

1st Radiology Department, Medical University of Lublin

ELŻBIETA CZEKAJSKA-CHEHAB, LUDWIK SMAJKIEWICZ,  
ANDRZEJ DROP

*Dynamic computed tomography assessment of local extent  
and resectability of esophageal carcinoma*

Carcinoma of esophagus is a difficult diagnostic and therapeutic problem which remains unsolved. Extreme malignancy of this tumour, its rapid growth even in cases of relatively small local involvement and too late diagnoses result in poor prognosis. The distinctive feature of therapy in esophageal cancer is the fact that each patient, even with an advanced tumour, should be subjected to the treatment restoring his adequate nutrition and some surgeons find resection of the esophagus to be the best palliative management, beside radio- and chemotherapy.

At present, the preoperative assessment of resectability and staging of esophageal carcinoma is based on three methods – computed tomography (CT), magnetic resonance tomography (MR) and endoscopic ultrasonography of the esophagus (EUS) (1-4, 7-15). The advantages of CT include its availability, relatively low cost, overall assessment of the thoracic and epigastric structures, well-defined changes and possible use in determining the radiation area. Moreover, the usefulness of positron emission tomography – PET was evaluated recently, especially in detecting nodal metastases (6, 10, 11). Compared to CT, MR is a more expensive and less available method, and, according to literature data, not superior in staging esophageal tumours. Endosonography of the esophagus is a complementary method to CT, superior to CT and MR in assessing tumour extent in the esophageal wall and thus in diagnosing early infiltration of the mucous and submucous membranes in T1 (1, 14). Most relevant limitations of this method are difficulties in leading the endoscope through the esophageal lumen: the percentage of failures varies from 26 to 50% (4, 14, 15).

The study was to define the usefulness of dynamic computed tomography in assessing local extent of esophageal cancer and in predicting radical resectability or palliative treatment in a large population of patients.

## METHODS

Ninety-three patients (91 men and 2 women, average age – 60) with carcinoma of the esophagus were subjected to CT in the Department of Radiology, Medical University of Lublin. The inclusion criterion was the possibility of intraoperative and histopathologic verification of the CT findings concerning local extent of the primary esophageal tumour.

All the patients were operated on in the 2nd Department of General Surgery, Medical University of Lublin. Sixty-one patients were subjected to total or partial resection of the esophagus by thoracic or abdominal approach. In the remaining patients the transhiatal resection was carried out (THE). In 6 patients the primary tumour was localised in the upper third, in 52 in the middle third and in 35 in the lower third of the thoracic esophagus.

The histopathological examinations were performed in the Department of Patomorphology, Medical University of Lublin. Eighty-six patients were diagnosed with squamous carcinoma; adenocarcinoma was found in 5 patients, undifferentiated carcinoma in 1 and mixed one in another one.

CT of the thorax and epigastrium was performed using the Somaton DRH scanner (Siemens) with the 8 mm thick contiguous slices and 80–100 ml of the contrast medium in iv bolus at the rate of 2 ml/s. The CT analysis involved the location and local extent of the primary tumour assessed in the TNM system (1, 14) according to AJCC (1, 2, 13) as



Fig. 1. The tumour of the retrocardial esophagus confined to its wall (T2).  
Radical resection



Fig. 2. The tumour of retrocardial part of esophagus. T3 diagnosed by CT confirmed histopathologically. Radical resection



Fig. 3. Carcinoma of the middle third esophagus infiltrating the area under the bifurcation of trachea. Right pulmonary artery and left main bronchus invasion confirmed intraoperatively



Fig. 4. The extensive tumour of the middle esophagus with CT infiltration of the aorta and left bronchus. Non-radical operation

T1/T2 – T4 on the basis of the measurements of the wall thickening and specific criteria of diagnosing infiltration of the structures adjacent to the esophagus.

The tracheal and upper bronchial infiltration was diagnosed when at least two scans showed displacement or/and distortion of the walls with the features of tumour indentation into the lumen. The sign excluding infiltration was the presence of fatty tissue between the tumour and structures mentioned above. The diagnosis of infiltration of the aorta when the tumour directly adhered to its walls in at least two scans was based on the measurements of the angle of tumour adhesion to the aorta (the borderline value –  $90^\circ$ ), on the criterion of opacity of the triangular space between the esophagus, aorta and spine as well as on the criterion of filling defects of the contrasted aortal lumen. The diagnosis of infiltration of the pleura, lung parenchyma, diaphragm and cardia was based on typical diagnostic criteria. All these criteria mentioned above were presented in detail in the previous paper (2).

Unresectability was assessed using the criterion of tumour invasion of the critical mediastinal structures and the presence of distant nodal and/or organ metastases.

The results were statistically analysed using the Chi-square test and correlation coefficient ( $r_p$ ). The admissible error was  $p < 0.05$ .

## RESULTS

The assessment of local extent of the primary tumour (Table 1) showed correlation of CT, operative and histopathological diagnoses in 68.8% (64/93 cases). The CT findings were confirmed in 78.8% (26/33) of tumours confined to the esophageal wall (T1/T2) and

Table 1. CT effectiveness in assessing local extent of esophageal carcinoma

Intraoperative and histopathological findings	CT findings			n (%)
	T1/T2	T3	T4	
T1/T2	26	9	5	40 (43.0)
T3	5	6	5	16 (17.2)
T4	2	3	32	37 (39.8)
n (%)	33 (35.5)	18 (19.3)	42 (42.5)	93 (100)

in 76.2% (32/42) of tumours infiltrating the adjacent organs (T4). In T3 tumours, however, only every third CT diagnosis was correct. The under- and overestimation errors were 10.8% and 20.4%, respectively (insignificant difference). The CT sensitivity was the highest one in T4 tumours (86.5%), lower in T1/T2 (65.0%) and the lowest one in T3 (37.5%). Specificity and accuracy was similarly highly irrespective of local extent of the primary tumour (82.1%–86.8% and 76.3%–83.8%, respectively).

The rates of diagnostic accuracy by CT in the diagnosis of T4, which are particularly important from the clinical point of view, were high. The negative predictive value (NPV) was 90.2%, which indicates high reliability of CT in excluding tumour infiltration of the adjacent organs. The positive predictive value (PPV), however, was slightly lower (72.2%).

The evaluation of infiltration of the trachea and bronchi whose incidence was 30.6% showed that PPV was 71.4% and NPV – 95.6%. The CT sensitivity, specificity and accuracy were 90.9%, 86.0% and 87.5%, respectively. The correlation of CT and intraoperative findings was also high ( $r_p = 0.84$ ,  $p < 0.001$ ).

In the cases of aorta infiltration (incidence – 16.2%), PPV was 65.5% and NPV – 90.2%. The CT sensitivity, specificity and accuracy were found to be 86.7%, 90.9% and 90.2%, respectively;  $r_p = 0.81$ ,  $p < 0.001$ .

The overall assessment of infiltration in 70 cases of tumours localised in their anatomical zone, PPV was 69.7% (23/33) while NPV – 97.3% (36/37).

Tumour infiltration of the structures adjacent to the esophagus – pleura, mediastinum, lung parenchyma, pericardium, pulmonary vessels and cardia – was found in 2.1%–12.0% of cases (Table 2). The tumour local extent was correctly assessed by CT in 5 out of 6 patients with the upper third esophageal carcinoma, in 38 out of 52 patients with the middle third esophagus tumour (diagnostic effectiveness – 73.1%) and in 22 out of 35 ones with the lower third esophagus tumour (diagnostic effectiveness – 62.9%). The differences in CT effectiveness indices were insignificant. The CT accuracy in assessing total

Table 2. CT assessment of esophageal tumour infiltration of the adjacent structures

CT result	Trachea and/or bronchi	Aorta	Lungs and pleura	Pulmonary arteries and veins	Pericardium	Cardia	Diaphragm
True positive	20	13	6	1	2	5	2
False negative	2	2	5	1	-	3	1
False positive	7	7	-	2	3	2	1
True negative	43	70	81	50	30	23	29
n	72	92	92	54	35	33	33

Table 3. CT effectiveness in classifying patients with esophageal cancers for radical resection

Intraoperative and histopathological findings	CT findings		n
	Resectable tumour	Unresectable tumour	
Radical resection	47	10	57
Palliative resection	7	29	36
n	54	39	93

resectability of the tumour (Table 3) was found to be 81.1%. PPV was high (87.0%) while NPV (indicating unresectability) was lower (74.4%). The correlation between the CT, intraoperative and histopathological findings predicting resectability was high. The CT reliability was found to be higher in predicting radical resection than its exclusion. The comparative analysis of CT effectiveness in assessing resectability of esophageal carcinoma according to its location (Table 4) revealed significantly higher sensitivity in tumours localised in the lower than in the middle third esophagus (92.5% and 69.2%, respectively).

The CT effectiveness index predicting local extent of primary tumours in patients operated on by thoracic approach was significantly higher (75.4%; 46/61) compared to the group subjected to the transhiatal method (54.8%; 17/31).

Table 4. CT assessment of esophageal tumour resectability according to its location

Esophageal section	CT findings				n
	TP	TN	FP	FN	
Upper	4	1	1	-	6
Middle	18	22	4	8	52
Lower	25	5	3	2	35

TP – true positive  
TN – true negative

FP – false positive  
FN – false negative

## DISCUSSION

The results presented above reveal quite high diagnostic effectiveness of DCT in assessing local extent of primary tumours, especially those confined to the esophageal wall (T1/T2) or highly advanced ones with infiltration of the adjacent organs (T4). The CT findings in both categories were confirmed histopathologically and intraoperatively in over 75% of cases. The biggest diagnostic difficulties concerned infiltration of the periesophageal fatty area (T3). The CT sensitivity for this category was only 37.5%. Using the same classification, Bot et al. (1) and Tio et al. (14) achieved the highest CT sensitivity in T3, however, diagnostic specificity was significantly reduced. At the same time, the negative predictive value in T1/T2 being 76.7% indicates reliability of the diagnosis of tumour invasion beyond the esophageal muscular coat (T3/T4). The separation of these two groups is essential for planning modern therapeutic management. Our rates of CT diagnostic effectiveness in the diagnosis of T4 local extent were high. The sensitivity of diagnosing infiltration of the structures adjacent to the esophagus (86.5) was similar to the one reported by other authors (4, 7, 12, 14).

The correlation of CT results with intraoperative and histopathological findings assessing local extent of the tumour (68.8%) is similar to that reported by Bot et al. (1) and Tio et al. (14). In the assessment of CT effectiveness in diagnosing infiltration of the aorta, tracheobronchial tree, high nosologic rates exceeding 80% were accompanied by substantial and clinically significant differences in predictive values. A very high negative predictive value (97.3%) is likely to indicate that the CT exclusion of infiltration of the structures described above may be treated as an almost certain result and used in classifying patients for operative resection. This fact is particularly relevant in planning transhiatal esophagectomy in elderly patients or those with circulatory-respiratory disorders (7, 9).

A significantly lower positive predictive value (69.7%), however, shows that infiltration of the aorta and tracheobronchial tree diagnosed by CT was not intraoperatively confirmed in almost 1/3 of cases. More strict diagnostic criteria used (8, 15) are associated with the fact that operative procedures with thoracotomy are too frequently performed in patients with severely advanced tumours, which results in high perioperative mortality. Thus, it seems that patients with signs of infiltration of the "critical" mediastinal structures found by CT should be subjected to re-assessment using EUS or MR (1, 4, 11, 12, 14, 15). At present, a promising, although not widely available method is endovascular ultrasonography of the aorta (5).

The present paper showed high CT effectiveness in assessing resectability of esophageal carcinoma (87%), which correlates with the opinions of other authors (4, 7 – 9, 13).

Significantly higher CT effectiveness obtained in predicting total resection of tumours of the lower and middle third esophagus (92.5% and 69.2%, respectively) does not corre-

late with the results presented by Botet et al. (1), yet their material included a high percentage of adenocarcinomas (76%) in which the value of CT is limited.

The results of the present study reveal that dynamic computed tomography with its advantages and limitations is a major and valuable method of assessing resectability of esophageal carcinoma.

### CONCLUSIONS

1. Dynamic computed tomography shows high effectiveness in assessing esophageal tumours infiltrating the adjacent organs, however, its value is limited by a relatively high index of false positive results.

2. The negative predictive value in T4 is very high, which allows proper classification for resection procedures in less advanced tumours.

3. CT effectiveness in assessing local extent of esophageal cancers does not depend on tumour location.

4. CT sensitivity in evaluating radical resectability of esophageal cancers is higher in lower esophageal tumours than in middle esophageal ones.

### REFERENCES

1. Botet J. F. et al.: Preoperative staging of esophageal cancer: comparison of endoscopic US and dynamic CT. *Radiology*, 181, 419, 1991.
2. Czekańska-Chehab E.: Zastosowanie komputerowej tomografii w ocenie stopnia zaawansowania raka przełyku i kwalifikacji chorych do leczenia chirurgicznego. Rozprawa doktorska, AM Lublin 1994.
3. von den Hoed et al.: CT prediction of irresectability in esophageal carcinoma: value of additional patient positions and relation to patient outcome. *Abdom Imaging*, 22, 132, 1997.
4. Jastrzębska M.: Strategie postępowania diagnostycznego w ocenie zaawansowania i monitorowaniu leczenia raka przełyku. *Pol. Przegl. Radiol.*, 61, 310, 1996.
5. Koda Y. et al.: Assessment of aortic invasion by esophageal carcinoma using intraaortic endovascular sonography. *AJR*, 170, 133, 1998.
6. Kole A. C. et al.: Positron emission tomography for staging of oesophageal and gastroesophageal malignancy. *Br. J. Cancer*, 78, 521, 1998.
7. Legmann P. et al.: Preoperative computed tomography for transhiatal esophagectomy. *Investigative Radiology*, 26, 987, 1991.

8. Markland C. G. et al.: The role of computed tomography in assessing the operability of oesophageal carcinoma. *Eur. J. Cardio-thorac. Surg.*, 3, 33, 1989.
9. van Overhagen H. et al.: CT assessment of resectability prior to transhiatal esophagectomy for esophageal/gastroesophageal junction carcinoma. *J. Comput. Assist Tomogr.*, 3, 367, 1993.
10. Rankin S. C. et al.: Computed tomography and positron emission tomography in pre-operative staging of oesophageal carcinoma. *Clin. Radiol.*, 53, 659, 1998.
11. Rice T. W.: Clinical staging of esophageal carcinoma. CT, EUS and PET. *Chest Surg. Clin. N. Am.*, 10, 471, 2000.
12. Saunders H. S., Wolfman N. T., Ott D. J.: Esophageal cancer. Radiologic staging. *Radiol. Clin. North Am.*, 35, 281, 1997.
13. Takashima S. et al.: Carcinoma of esophagus CT vs MR imaging in determining resectability. *AJR*, 156, 297, 1991.
14. Tio T. L. et al.: Endosonography and computed tomography of esophageal carcinoma. Preoperative classification compared to the new (1987) TNM system. *Gastroenterology*, 96, 1478, 1989.
15. Vilgrain V. et al.: Staging of esophageal carcinoma: comparison of results with endoscopic sonography and CT. *AJR*, 155, 277, 1990.

2001.12.06

## SUMMARY

The aim of this study was to define the usefulness of dynamic computed tomography in the preoperative assessment of esophageal cancer. CT scanning was performed in 93 patients with proven carcinoma of the esophagus. All results of CT were compared with surgical and pathologic findings. The analysis used the AJCC classification adapted to the needs of CT. The local extent of the primary tumour (T-stage) and its resectability were assessed and compared for different locations of the tumour. The overall accuracy of CT in tumour staging was 68.8%, 20.4% cases were overstaged and 10.4% were understaged. The highest sensitivity of CT has been obtained in estimation of tumours involving adjacent organs –T4– (86.5%) and the lowest for T3 (37,5%). Infiltration of surrounding vital structures could be proven with the positive predictive value of 69.7% and the negative predictive value of 97.3%. The efficiency of CT estimation for local tumour extent did not differ according to the tumour location. A high agreement (81.7%) was noted between CT results and intraoperative findings in assessing resectability.

### Dynamiczna tomografia komputerowa w ocenie miejscowej rozległości i resekcyjności raka przełyku

Celem pracy była ocena przydatności dynamicznej tomografii komputerowej w diagnostyce przedoperacyjnej raka przełyku. Badanie KT klatki piersiowej i nadbrzusza zostało wykonane u 93 pacjentów z potwierdzonym rakiem przełyku, a wyniki zweryfikowano operacyjnie i histopatologicznie. W pracy posługiwano się zaadaptowaną do potrzeb KT klasyfikacją AJCC. Poddano analizie wyniki KT oceny resekcyjności i miejscowej rozległości guza pierwotnego przełyku oraz dokonano porównania w zależności od jego lokalizacji. Wskaźnik ogólnej skuteczności KT w ocenie miejscowej rozległości guza pierwotnego wyniósł 68,8%, przy wskaźnikach błędu z przecenienia i niedocenyenia odpowiednio 20,4% i 10,8%. Uzyskano najwyższą, wynoszącą 86,5%, czułość KT dla rozpoznania kategorii guza T4, a najniższą dla T3 (37,5%). Wartość predykcyjna dodatnia w odniesieniu do rozpoznania w KT naciekania krytycznych struktur śródpiersia wyniosła 69,7%, a ujemna – 97,3%. Skuteczność KT w ocenie miejscowej rozległości guza nie różniła się w zależności od jego lokalizacji. Stwierdzono dużą zgodność (81,7%) wyników KT i operacyjnych w przewidywaniu możliwości wykonania radykalnej onkologicznie resekcji raka przełyku.