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**Research Article**

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# The role of computer tomography in esophageal cancer surgery

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**ABSTRACT**

*To investigate the role of Computer Tomography (CT) in the esophageal cancer surgery. 97 cases confirmed by pathology as esophageal cancer were retrospectively analyzed with preoperative Computer Tomography images and intraoperative situation. Tthe Computer Tomography can accurately display the thickness and length of the lesion segment esophageal wall, the relations between tumor and the aorta, the trachea, bronchus, pericardial and pulmonary vein, and local lymph node metastasis, prompt possible difficulties in surgical resection; Correctly grasp the esophageal preoperative Computer Tomography staging helps to select appropriate treatment to reduce the rate of surgical exploration. CT images is clear with high density resolution in human tissue; spiral CT-3D reconstruction technique can display clearly human body structure and relationship with the adjacent structures; the CT scan has important significance in preoperative staging of esophageal cancer; the CT scan has operation resection rate of esophageal cancer improvement.*

**Keywords:** Computer Tomography; esophageal cancer; surgery

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## INTRODUCTION

Esophageal cancer is one of the common malignant tumors in China. Esophageal barium meal and *esophageal* endoscopy are effective methods of positioning and qualitative diagnosis of esophageal *cancer.* They can observe the position, morphology and size of the lesion in esophageal lumen. Chest Computer Tomography has made up the deficiency that the traditional esophageal X-ray barium meal examination can only observe the lesions in esophageal lumen. Domestic and international studies have shown that: the CT scan can show the relationship of the esophagus and adjacent mediastinal organs, tissues, and determine the extent and scope of invasion of the tumor, the surrounding and distant lymph node metastasis, to provide more information for clinical. In order to get a further evaluation about the role of CT scanning in staging of esophageal cancer, judging whether operation and designing treatment regimens, we have collected 97 esophageal cancer cases in China-Japan Union Hospital during December 2010 to December 2011 and retrospectively analyzed with preoperative chest CT images, intraoperative situation and postoperative pathological.

## EXPERIMENTAL SECTION

2.1 Materials and reagents

In 97 cases of esophageal cancer patients, age from 31 to 68 years old, median age 56.78 years, 87 cases are male, 10 cases are female. Among them the number of upper, middle, lower segment esophageal cancer are 14, 70 and 13, respectively. Pre-operative examination and imaging examination showed no distant metastasis. All patients accepted preoperative chest CT scan within 2 weeks before surgery, some patients (n=15) received enhanced scan. CT detected 93 cases of esophageal cancer, and the remaining four cases of small lesions confined to the mucosal layer, the CT scan did not show esophageal wall thickening and missed. In 97 cases, 91 cases underwent radical resection, six cases of unresectable accepted exploratory surgery. Pathological: 92 cases of squamous cell

carcinoma, adenocarcinoma in 3, undifferentiated small cell carcinoma in 2 cases. Preoperative symptoms: progressive dysphagia in 60 cases; burning or prickling-like retrosternalpain in 9 cases; the substernal discomfort associated with foreign body sensation in 11 cases; 13 cases of weight loss; melena in 3 cases and one case of hoarseness.

2.2 Use the GE9800 Hilight CT scanner

Hollow patients accept antispasmodic 20 mg intramuscular injection 10 minutes before the scanning, and drink aerogenic powder, in order to make esophageal dilatation and air inflation; Continuous scan with thickness of 10 mm, interval of 10 mm since the top of sternoclavicular joint to the level of porta hepatis confined to the supine position; Take the enhancement scanning after rapidly intravenous injectiing iodinated contrast agent 100 mL ,within the region that 30-50 mm apart from the lesion's lower and upper borders with thickness of 5 mm, interval of 5 mm. Radiography with mediastinal window is given priority to, adding up bronchial window at the parts containing trachea and bronchus, as well as lung window where tumor inburst the lung. Observe the thickness of the esophageal wall with lesion, the tumor invasion, the relationship of the tumor and other organs, such as the aorta, the trachea and bronchus, pericardial, pulmonary vein and prevertebral fascia, and the situation of local lymph node metastasis.

## RESULTS AND DISCUSSION

3.1. Location and length of the tumor

The length of the tumor is calculated according to the number of layers in CT scan. CT scan shows that the length of lesions are 3-10 cm, 6.5 cm in average, which is 2.5 cm longer than that was measured by esophageal barium meal. 14 cases are upper esophageal carcinoma, 25 cases of mid upper segment, 12 cases of middle segment, and the number of mid lower and lower segment esophageal carcinoma is 17 and 29, respectively.

3.2. Changes of the wall and lumen

In 97 patients who underwent CT examination, 93 cases showed the accurate position and size of the tumor. The segment of tumor have varying degrees of esophageal wall thickening and luminal stenosis, thickness of 0.8-2.9 cm, average 1.45 cm while stenosis was concentric or eccentric changes “Fig.1”, including 68 cases with lumen expansion above the lesion. The remainder four cases have no obvious wall thickening because the lesions confined to the mucous layer or submucosa.

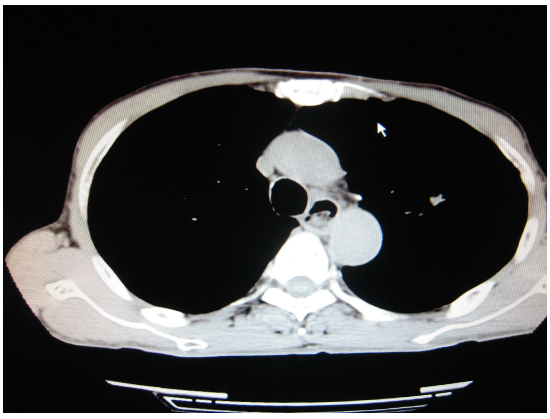

**Figure1. Stenosis was eccentric growth**

3.3. Changes of paraesophageal fat space

In 97 patients who underwent CT examination, 78 cases shown the paraesophageal fat space clearly, six cases fuzzy. In the remaining 13 cases those paraesophageal fat space disappear “Fig.2”, 6 cases were unresectable and took exploratory surgery, with the ratio of 46.1%, suggesting that the paraesophageal fat space is an important indicator for the possibility of resection.

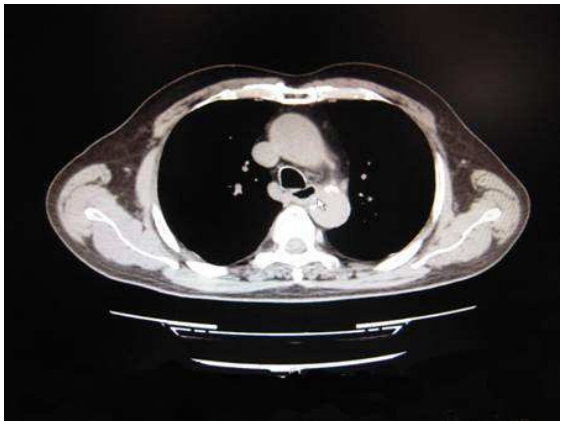

**Figure2. Paraesophageal fat space is disappeared**

3.4. Tumor in contact with the aorta

In 77 cases of 97 patients who underwent CT examination, the contact surface of esophageal and aortic<45 “Fig.3”, 11 cases between 45-90, in which one case is unresectable; 9 cases> 90, in which 5 cases could not be resected, with the exploration ratio of 55.5%, suggesting that surgeons should be more considerate about the resection operation when the contact surface of the tumor and the aorta> 90. Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Do not use abbreviations in the title unless they are unavoidable.

**Figure3. The contact surface of esophageal cancer and aortic<45 degree, arrow shown**

3.5. Tracheal compression

In 97 patients who underwent CT examination, 6 cases showed tracheal compression, mainly in tracheal membrane “Fig.4”, in which 2 cases could not be resected and took exploration operation, with the proportion of 33.3%, suggesting that tracheal compression is another important index for the possibility of resection.

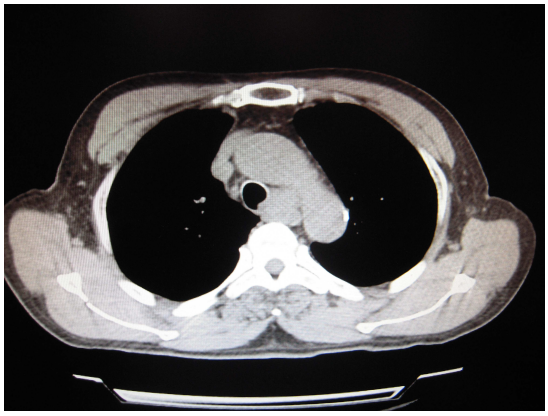

**Figure4. Tracheal membrane is compressed and transformed**

3.6. Pericardial and pulmonary vein compression

In 97 patients who underwent CT examination, 8 patients with pericardial compression "Fig.5", 5 cases of pulmonary venous compression, cardiac and pulmonary vein were involved in 2 cases, including 1 cases of unresectable, with the exploration ratio of 50%, suggesting that when pericardial and pulmonary vein are compressed by the tumor simultaneously, surgeons should try to avoid the selection of resection operation.

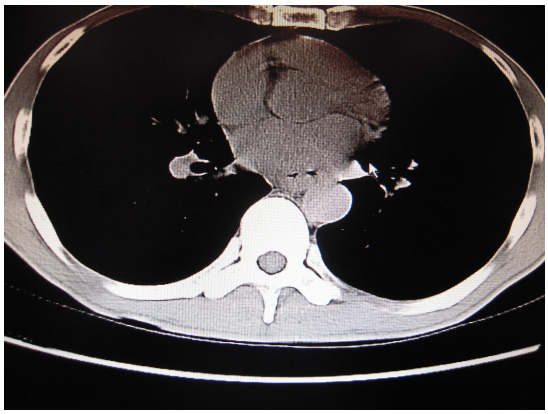

**Figure5. pericardial compression extensive**

3.7. Lymph node involvement

1082 lymph node located in paraesophageal, subcarinal, paratracheal, left gastric artery respectively was cleared away in 97 cases. The sensitivity, specificity, accuracy of preoperative CT judging lymph node metastasis for esophageal carcinoma were 31.1%, 83.9% and 69.7%, respectively.

3.8. CT staging and operation effect of esophageal carcinoma

The patients whose CT staging for stage I, II were resected successfully, 6 cases of 21 patients whose CT staging for stage III esophageal cancer took exploration operation.( Table ).

**TABLE 1. CT staging and operation effect of esophageal carcinoma**

| | Resction | Exploration | Total |
|---|---|---|---|
| Stage I | 5 | 0 | 5 |
| Stage II | 67 | 0 | 67 |
| Stage III | 19 | 6 | 25 |

## DISCUSSION

For the symptoms of early esophageal cancer are mild, it was difficult to find, while most of the tumors progress to middle-late stage and big when patients see a doctor. Esophageal is the only organ which is lack of serous membrane in digestive system, so esophageal cancer is very easy to saturate fiber membrane and adhere with the surrounding tissue. The traditional esophageal barium meal can be displayed signs of esophageal carcinoma directly: mucosal disorders, damage; wall stiffness, loss of peristalsis; luminal stenosis, lumen dilation above the stenosis; niche and intraluminal filling defection. Esophageal barium meal cannot show the adjacent tissue, organ invasion and lymph node metastasis clearly, but can show the early changes of mucosal plicae, the wall and the lumen of the esophageal. The 4 patients with early esophageal in this group were displayed well by barium meal radiography, but not be finding in CT scan. But CT scan showed esophageal wall and adjacent tissues and organs well, especially superior to barium and endoscopy on the diagnose of the lesions out of the lumen [1-3]. Especially when the esophageal barium meal showed deep ulceration or the soft tissue around the lesion suggest the possibility of invasion, chest thin slice CT scan can display the depth of niche accurately, and help to determine the extent of invasion. Several domestic and foreign researches about esophageal carcinoma in recent years show that preoperative CT scan is very important for esophageal carcinoma, especially in the discovery of tumor invasion, determining the tumor staging; CT scanning has the unique superiority. CT scanning can also assist the surgeon to determine the way of operation, assist the radiotherapy physicians to identify the target district of radiotherapy, and design satisfied radiotherapy planning. We retrospectively analyzed 97 cases of esophageal cancer patients with preoperative CT scanning, intraoperative findings and postoperative pathology. Confirm the important role of CT scan in staging esophageal cancer, judging the possibility of tumor resection, and designing treatment plan.

*3.9.1. Principle and application of CT*

Following the X-ray computed tomography (CT) was utilized in clinic in 1972 and spiral computed tomography was manufactured in 1991; multislice computed tomography (MSCT) has become the third milepost in the history of CT.

The basic principle of spiral CT including:

1-Slip rings base: The slip ring technology requires the unidirectional rotation of slip rings on the base, which contact with pulley or carbon brush. CT device has a plurality of mutually parallel slip rings, one of them supply high or low voltage electric power sources, the other one transmit the data from the detector to the computer, and another one transmit instruction from control system and feedback messege to control system. The later two are lower voltage.

2-Detector technology: It is not important for conventional CT scanning detector in X-ray tube protection, because there are time intervals between different levels scanning for X X-ray tube cooling. The performance of the detector is more important in spiral CT, because it needs a longer time for continuous exposure. Improving the efficiency of the detector reduce the exposure time, can not only reduce the accumulation of heat in X-ray tube, but also can reduce the patient's exposure. At present most of spiral CT use solid detector, whose effectiveness (photon utilization rate) is higher than 80%.

3-X-ray generator: X ray tube used in spiral CT generally has larger anode target (such as a target disc diameter up to 18cm), heat capacity of 210-412 million thermal unit, heat dissipating capacity of 1 millions of thermal unit/division. For the X ray tube which continuously expose under high load, focus rail heat dissipation factors is much more important than the heat capacity and cooling rate of X-ray tube, therefore it should be strictly limited to use within the allowable range of the scan parameters.

4-Slicing profile and reconstruction algorithm: If the spiral CT scanning data has not been reconstructed and corrected by special mathematical method, the image is similar to conventional CT scanning with motion artifact, causing the edge of soft tissue structure looks fuzzy and compact structure have serious shadow. The data collected from spiral CT scan should be manipulated by helical reconstruction algorithm.

The key of spiral CT is to cancel the cable, supply the electric power to the X-ray tube and transfer information collected by the detector through a slip ring system. The patients on the scanning bed are continuously propulsed when the spiral CT works, so that after several circuits consecutive scans, data within the helical scanning trace can be collected and reconstructed as multilayer image. Most spiral CT image quality indicators, such as the spatial resolution, the density resolution, image uniformity and linearity, etc., is substantially identical with the conventional CT. Multislice spiral CT has only an X-ray tube, but there are sereval rows (rows 4-32) of detectors arranged along the patient's body axis (z-axis) in a two-dimensional curved array, each row has 50-90 only detects, a total of 4000-15000. The multi-row detector array form a plurality of data acquisition systems, and generate more than four data channels, multiple digitized image can be reconstructed simultaneously based on the data collected in one scan. Compared with single-slice spiral CT, multi-slice spiral CT technology has great breakthroughs in detector array design, layer thickness improvement and reconstruction algorithm, as well as improve the scanning speed. Multislice CT scanner can produce four or more layers of images, so the scanning speed is as eight or more times as conventional single-slice spiral CT.

The control of parameters of spiral CT is of vital importance for the imaging quality; important parameters such as contrast, contrast resolution, spatial resolution and uniformity are included. (1) Contrast and contrast resolution: contrast represents density difference, or X-ray transmission difference of different substance, characterized by different gray level in the image. The contrast is determined primarily by the difference in density between the objects, but also related to the energy of the X-ray. (2) Spatial resolution: refers to the ability to distinguish two very close tiny tissue or lesions, in the abstract is the ability to distinguish two nearly point within the body by CT image. (3) Uniformity: describe the consistency of CT when display the same tissue in different position within a section, evaluate whether the CT can get the same average of CT values in homogeneous structure. Therefore, the above important parameters affect the image quality and restrict each other. We can optimize the quality of the image by means of adjusting the relation between the parameters.

*3.9.2.* Judge *the tumor invasion by means of CT scan*

As a result of without serosal layer, esophageal tumor is easy to directly invade the aorta and other adjacent organs. Before the advent of CT, it is quite difficult to give accurately preoperative predict and staging of esophageal cancer [4-6]. After the advent of CT, some foreign scholars achieved some success on distinguish whether the esophageal cancer has invaded the aorta before the operation. Spiral CT scanning can improve the detection rate of the small

lesions [7]. Doyle [8] proposed the chest CT scan on prone position can show the esophageal cancer aortic invasion better, due to the clearance between heart and esophageal neoplasm, aortic increased slightly, so the image does not overlap, thereby reducing false positive and false negative. The value of the esophageal CT scan is to clearly show the relationship of the tumor and surrounding tissues, organs, to provide more information and help on tumor stage, treatment plan designing, judging the possibility and difficulty of surgical resection.

Thickness of lesion segment wall: CT can show and measure the thickness of esophageal wall more accurately. It is defined as thickening if thickness >5 mm [9-10], while the normal thickness of esophageal wall is <3 mm. Thickening of the esophageal wall caused by the tumor can be the entire circumference thickening, can also be oriented in a side wall, but the thickness is not in proportion to the extent of external invasion. Judge the adjacent organs and tissue invasion extent of esophageal carcinoma using CT scanning.

Both tracheal and bronchial wall are flexible and expandable, tumor compression make them narrow or shift. The sign of disappeared fat gap could just tell the possibility of adhesion. It was known that clear signs of trachea and bronchial included the wall of tracheal and bronchial wall were looked as sawtooth-like or angle, or tumor invasion into the lumen. Studies have pointed out that CT can be used to display the invasion and metastasis of adjacent organ by signs of disappeared layer of fat between the tumor and trachea, notch and esophageal tracheal fistula [11]. Our study included 97 patients, all of them underwent CT examination, six cases indicated tracheal compression which character as tracheal membranous involvement, 33% (2/6) two cases could not endure surgery. The result told that compression of trachea-bronchial wall might be the important indication of surgery.

There is normally a fat gap between the esophagus and the aorta, and the disappearance of the fat gap is due to the invasion of the tumor. Picus group [12] proposed the contact surface that esophageal tumor contact with the aortic circumference determine whether invasion of the aorta the more contact surface, the higher the probability of infringement. Enhanced CT helps us more in judging the disappearance of the fat layer. The size of the contact surface of lumps with aortic was used to distinguish the relationship between the mediastinal membrane and tumor and also show the presence or absence of lymph nodes.

Takashima determined aortic invasion by measurement of fat triangle method, the fat gap was completely occluded by soft tissue when aortic invasion. Our study combined both Picus and Takashima method and increased the sensitivity and specificity of diagnosis. Nine patients were found the aortic contact surface more than 90 by CT scan; five cases could not tolerate surgery. Our result suggested that surgical resection should be quite cautious when the contact surface of the tumor and the aorta were found over 90. we usually adopted the palliative surgery or give up surgery when cases were diagnosed as esophageal tumor involved in thoracic aortic, and also poor prognosis were accompanied as the 5-year survival rate was 10% -15%. Fat gap between tumor and multidimensional pericardial disappears might be sign of pericardial invasion, same as pericardial pressure depression, pericardial thickening or pericardial effusion. Some have pointed out that the fat gap disappears, accompanied by pericardial thickening or nodular pericardial invasion were reliable performance. Thompson believes when the consecutive two levels of fat gap between the mass and the pericardium disappeared, pericardial infringement could be diagnosed. Two cases showed pericardial and pulmonary vein invasion by CT scan in our study, and one of them could not tolerate the surgery. The result of our study indicated that invasion of pericardial and pulmonary vein should avoid surgery.

Lymph node metastasis is important in the progression of esophageal tumor, Tumor cells reaches the area corresponding to the tumor through the muscular layers after breaking into the submucosal lymph node. Esophageal cancer can be transferred to the throat, supraclavicular lymph nodes, and esophageal tracheal ditch lymph, down to the pericardial and perigastric lymph. Most scholars agree that the lymph node size could be used as a standard of lymph node metastases, and it is generally believed that diameter of the lymph node <10 mm was defined as normal, 10-15 mm suspicious lymph nodes, while diameter is more than 15 mm abnormal. But to our disappointed, it proved the standard is not so satisfied. We found paraesophageal lymph node usually small, and merged into the tumor. K.Sndenaa analyzed 85 cases of esophageal cancer; the sensitivity of lymph node metastasis by CT scan was 22%, specificity 95%, accuracy of 55%. Recent studies have pointed out that a higher rate of false-negative lymph node metastasis by CT scan; the reason is that the invasion enlarged lymph nodes are often enveloped within the tumor. It is difficult to distinguish enlarged lymph node from benign to malignance by scan.

*3.9.3. CT* staging *of esophageal cancer*

It is known as CT could be used as preoperative staging imaging methods. Moss [13] proposed a more reasonable CT staging standards. Reining [14] made the supplement, and then esophageal cancer is divided into four phages: □esophageal intraluminal mass or partial wall 3-5 mm; □partial or annular esophageal wall thickening> 5mm; □ with metastasis including the trachea, main bronchus, aorta or pericardium; □ local lesions with distant organs and lymph node metastasis. Our study include 97 cases,□5 cases, □ 67 cases, III 25 cases and □ 0 cases. All Phase I and

II underwent successful surgical resection, 19 cases of  finished surgical resection, 6 just did surgical exploration, our results confirmed that staging of I and II by CT stage can complete surgery, staging  surgery need to be fully assessment,  stage unsuitable for surgery. Surgeon can choose the appropriate treatment options such as radical surgery, radiotherapy after surgery and (or) simply chemoradiotherapy with the CT staging criteria.

Preoperative CT scan can display esophageal tumor and surrounding structures, show the lesions, organs invasion and lymph node metastasis, determine the stage of esophageal cancer. It is useful for the treatment, too. But CT scan is difficult to find early esophageal cancer, because the esophageal mucosa can not display in the CT scan. The combination of CT and X-ray fiber esophagoscopy [15] was necessary.

## CONCLUSION

(1). CT images are clear with high density resolution in human tissue;
(2). Spiral CT-3D reconstruction technique can display clearly human body structure and relationship with the adjacent structures;
(3). The CT scan has important significance in preoperative staging of esophageal cancer;
(4). The CT scan has operation resection rate of esophageal cancer improvement.

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