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ORIGINAL ARTICLE

Usefulness of positron emission tomography-computed tomography in pre-operative evaluation of intra-thoracic esophageal cancer

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Abstract

Background: The purpose of the study was to clarify the usefulness of positron emission tomography-computed tomography (PET-CT) for pre-operative evaluation of intra-thoracic esophageal cancer, especially in terms of regional lymph node status.

Methods: Medical records of 93 consecutive cases from July 2007 to October 2012 were retrospectively reviewed. All patients underwent curative and complete esophagectomies for intra-thoracic esophageal cancer. We compared pre-operative maximum standard uptake values (SUVmax) of esophageal tumors and regional lymph nodes (LN) with other variables (chronic obstructive pulmonary disease, history of previous other primary cancer, gender, differentiation, and neoadjuvant therapy). In addition, the SUVmax of tumors and LNs were analyzed with pathologic findings.

Results: There was no significant difference of each tumor and LN SUVmax according to factors including chronic lung disease, age, history of previous other cancer, differentiation, and gender. Pre-operative evaluations by PET-CT were not accurate (tumor sensitivity 76.4%, specificity 25%; LN sensitivity 45.2%, specificity 54.8%). Receiver operating characteristic analysis showed that LN metastasis could not be appropriately diagnosed with SUVmax ($P = 0.871$). There was no difference in SUVmax between pathologically positive and negative LN subgroups. Tumor SUVmax correlated with the progression of esophageal cancer in patients without neoadjuvant therapy ($P < 0.001$). However, LN SUVmax had no correlation with overall pathologic stage. After neoadjuvant therapy, there were significant decreases in SUVmax in both pathologically positive and negative LN subgroups ($P = 0.043$, $P = 0.008$).

Conclusion: Surgery should not be withheld in N-stage according to PET-CT findings and carefully considered in conjunction with other conditions.

Introduction

It is important to evaluate lymph node metastasis when treating esophageal cancer, especially before surgery.[1,2] Positron emission tomography-computed tomography (PET-CT) has become essential for the evaluation of lymph node metastasis in esophageal cancer.[3,4] Because the uptake of ^{18}Fludeoxyglucose (^{18}FDG, a radiopharmaceutical for PET-CT) by tissues is a marker for the tissue uptake of glucose, which, in turn, is closely correlated with tissue metabolism, it is well-known that there are correlations between maximum standard uptake value (SUVmax) in lesions and cancer progression.[3,4] If the pre-operative stage is T2N1 or greater in esophageal cancer, a neoadjuvant therapy is generally recommended before surgery.[1,2] However, there are common discrepancies between PET-CT and pathologic findings, especially in regard to regional lymph node (LN) status. Pre-operative diagnosis using PET-CT may provide inaccurate

information and influence the treatment strategy for esophageal cancer.[5–7] A lesion is usually suspected of being malignant or prone to metastasis when SUVmax exceeds 2.5 and the lesion is greater than 1 cm in diameter.[1,8] However, there have been no definitive guidelines or established findings for the diagnosis of esophageal tumors and regional LN metastasis using PET-CT in patients with esophageal cancer.[2,7,9] The purpose of the present study was to clarify the usefulness of PET-CT for pre-operative evaluation of intra-thoracic esophageal cancer, especially in terms of LN status.

Materials and methods

Study subjects and methods

Medical data from 93 consecutive cases from July 2007 to October 2012 were compiled from patients who underwent curative and complete esophagectomies for intra-thoracic esophageal cancers at Seoul St Mary's Hospital. Inclusion criteria were: pre-operative PET-CT acquisition, both neoadjuvant and non-neoadjuvant therapy cases, complete and curative surgery, pre-operatively proven histology of squamous cell carcinoma, and intra-thoracic esophageal cancer. Exclusion criteria were: coexisting active inflammations, other uncured previous or current primary cancers, symmetric increased SUVmax cases, and palliation or salvage cases. Pre-operative evaluations consisted of esophagogastroscopy, esophagography, chest CT, abdominal CT, PET-CT, endoscopic ultrasound or bone scan as needed. Neoadjuvant or adjuvant therapies were performed following National Comprehensive Cancer Network (NCCN) guidelines, recommendations of a multidisciplinary team who review cancer status, resectability or operability, and patient condition. Neoadjuvant therapies consisted of two cycles of cisplatin and 5-fluorouracil, plus 25 fractions of radiation therapy (over 5 weeks) to a total of 40 Gray. Esophagectomies were performed five or six weeks after completion of neoadjuvant therapy and restaging by PET-CT. Pre-operative stage in neoadjuvant cases was defined as clinical stage after neoadjuvant therapy and before surgery.

Three surgeons performed surgery, using Ivor Lewis and McKeown procedures, according to cancer status and patient condition. Two or three field lymph node dissections were performed as appropriate. We retrospectively measured and compiled pre-operative SUVmax data of tumors and LNs. To clarify the usefulness of PET-CT in pre-operative evaluation of esophageal cancer, the diagnostic accuracy using PET-CT was calculated, the relationship between tumors and LN SUVmax was assessed, and the findings were analyzed in the context of pathologic findings. In addition, the influences on SUVmax of other various factors, including chronic lung disease (chronic obstructive pulmonary disease [COPD], bronchiectasis), history of previous other primary cancer, gender, differentiation, and neoadjuvant therapy were examined, and pre-operative N stages using PET-CT and pathologic N staging were compared. Histopathological analysis of lymph nodes was performed by serial sectional and immunohistochemistry methods. The stages were determined according to the seventh American Joint Committee on Cancer (AJCC) staging system.

Positron emission tomography-computed tomography (PET-CT) measurements and evaluations

Patients fasted for six hours prior to PET-CT scans (Siemans Healthcare, Erlangen, Germany), and a blood glucose measurement was taken prior to the injection of ^{18}FDG. If the blood glucose level exceeded 160 mg/dL, the scan was rescheduled. After an injection of ^{18}FDG (dosage 0.2 mCi/kg) for one hour, emission images were acquired from the orbitomeatal line to the proximal thighs. A CT scan was also simultaneously taken with the PET-CT scan for more accurate anatomic localization of any PET positive lesion. SUVmax was used to represent the uptake of ^{18}FDG within the lesion and was calculated by identifying the region of interest on an axial slice with the highest uptake of ^{18}FDG within the lesion. Two nuclear medicine physicians independently calculated the SUVmax values, and both were blinded to results. Medical records were also consulted to distinguish a malignancy or metastasis from a non-specific ^{18}FDG-avid lesion. We compiled SUVmax values as the highest uptake of ^{18}FDG within a tumor and individual LN and these were pathologically confirmed. LN SUVmax was defined as the highest SUVmax value among all pathologically confirmed LNs. Tumors and LNs were considered as positive for malignancy or metastasis when the SUVmax was >2.5 on PET scan and the size was >1 cm on CT scan, according to previous studies and our hospital policy.

Statistical analyses and study approval

Because of non-normal distribution, all data were analyzed with non-parametric, statistical methods. Data are represented as the median (range) or as a proportion. The comparisons among subgroups were evaluated using the Wilcoxon rank, Mann-Whitney U or Jonckheere-Terpstra test as appropriate. Comparisons for categorical variables were evaluated with χ^2 or Fisher's exact tests as appropriate. Association studies were evaluated using Spearman's RHO test. The results were analyzed using SSPS version 18.0 (SPSS Inc., Chicago, IL, USA). A P-value of <0.05 was considered statistically significant. The institutional review board of Seoul St Mary's Hospital approved the study (Approval number: KC14RISI0047).

Results

Study subjects

The medical records of 93 patients (84 men, 9 women; median age 64 years, range 32–88 years) who had undergone curative and complete esophagectomies for esophageal cancers from July 2007 to October 2012 were analyzed. Nineteen patients received neoadjuvant therapy (clinical stage using PET-CT: 1IIb, 7 IIIa, 4 IIIb, and 7 IIIc cases). All cancer histologies were squamous cell carcinomas. Tumors were located in the upper thoracic (13 patients), middle thoracic (49), and lower thoracic (31) esophagus. The median tumor length and size were 3 cm and 6.2 cm^2, respectively. The median tumor and regional LN SUVmax were 5.2 (1.0–28.4) and 2.3 (1.0–15.3), respectively. The median number of regional LN dissections was 19. The overall clinic-pathologic characteristics for the study population are summarized in Table 1.

Table 1 Overall clinico-pathologic characteristics

Characteristics	Number of patients (n = 93)
Age (year)	Median 64 (range 32–88)
Gender	
Male	84
Female	9
Previous other primary cancers	
No	85
Yes	8
Preoperative stage including neoadjuvant cases	
Ia	3
Ib	37
IIa	19
IIb	16
IIIa	14
IIIb	4
Pathologic stage	
Complete remission after neoadjuvant therapy	4
Ia	4
Ib	33
IIa	8
IIb	28
IIIa	8
IIIb	5
IIIc	3
Location of cancer	
Upper thoracic	13
Middle thoracic	49
Lower thoracic	31
Method of surgery	
Ivor Lewis	77
McKeown	16
Pre-operative SUVmax	
Esophageal tumor	Median 5.2 (range 1.0–28.4)
Regional lymph node	Median 2.3 (range 1.0–15.3)
Differentiation	
Well	11
Moderate	73
Poor	9
Neoadjuvant therapy	
No	74
Yes	19

SUVmax, maximum standard uptake value.

Evaluation of tumor and regional lymph node (LN) using PET-CT in patients with esophageal cancer

When SUVmax exceeded 2.5 on PET scan and the lesion size was >1 cm on CT scan, the lesion was regarded as malignant or metastatic. Diagnostic accuracy of esophageal cancer using PET-CT was calculated by subgroups according to neoadjuvant therapy. Diagnostic accuracy of tumors was relatively high. However, evaluation of LN using PET-CT was not accurate. Diagnostic accuracy of the tumor and LNs using PET-CT in patients with esophageal cancer is summarized in Table 2.

Receiver operating characteristic analysis of regional LN maximum standard uptake value (SUVmax) for metastasis

Thirty-one of 47 patients with a LN SUVmax of >2.5 had zero pathologic N stage (pN0) and 15 of 46 patients with LN SUVmax ≤2.5 had one or greater pathologic N stage (pN1-3). Receiver operating characteristic (ROC) analysis showed that the area under the ROC curve was 0.510 ($P = 0.871$, 95% confidence interval 0.381–0.639), indicating that SUVmax level was not an appropriate diagnosis value for LN metastasis. ROC analysis of SUVmax in the diagnosis of metastatic LN is shown in Figure 1.

Analyses of tumor and regional LN SUVmax findings in terms of various factors

There was no significant difference in each tumor or LN SUVmax compared with other various factors including chronic lung disease (COPD and bronchiectasis), age, history of previous other primary cancer, differentiation, and gender. There was a significantly positive correlation between tumor and LN SUVmax ($P = 0.040$), and between tumor SUVmax and size ($P < 0.001$) in patients who did not undergo neoadjuvant therapy. There was a positive correlation between tumor SUVmax and pathologic T stage, regardless of neoadjuvant therapy (with neoadjuvant therapy $P < 0.001$, without $P = 0.007$). However, there was no correlation between LN SUVmax and pathologic T stage, regardless of neoadjuvant therapy. There was no significant correlation of each tumor and LN SUVmax with pathologic N stage

Table 2 Diagnosis accuracy of tumors and regional LNs using PET-CT

	PET-CT		
	Positive	Negative	
Tumor with neoadjuvant therapy (n = 19)			
Pathology			
Positive	12	3	Sensitivity 80%
Negative	3	1	Specificity 25%
LNs with neoadjuvant therapy (n = 19)			
Pathology			
Positive	3	3	Sensitivity 50%
Negative	5	8	Specificity 61.5%
Tumor without neoadjuvant therapy (n = 74)			
Pathology			
Positive	56	18	Sensitivity 75.7%
Negative	0	0	
LNs without neoadjuvant therapy (n = 74)			
Pathology			
Positive	11	14	Sensitivity 44%
Negative	23	26	Specificity 53.1%

LN, lymph node; PET-CT, positron emission tomography-computed tomography.

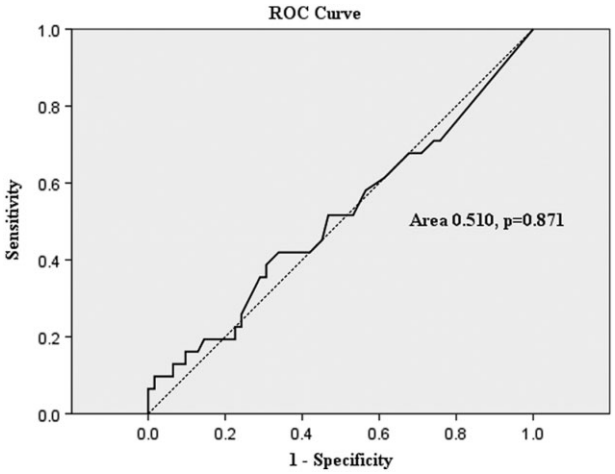

Figure 1 Receiver operating characteristic (ROC) analysis of regional lymph node (LN) maximum standard uptake value (SUVmax) for metastasis. The area under the ROC curve is 0.510 (P = 0.871, 95% confidence interval 0.381–0.639), indicating that regional LN metastasis cannot be appropriately diagnosed with SUVmax.

regardless of neoadjuvant therapy. There was a positive correlation between tumor SUVmax and overall pathologic stage in patients without neoadjuvant therapy ($P < 0.001$). However, LN SUVmax had no relationship with the overall pathologic stage, regardless of neoadjuvant therapy (Fig 2). Tumor SUVmax in the subgroup with lymphatic invasion

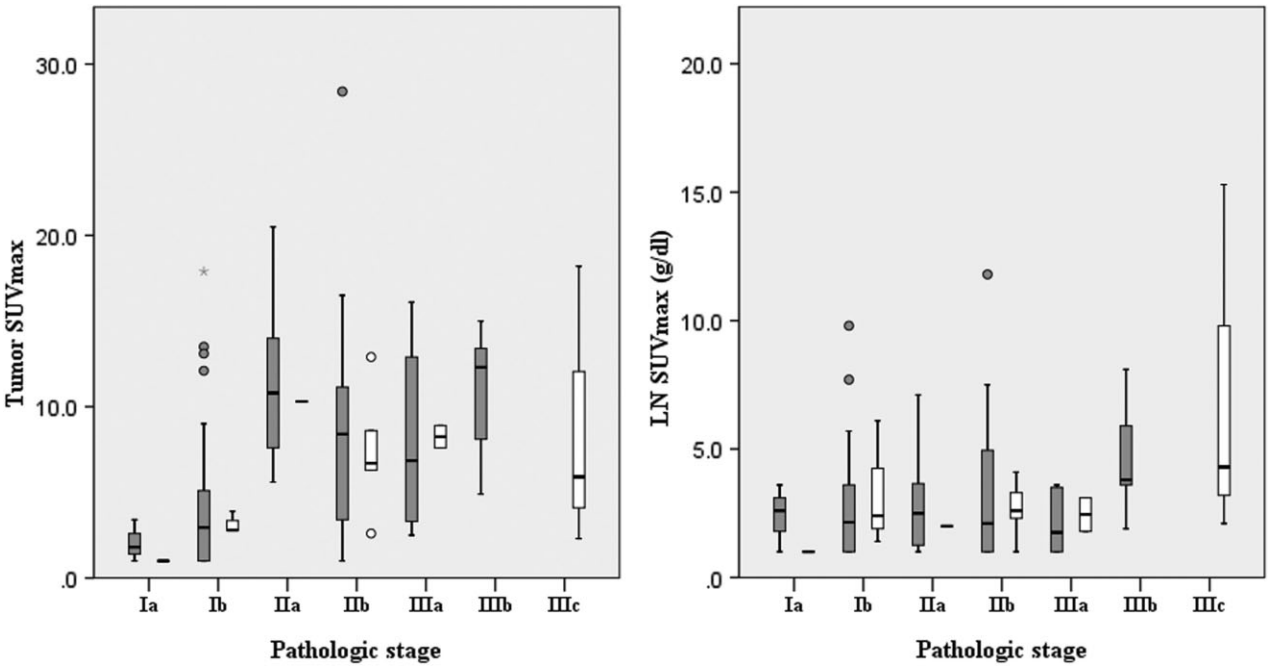

Figure 2 The relationship of esophageal tumor and regional lymph node (LN) maximum standard uptake value (SUVmax) with pathologic stage. There was positive correlation between tumor SUVmax and overall pathologic stage in patients who did not undergo neoadjuvant therapy ($P < 0.001$). However, regional LN SUVmax had no relationship with overall pathologic stage, regardless of neoadjuvant therapy. ▩, No; □, Yes.

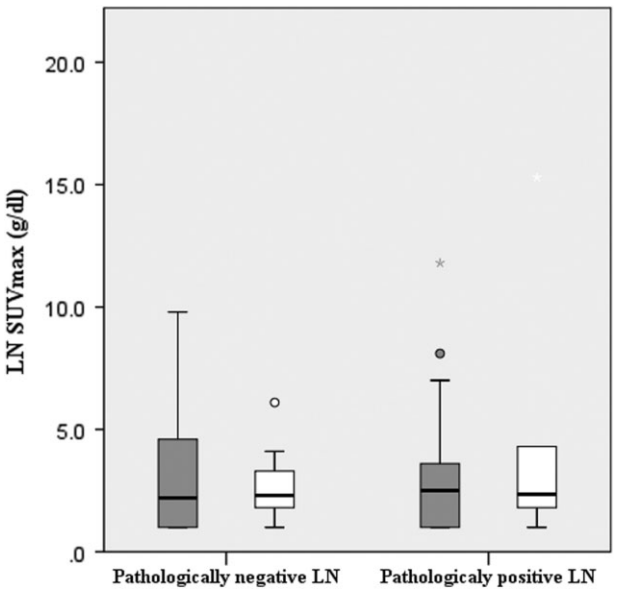

Figure 3 Comparison of maximum standard uptake value (SUVmax) between pathologically negative and positive regional lymph nodes (LNs). There was no significant difference in SUVmax between pathologically positive and negative regional LNs, regardless of neoadjuvant therapy. It was impossible to distinguish pathologically positive and negative regional LNs by SUVmax. ☐, No; ☐, Yes.

was higher than in the subgroup without lymphatic invasion in patients without neoadjuvant therapy ($P = 0.007$). When the ratio of LN to tumor SUVmax was >1.0 (when LN SUVmax was higher than tumor SUVmax), the LN was statistically benign, regardless of SUVmax, in patients without neoadjuvant therapy ($P = 0.026$). Interestingly, there were no significant differences in LN SUVmax between pathologically positive and negative LN, regardless of neoadjuvant therapy (Fig 3).The analyses of tumor and LN SUVmax according to pathologic findings are summarized in Table 3.

Neoadjuvant therapy effects on tumor and regional LN SUVmax

Nineteen patients received neoadjuvant therapy (clinical stage: 1IIb, 7 IIIa, 4 IIIb, and 7 IIIc cases). There were discrepancies in the clinical stage using PET-CT in patients with neoadjuvant therapy (down staging 16/19 = 84.2%, up staging 1/19 = 5.3%, and no change 2/19 = 10.5%). There were significant decreases in both tumor and LN SUVmax after neoadjuvant therapy ($P < 0.001$, $P = 0.001$ respectively; Table 4). There were significant decreases of SUVmax in both pathologically positive and negative LN subgroups ($P = 0.043$, $P = 0.008$ respectively; Table 5). In addition, we analyzed the effects of neoadjuvant therapy in terms of the prediction of metastases based on the SUVmax of the primary lesions. However, the analysis showed that

Table 3 SUVmax of esophageal tumors and regional LNs according to pathologic findings

	SUVmax (median) ratio of SUVmax	Number (SUVmax > 2.5, ratio > 1.0)	Pathologically positive ratio (%) (SUVmax > 2.5, ratio > 1.0)
Overall (n = 93)			
Tumor	5.2	72	72 (100%)
LN	2.3	42	14 (33.3%)
Ratio of LN to tumor SUVmax	0.55	11	0 (0%)
With neoadjuvant therapy (n = 19)			
Tumor	4.95	16	13 (81.3%)
LN	2.35	8	3 (3.8%)
Ratio of LN to tumor SUVmax	0.63	1	0 (0%)
Without neoadjuvant therapy (n = 74)			
Tumor	5.15	56	56 (100%)
LN	2.35	34	11 (32.4%)
Ratio of LN to tumor SUVmax	0.55	10	0 (0%)

LN, lymph node; SUVmax, maximum standard uptake value.

Table 4 Effects of neoadjuvant therapy on SUVmax of esophageal tumors and regional LNs

	Before neoadjuvant	After neoadjuvant	*P*-value
Tumor	Median 15.15 (8.5–28.2)	Median 4.95 (1.0–10.3)	$P < 0.001$
LN	Median 4.30 (1.5–12.1)	Median 2.05 (1.0–6.1)	$P = 0.001$

LN, regional lymph node.

Table 5 Effects of neoadjuvant therapy on regional LN SUVmax (pathologically positive regional LN vs. negative regional LN)

	Before neoadjuvant	After neoadjuvant	*P*-value
Pathologically positive LN	Median 4.4 (2.9–12.1)	Median 2.1 (1.0–4.3)	$P = 0.043$
Pathologically negative LN	Median 4.2 (1.5–11.4)	Median 2.00 (1.0–6.1)	$P = 0.008$

LN, lymph node.

prediction of LN metastases based on SUVmax of the primary lesions was impossible, regardless of neoadjuvant therapy.

Comparisons of SUVmax between complete remission and non-complete remission after neoadjuvant therapy

Decreases of SUVmax of each tumor and LN were evident in cases of both complete remission and non-complete remission. However, only non-complete remission cases displayed statistical significance and this was probably a result of the small sample size of complete remission cases ($n = 4$) (tumor $P = 0.005$, LN $P = 0.002$; Table 6).

Comparison of pre-operative N stage using PET-CT and pathologic N stage

Pre-operative N staging using PET-CT had a tendency of overestimation, regardless of neoadjuvant therapy. However, in spite of inaccurate evaluation of individual LN status using PET-CT, there was no significant difference between pre-operative and pathologic N stage (Table 7).

Discussion

Positron emission tomography-computed tomography has become essential in the evaluation of LNs and distant metastases in patients with esophageal cancer.[3,10] From the viewpoint of a thoracic surgeon, if LN metastases were suspected on PET-CT, the surgeon would hesitate in performing surgery without the patient having been treated with neoadjuvant therapy first.[11] However, misdiagnosis of esophageal cancer using PET-CT is not unusual, especially in regional LN metastasis.[6,12,13] Some studies have reported that PET-CT has a limited role in the identification of regional LN metastasis, but is highly useful for detecting remote LNs and organ metastasis.[6,10] PET-CT measures the metabolic activity of a lesion, provides qualitative and quantitative data of the lesion, and suggests a more accurate decision to treat.[6,7] However, because there are no established findings and because of the qualitative features of PET-CT, the evaluation of regional LN metastasis using PET-CT in patients with esophageal cancer varies from institute to institute and doctor to doctor.[2,7,9] Therefore, the usefulness of PET-CT in the pre-operative evaluation of esophageal cancer, especially in regional LN status, required investigation from the viewpoint of a thoracic surgeon. In our study, when SUVmax exceeded 2.5 on PET scan and the lesion size was >1 cm on CT scan, the lesion was regarded as malignant or metastatic.

In our study, the evaluation of tumors using PET-CT was relatively accurate, and tumor SUVmax correlated with the progression of esophageal cancer (i.e. with pathologic

Table 6 Comparisons of SUVmax between complete and non-complete remission after neoadjuvant therapy

	Before neoadjuvant	After neoadjuvant	*P*-value
Complete remission ($n = 4$)			
Tumor	Median 15.0 (8.5–20.8)	Median 3.65 (1.9–6.5)	$P = 0.068$
LN	Median 4.60 (1.5–10.2)	Median 1.90 (1.0–3.5)	$P = 0.068$
Non-complete remission ($n = 15$)			
Tumor	Median 15.15 (9.8–28.2)	Median 6.10 (1.0–10.3)	$P = 0.005$
LN	Median 4.25(1.6–12.1)	Median 2.20 (1.0–6.1)	$P = 0.002$

LN, lymph node.

Table 7 Comparisons of pre-operative N stage using PET-CT and pathologic N stage

	Pre-operative N stage		Pathologic N stage	
N stage	With neoadjuvant therapy	Without neoadjuvant therapy	With neoadjuvant therapy	Without neoadjuvant therapy
0	1	36	13	49
1	6	22	3	18
2	6	15	0	7
3	6	1	3	0

PET-CT, positron emission tomography-computed tomography.

stage and lymphatic invasion), which has previously been reported.[1,5,6] However, evaluation of regional LNs using PET-CT was inaccurate, and regional LN SUVmax did not correlate with the progression of esophageal cancer. In addition, pre-operative N staging using PET-CT had a tendency for overestimation. Interestingly, there was a significant decrease in the SUVmax in both pathologically positive and negative regional LNs after neoadjuvant therapy, while there was no difference in SUVmax between pathologically positive and negative regional LNs regardless of neoadjuvant therapy. These observations indicate that it is impossible to distinguish pathologically positive and negative regional LNs by SUVmax level, and that it is important to consider other conditions to precisely evaluate regional LNs. In our study, when regional LN SUVmax was higher than that of the tumor, the regional LN was considered benign, regardless of SUVmax. In addition, there were decreases in tumor and regional LN SUVmax after neoadjuvant therapy in both complete remission and non-complete remission cases; but this was significant only in non-complete remission cases. This was probably a result of the small number of complete remission cases ($n = 4$) used in the study. These findings show that it is impossible to distinguish complete from non-complete remission by SUVmax level because a significant portion of pathologically positive regional LNs were converted to negative after neoadjuvant therapy, and neoadjuvant therapy had less impact on pathologically positive regional LNs than in pathologically negative ones.

Many studies have investigated the effects of neoadjuvant therapy and have shown the possibility of predicting metastases based on the SUVmax of primary lesions, such as in hepatocellular carcinoma, and breast and lung cancers.[14] However, the present study showed that prediction of LN metastases based on the SUVmax of primary lesions was impossible in esophageal cancer. This is likely because of the characteristics of esophageal cancer anatomy and progression.[15] In addition, different statistical results of the PET-CT study between neoadjuvant and non-neoadjuvant therapy subgroups were found, probably a result of the various effects of neoadjuvant therapy on tumors and LNs. Further studies on the effects of neoadjuvant therapy on PET-CT findings are needed to improve the evaluation of regional LNs using PET-CT in esophageal cancer.

Previous studies have analyzed the relationship between SUVmax and various factors.[6,8,13] However, the present study showed that there were no significant differences in tumor and lymph node SUVmax according to various factors, including chronic lung disease (COPD, bronchiectasis), age, previous cancers, differentiation, and gender. Except for chronic lung disease, these results were compatible to previous studies. If there were no active/acute infections or inflammation, SUVmax was not influenced by chronic lung disease in the present study, likely reflecting that many of the patients were elderly and had chronic lung disease.

A recent meta-analysis study showed a survival benefit of neoadjuvant therapy followed by surgery over surgery alone in patients with esophageal cancer; improved survival rates resulted from the addition of neoadjuvant therapy and not from further radical surgery.[3] However, because PET-CT cannot provide accurate pre-operative evaluation in patients with esophageal cancer, especially of regional LN metastasis, and can up stage apparently operable patients in early-stage, the superiority of neoadjuvant therapy followed by surgery over surgery alone is considered to be because of occult metastasis, which is not detected by PET-CT.[4,5,11,12] In addition, some studies have reported that pre-operative staging using PET-CT shows no survival benefit and no improvement of early recurrence following surgery. More accurate imaging modalities are needed to detect regional LN metastasis in patients with esophageal cancer.[16] We suggest with caution that neoadjuvant therapy should be performed according to T stage, not N stage, and then evaluated by PET-CT, because there is no current method to evaluate regional LN metastasis with certainty and T stage is a fairly good indicator of regional LN status.

Presently, because the policy of our hospital is to perform prompt surgery without neoadjuvant therapy at T2N1 stage or lower, regional LN evaluation by SUVmax using PET-CT is not fully reliable. We performed prompt surgeries without neoadjuvant therapy in a significant number of cases with high pre-operative N stage, evaluated by PET-CT findings.

Limitations of the study include the retrospective, single center design, small sample size, selection bias, and the shine-through phenomenon. Because the present study included only surgical cases, more cases were early-stage esophageal cancer, which had a low prevalence of regional LN metastasis; therefore, our results may be associated with selection bias. There were also only a small number of patients who underwent neoadjuvant therapy. Heterogeneity of data can be associated with selection bias; therefore, could influence the final results. PET-CT measures the metabolic activity of the lesions with great variability in conditions. There can be various confusing factors to FDG uptake, especially in cases with early-stage esophageal cancer. Empirical and only quantitative standardization of SUVmax can influence evaluation, especially in early-stage. The results gathered from the present study should be further verified with prospective or randomized trials to apply clinically and to evaluate usefulness.

Conclusion

Regional LN evaluation by SUVmax using PET-CT is not fully reliable and the superiority of neoadjuvant therapy followed by surgery over surgery alone may be a result of occult metastasis, which is not detected by PET-CT. Therefore,

surgery should not be withheld only by N-stage from PET-CT findings and carefully considered in conjunction with the other conditions. In addition, there is no current method to evaluate LN metastasis with certainty, but T-stage is a fairly good indicator of regional LN status. We suggest T-stage as an indication for neoadjuvant therapy. Further studies upon the relationship between tumor and regional LNs, the difference between neoadjuvant and non- neoadjuvant therapy cases, and the influences of various factors are needed to improve pre-operative evaluation of regional LNs using PET-CT in esophageal cancer.

Disclosure

No authors report any conflict of interest.

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