthetic agent is helpful. Patients need to be explained about the procedure clearly beforehand and instructed properly. Use of hypotonic agents like hyoscine butyl bromide 10–15 minutes before the procedure may be valuable in producing optimal distension [13]. Compared to the use of effervescent agents causing passive esophageal distension, this procedure needs lesser co-operation by the patients [13]. Further, distension of stomach in addition to esophagus is possible with tube insufflation which helps in defining the lower extent of the disease in gastro-esophageal junction tumors [11]. Many patients with oesophageal cancer have absolute dysphagia and have retained fluid in the oesophageal lumen which affects quality of VE images. This can be overcome by aspiration of the retained fluid prior to MDCTE.

There were a few limitations in this study. Firstly, there was no gold standard in our study. No patient was operated directly and all patients received chemotherapy (neo-adjuvant or palliative). Hence, correlation at surgery was not possible. Secondly, we did not evaluate the diagnostic ability of MDCTE as all patients had confirmed malignancy. Thirdly, the images on VE do not have enough resolution to detect minute mucosal details, especially ulcerations. Therefore, it was often difficult to characterize confidently the mucosal ulcerations in a lesion. Further, obtaining biopsy and qualitative information (e.g. easy touch bleeding) is not possible with VE. Lastly, the post-processing of CT images requires special software, time and expertise.

Conclusion

In conclusion, MDCTE by tube insufflation of room air provides adequate esophageal distension in 90% of patients of esophageal carcinoma without causing significant discomfort. The results are better than barium esophagogram in most patients. Thus it can be a one-stop modality for accurate definition of longitudinal extent of the disease as well as staging in patients of esophageal carcinoma.

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