

Comparison of conventional magnetic resonance imaging, cine-magnetic resonance imaging, and operation findings in invasion assessment of esophageal cancer

Özofagus kanserinde invazyonun değerlendirilmesinde konvansiyonel manyetik rezonans görüntüleme, sine-manyetik rezonans görüntüleme ve ameliyat bulgularının karşılaştırılması

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ABSTRACT

Background: This study aims to compare the conventional magnetic resonance imaging and cine-magnetic resonance imaging findings with the operation results in terms of invasion existence in esophageal cancer.

Methods: This prospective study included a total of 37 suspected cases (21 males, 16 females; mean age 63.3 years; range 28 to 81 years) with respect to whether or not invasion in esophageal masses between January 2012 and February 2016. Initially, conventional magnetic resonance imaging (T₁-weighted, T₂-weighted, short tau inversion recovery), lesion characteristics and invasion areas were evaluated in all cases. The cases with invasion were re-evaluated according to dynamic moving features of the lesion and adjacent tissue by cine-magnetic resonance imaging in three planes. The relative motion of the mass with adjacent tissues, fatty planes, and invasion status were evaluated according to size and structure.

Results: The presence of invasion was detected by conventional magnetic resonance imaging in all of the cases. Invasion was not detected in 28 of 37 cases, while it was observed in nine cases by cine-magnetic resonance imaging. Twenty of 28 non-invasion cases were operated and results were compatible with the cine-magnetic resonance imaging results. The remaining eight cases were not operated due to severe comorbidities and the refusal of operation.

Conclusion: Cine-magnetic resonance imaging may contribute to detect invasion accurately in esophagus cancer which is adjacent to moving tissues such as heart and main vascular structures. Based on our study results, cine-magnetic resonance imaging appears to be superior to conventional magnetic resonance imaging.

Keywords: Cine-magnetic resonance imaging; esophageal cancer; invasion.

ÖZ

Amaç: Bu çalışmada özofagus kanserinde konvansiyonel manyetik rezonans görüntüleme ve sine-manyetik rezonans görüntüleme ile invazyon varlığı açısından ortaya çıkan bulgular ameliyat sonuçları ile karşılaştırıldı.

Çalışma planı: Bu prospektif çalışmaya Ocak 2012 - Şubat 2016 tarihleri arasında özofagusta tespit edilen kitlelerde invazyon varlığı ya da yokluğu açısından şüpheli toplam 37 olgu (21 erkek, 16 kadın; ort. yaş 63.3 yıl; dağılım 28-81 yıl) alındı. Tüm olgularda öncelikle konvansiyonel manyetik rezonans görüntüleme (T₁ ağırlıklı, T₂ ağırlıklı, short tau inversion recovery) ile lezyon özellikleri ve invazyon alanları araştırıldı. İnvazyonlu olgular, lezyonun dinamik özellikleri ve komşu dokular üç planda sine-manyetik rezonans görüntüleme alınarak tekrar değerlendirildi. Kitlenin komşu dokular ile olan bağlı hareketi, yağlı düzlemler ve invazyon durumu, boyut ve yapıya göre değerlendirildi.

Bulgular: Olguların tümünde konvansiyonel manyetik rezonans görüntüleme ile invazyon varlığı saptandı. Otuz yedi olgudan 28'inde sine-manyetik rezonans görüntüleme ile invazyon saptanmaz iken, dokuz olguda tespit edildi. İnvazyon tespit edilmeyen 28 olgunun 20'si ameliyat edildi ve sonuçlar sine-manyetik rezonans görüntüleme bulguları ile uyumlu idi. Kalan sekiz olgu ise, ciddi komorbiditeler ve ameliyatı reddetme nedeni ile ameliyat edilemedi.

Sonuç: Kalp ve ana vasküler yapılar gibi hareketli dokulara yakın komşulukta olan özofagus kanserinde invazyonun doğru tespit edilmesinde sine-manyetik rezonans görüntüleme katkı sağlayabilir. Çalışma sonuçlarımıza göre, sine-manyetik rezonans görüntüleme, konvansiyonel manyetik rezonans görüntülemeden üstün görünmektedir.

Anahtar sözcükler: Sine-manyetik rezonans görüntüleme; özofagus kanseri; invazyon.



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Esophageal cancer accounts for 1% of all cancers, and it is seventh between cancer-related death events.^[1,2] Due to poor prognosis, about half of cases is detected in the inoperable stage. Overall five-year survival is lower than 20%.^[3] There is no serosa layer in esophagus, unlike other gastrointestinal system organs. The absence of serous is also effective on early and rapid spread of esophageal cancer.

Potentially early excision of curative esophageal cancer is often associated with low operative mortality rates. Although the operative mortality is under 5%, morbidity is still high even in high-volume centers.^[2,3] Therefore, well-known resection and reconstruction may not be adequate for the surgeon. In addition, favorable preoperative assessment and postoperative care are of utmost importance for the success.^[4,5]

Staging of esophageal cancer has a major role in determining grade of the disease, planning of treatment, and prognosis. In the preoperative staging of esophageal cancer, endoscopic ultrasonography (EUS), positron emission tomography (PET), computed tomography (CT), multi-detector computed tomography (MDCT), and magnetic resonance imaging (MRI) are used. Conventional MRI and particularly cine-MRI are rarely used in staging of esophageal cancer and determining the grade of invasion.^[6-8]

In the present study, we aimed to compare the conventional MRI and cine-MRI findings evaluate with the operation results in terms of invasion existence in esophageal cancer.

PATIENTS AND METHODS

This prospective study was approved by Medical Faculty of Ataturk University Ethics Committee, and a written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

A total of 37 patients (21 males, 16 females; mean age 63.3 years; range 28 to 81 years) with esophageal tumors who had a suspicious invasion between mediastinal structures and adjacent to missing fatty planes as assessed by thoracic CT were included in this prospective study between January 2012 and February 2016. The final diagnosis were established by conventional MRI and electrocardiography (ECG)-triggered induced cine-MRI in suspicious invasion cases. Patients without suspicious invasion findings by thoracic CT and conventional MRI, those with distant metastasis, and medically inoperable cases were excluded from the study.

The tumor level, size and grade of the mediastinal compartments, relations to adjacent mediastinal structures, whether or not deletion of fatty plan and grade of lung parenchyma were analyzed by thoracic CT. The unclear monitoring of missing fatty plane was assessed by cine-MRI and then conventionally assessed, if required. All patients were informed about the process, and cine-MRI (ECG-induced, breath-holding, and moving image) was performed. Magnetic resonance imaging in 1.5 Tesla Magnetom Symphony (Siemens Medical Systems, Erlangen, Germany) was selected as ECG-triggering by using body coil for suitable cases. Four ECG probes were installed suitably in the right ventricle, left ventricle, right atrium, and left atrium localization for ECG-triggered imaging. Initially, T₂-TRUFI images (TR: 10.2 ms, TE: 4.7 ms) containing all thoracic and upper abdominal taken on coronal plane after lesion was localized. The conventional spin ECHO (SE) sequence used in the axial T₁ (TR/TR= 700/7.1 msec, warning number= 1, section thickness= 6 mm, section spacing= 15 mm, matrix= 125×256, FOV= 360 mm) and axial T₂ images (TR/TE= 700/71 msec, warning number= 1, section thickness= 6 mm, section spacing= 15 mm, matrix= 119×256, FOV= 360 mm) with axial short tau inversion recovery (STIR) turbo SE images (TR= 800 msec, TE= 66 msec, TE= 150 msec, the warning number= 1, section thickness= 5 mm, section gap= 15 mm, matrix= 119×256, FOV= 340 mm) sequence with cine images (TR= 43.26 msec, TE= 1.3 msec, FA= 80, section thickness= 6 mm, matrix= 156×192, FOV= 320 mm) were detected by image parameters. The patients were instructed to hold their breathe for 15 to 20 sec for each section in cine-MRI.

In location including the mass lesion, particularly previously taken conventional sequences with (T1-weighted, T2-weighted, and STIR images) deleted or direct invasion considered regions of missing fatty plane and all lesion were scanned in sagittal, coronal, and axial planes with sequential sections, after cine-MRI images were taken using the steady state free precession (SSFP) technique.

These images were, then, analyzed according to the tumor size, edge structures, relations with adjacent tissue, opening or unopening of fatty plane, presence or absence of free or relative motion with the adjacent structures and ratio of change position of lesion in moving images with a team of a single surgeon and radiologists in workstation. After the evaluation, these tumors were compared with conventional MRI scans in terms of invasion presence.

In our study, dynamic evaluation was performed with obtainment of 25 images within about 5 to 6 sec with cine-MRI similar to mediastinoscopic image or thoracic mediastinal ultrasonography (USG) in esophageal tumors without contrast by SSFP which routinely used sequence in cardiac MRI. The presence of compression without invasion might be misleading due to the mass effect. Separate tumor motion along the adjacent cardiovascular area was accepted as negative for the possibility of invasion, while its simultaneous motion or limited motion were accepted as positive for the possibility of invasion. The relative motion in other words along with the joint motion of lesion, and free wall motion were evaluated depending on whether or not to deletion of fatty plane. Then, these images were evaluated in terms of grade of invasion, and decision concerning operability was taken. In addition, these findings were compared for superiority in both conventional MRI and operation results.

RESULTS

Two esophageal tumors (5.4%) were observed in the cervical esophagus, nine (24.4%) in the midesophageal region, and 26 (70.2%) in the distal esophagus according to the imaging findings.

There was a suspicion of thoracic CT and conventional MRI with the invasion in 37 patients. There was a suspicion of thoracic CT and conventional MRI with tracheal invasion in two patients. Two patients underwent bronchoscopy, which resulted normal results. There was no invasion found in 28 of 37 cases in terms of the absence of any relative motion in preoperative cine-MRI and absence of deletion in fatty plane or obliterating fatty tissue opened in dynamic aspect. Twenty of 28 cases were operated. Preoperative cine-MRI findings of the patients with surgery were similar with the operation results. The remaining eight patients whose cine-MRI findings were normal were not operated; four of them did not accept operation, two of them had accessory medical problems such as hypertension and diabetes mellitus, and two of them had a high cardiovascular risk (17th, 20th, 22nd, 23rd, 26th, 27th, 30th and 31st patients in Table).

Of 37 cases with suspicious invasion by conventional MRI, the presence of relative motion and deletion of the fatty plane by cine-MRI in nine cases was accepted as invasion. There were aorta and pulmonary vein invasions in two of nine cases, aorta, and left atrium invasion in one case. There were azygos vein, carina, aorta, pulmonary vein,

pericardium, and tracheal invasion in one each case (Figures 1-3). These patients were not operated due to the joint decision of the Surgery Team.

DISCUSSION

Mediastinum has a complex dynamic characteristic due to moving structures such as superior vena cava, trachea, vascular structures, pericardium, and esophagus. It reserves various group of diseases. In addition, mediastinum is important, as it contains vital tissues such as main vascular structures, trachea and heart. Therefore, possible invasion in these tissues also affects the mortality. This shows the importance of using moving sequence in mediastinum.

Computed tomography is most frequently used in the evaluation of mediastinal lesions. Also, CT supplies prominent information such as localization of tumor in thorax, invasion and infiltration, relationship with vascular structures, grade of the involvement, presence of calcification, mass density, evaluation of mediastinal lymph nodes, and presence of pleural pathology. However, CT is not reliable enough for preoperative evaluation in thoracic masses and lung cancer.^[9-11] In particular, it has been reported that MRI is superior to CT in discrimination of T₃/T₄, and local invasion.^[7,8] It has been shown that coverage of bronchus or large vessels by tumor tissue is the most reliable finding of mediastinal spread.^[6] Sensitivity should be ranged between 40 and 77% and specificity between 67 and 99% to evaluate mediastinal invasion by CT.^[12,13] Aortic invasion is suggested, if the contact area between the tumor and aorta is greater than 90° or if there is obliteration of the triangular fat space between the esophagus, aorta, and spine adjacent to the primary tumor.^[14,15] Thoracic CT scans are static, and are incapable of temporal and kinetic evaluation of the size differences, compression, and deletion of the fatty plane of the main moving structures such as esophagus and aorta. Thus, the importance of cine-MRI with breath-holding and ECG-triggered is emerged by using of the SSFP technique which used in cardiac scan as moving sequence, considering the risk of operation and mortality of presence of preoperative invasion.

Invasion of the adjacent structures such as aorta, pericardium, and pulmonary vein by tumor is accepted as T₄ in esophageal cancer, according to tumor-node-metastasis (TNM) staging system. The surgery or definitive chemoradiotherapy have been suggested in patients with T₄ thoracic esophageal carcinomas after the neoadjuvant chemoradiotherapy.^[16] The incidence of Stage T₄, in which the tumor invades the adjacent structures, is reported as 8 to 30% among thoracic

Table 1. Characteristics of the patients

No	Age/gender	Localization	Surgery	Conventional MRI	Cine-MRI
1	68/F	1/3 proximal	No	Invasion (+)	Invasion (+)
2	42/M	1/3 proximal	Yes	Invasion (+)	Invasion (-)
3	49/M	Midesophageal	Yes	Invasion (+)	Invasion (-)
4	75/M	Midesophageal	Yes	Invasion (+)	Invasion (-)
5	70/M	Midesophageal	Yes	Invasion (+)	Invasion (-)
6	76/M	Midesophageal	No	Invasion (+)	Invasion (+)
7	67/M	Midesophageal	No	Invasion (+)	Invasion (+)
8	44/M	Midesophageal	Yes	Invasion (+)	Invasion (-)
9	63/M	Midesophageal	Yes	Invasion (+)	Invasion (-)
10	42/F	Midesophageal	Yes	Invasion (+)	Invasion (-)
11	28/F	Midesophageal	Yes	Invasion (+)	Invasion (-)
12	64/F	Distal esophagus	No	Invasion (+)	Invasion (+)
13	65/F	Distal esophagus	Yes	Invasion (+)	Invasion (-)
14	77/M	Distal esophagus	Yes	Invasion (+)	Invasion (-)
15	78/M	Distal esophagus	Yes	Invasion (+)	Invasion (-)
16	71/F	Distal esophagus	No	Invasion (+)	Invasion (+)
17	65/F	Distal esophagus	No	Invasion (+)	Invasion (-)
18	58/F	Distal esophagus	Yes	Invasion (+)	Invasion (-)
19	63/M	Distal esophagus	No	Invasion (+)	Invasion (+)
20	70/M	Distal esophagus	No	Invasion (+)	Invasion (-)
21	55/F	Distal esophagus	Yes	Invasion (+)	Invasion (-)
22	72/F	Distal esophagus	No	Invasion (+)	Invasion (-)
23	46/M	Distal esophagus	No	Invasion (+)	Invasion (-)
24	76/M	Distal esophagus	Yes	Invasion (+)	Invasion (-)
25	64/F	Distal esophagus	Yes	Invasion (+)	Invasion (-)
26	76/M	Distal esophagus	No	Invasion (+)	Invasion (-)
27	81/M	Distal esophagus	No	Invasion (+)	Invasion (-)
28	59/F	Distal esophagus	Yes	Invasion (+)	Invasion (-)
29	75/M	Distal esophagus	No	Invasion (+)	Invasion (+)
30	74/F	Distal esophagus	No	Invasion (+)	Invasion (-)
31	67/M	Distal esophagus	No	Invasion (+)	Invasion (-)
32	43/M	Distal esophagus	No	Invasion (+)	Invasion (+)
33	56/F	Distal esophagus	Yes	Invasion (+)	Invasion (-)
34	60/F	Distal esophagus	No	Invasion (+)	Invasion (+)
35	58/F	Distal esophagus	Yes	Invasion (+)	Invasion (-)
36	77/M	Distal esophagus	Yes	Invasion (+)	Invasion (-)
37	69/M	Distal esophagus	Yes	Invasion (+)	Invasion (-)

MRI: Magnetic resonance imaging.

esophageal carcinomas.^[17] Initially, the surgical treatment of patient with T₄ invasion for thorax would negatively affect the treatment process. The resection may be inadequate or accepted as inoperable and, then, neoadjuvant chemoradiotherapy decision can be made in these cases. In such cases, second thoracotomy would be a more invasive method for the patients. Another important issue is that, as in our study, many cases with appearance of invasion in the conventional thoracic CT and conventional MRI are not actually T₄. Surgery operation should not be delayed in suitable patients with the absence of invasion by cine-MRI.

Magnetic resonance imaging has the highest contrast for soft tissues among imaging modalities. No contrast material requirement (thus patients with allergy can use), absence of radiation effect, and high resolution of soft tissue have shown superiority of MRI over CT. According to the relationship between masses and chest wall, adjacent vascular/mediastinal structures, MRI have shown superiority over CT.^[18]

Furthermore, the artifacts, which causes due to MRI sensitivity on moving tissue, are an important

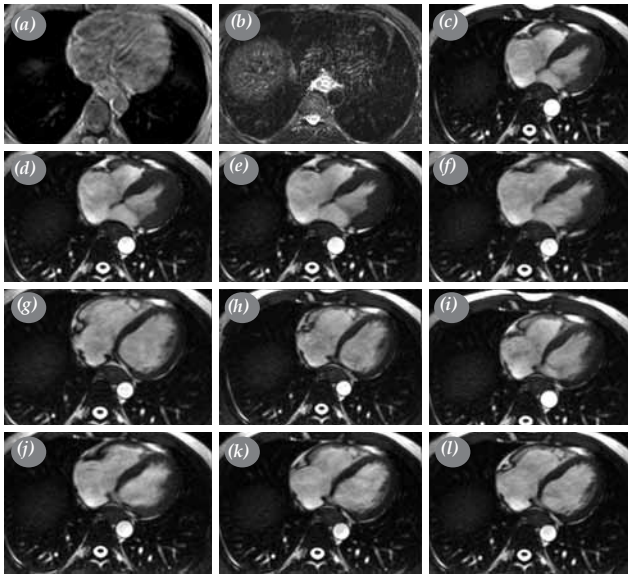


Figure 1. (a, b) There was a distal esophageal tumor without border differentiation between aorta and heart. (c-l) Pericardium and fatty planes were between esophagus and aorta as seen in cine-magnetic resonance imaging. In addition, relative motion of adjacent atrium was not seen on cine-magnetic resonance imaging. There was no invasion on operation.

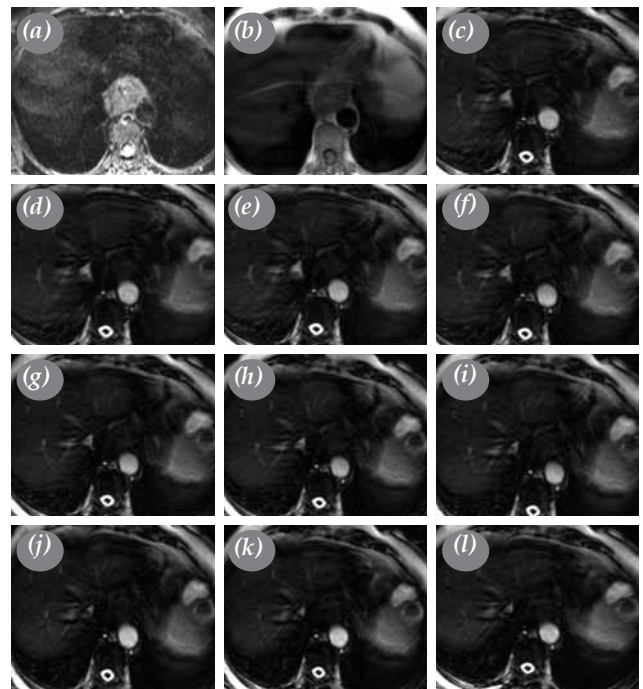


Figure 2. (a, b) There was a distal esophageal tumor without border differentiation between aorta. (c-l) Fatty planes were located between esophagus and aorta as seen on cine-magnetic resonance imaging. There was no invasion during operation.

disadvantage. Therefore, fast imaging methods and cardiac triggering should be preferred to minimize the motion artifact due to cardiac. As indicated in several studies, separate movement between two adjacent area is demonstration of the absence of invasion with a specificity of 100%.^[19,20] In a study, performed by Seo et al.,^[21] to assess the separate or together movement between cine-MRI with thoracic mass and adjacent structures, evaluation of direct invasion in thoracic mass on adjacent cardiovascular structures has yielded 94.4% accuracy, 100% sensitivity, and 92.9% specificity by showing separate movement between the adjacent structures and mass. Preoperative motion is obtained with cine-MRI similar to virtual mediastinoscopy or mediastinal ultrasound image. In addition to imaging of the movements, whether or not the fatty planes are open between the adjacent structures is a major indicator for the presence of invasion. Therefore, obtained images with conventional CT and MRI give edge and neighborhood information in single plane immediately. In addition, all movements of the lesion with adjacent structures are observed at a certain time using dynamic images with cine-MRI. In our study, invasion findings in conventional MRI were observed in 37 cases, while invasion findings in cine-MRI were observed in only nine cases of these 37 patients. Surgery was performed in 20 patients

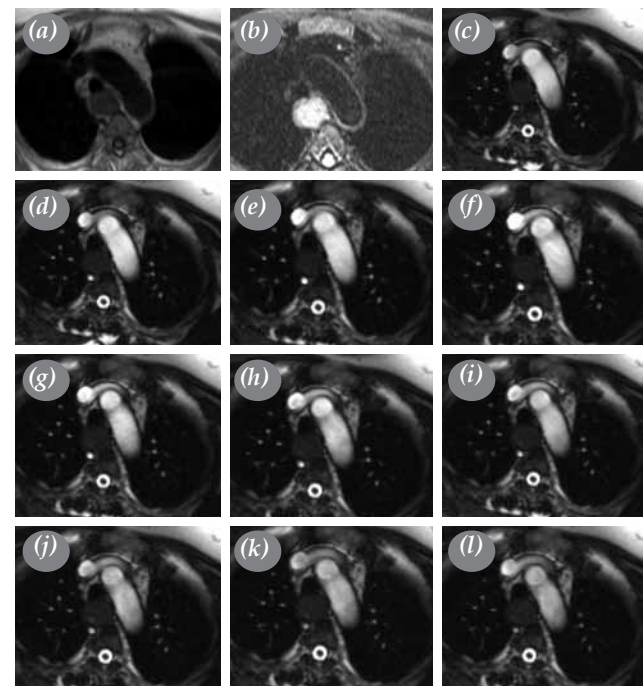


Figure 3. (a, b) There was a proximal esophageal tumor which invaded the membranous wall of trachea. (c-l) The mass and wall of trachea were unable to be separated in whole motion on cine-magnetic resonance imaging; it was positive relative motion.

without invasion of 28 patients in cine-MRI and absence of invasion was confirmed.

In conclusion, in this study, non-vascular invasion was correctly estimated with preoperative cine-magnetic resonance imaging in the patients who underwent surgical treatment. According to our findings, this method gives more sensitive results than conventional imaging methods in the assessment of adjacent structures with grade of invasion in esophageal tumors. Considering the importance of the detection of invasion for preoperative surgical decision and survival, we believe that cine-magnetic resonance imaging can be used as a more definitive and reliable method in patients who require a surgical decision.

Declaration of conflicting interests

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