Postoperative Recurrence and Survival After Segmentectomy for Clinical Stage 0 or IA Lung Cancer

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Abstract

The present study aimed to elucidate recurrence patterns and identify predictors of time to recurrence after intentional segmentectomy for early stage lung cancer. Two of 166 patients developed local recurrences, and consolidation to maximum tumor diameter ratio was an independent predictive factor for time to recurrence. Favorable survival is expected after intentional segmentectomy, and higher consolidation to maximum tumor diameter ratio increases the risk of recurrence.

Background: Although radical segmentectomy is an accepted treatment option for small-sized lung cancer, the outcomes remain unclear. The present study aimed to elucidate recurrence patterns and to identify predictors of time to recurrence after intentional segmentectomy for early lung cancer. **Patients and Methods:** Prospectively collected data of 166 patients who could tolerate lobectomy and underwent intentional segmentectomy for clinical stage 0 or IA non–small-cell lung cancer between 2007 and 2016 were retrospectively analyzed. Surgical indication for intentional segmentectomy was clinical stage 0 or IA ground glass opacity-dominant tumor $\leq$ 3 cm or solid-dominant tumor $\leq$ 2 cm on high-resolution computed tomography. **Results:** The median follow-up duration was 48.8 months, during which 6 (3.6%) patients developed recurrences. The 5-year recurrence-free survival and 5-year overall survival rates were 93.1% (95% confidence interval [CI], 87.9%-96.1%) and 93.5% (95% CI, 87.7%-96.4%), respectively. Two (1.2%) patients who developed local-only recurrences subsequently underwent completion lobectomy; no cancer-related deaths were seen for these patients. In multivariable analysis, consolidation to maximum tumor diameter (C/T) ratio (hazard ratio, 1.07; 95% CI, 1.01-1.22; $P = .02$) was an independent predictive factor for time to recurrence. All 6 patients with recurrence had a tumor with a C/T ratio of 86% or higher. **Conclusions:** Based on these findings, favorable survival is expected after intentional segmentectomy for selected patients with clinical stage 0 or IA non–small-cell lung cancer. Patients with a higher C/T ratio tumor appear to be at higher risk of recurrence after intentional segmentectomy.

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Introduction

Lung cancer is the leading cause of cancer-related death worldwide, resulting in approximately 1.3 million deaths annually with a 5-year survival rate of 15%.[1] At present, lobectomy is recommended as standard surgical procedure for early non–small-cell lung cancer (NSCLC), based on the results of a randomized controlled trial comparing sublobar resection with lobectomy performed in 1955 by the Lung Cancer Study Group.[2] The number of cases of segmentectomy for early stage lung cancer is expected to increase owing to greater detection of smaller and indolent early stage lung cancer owing to the greater availability of high-performance high-resolution computed tomography (HRCT) and 18-fluorodeoxyglucose positron emission tomography/computed tomography (FDG-PET/CT) in recent years. Several reports have indicated that lesser resection of pulmonary parenchyma has advantages in terms of

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postoperative pulmonary function—particularly forced vital capacity and forced expiratory volume in 1 second.[3,4] Moreover, previous reports have indicated the feasibility of segmentectomy in terms of pulmonary function as well as overall survival.[5-8] On the basis of these results, we proactively perform segmentectomy, rather than lobectomy, for small-sized lung cancer at our institute. However, there is concern about the potential of a higher recurrence rate after segmentectomy owing to the preservation of lung parenchyma, the difficulty securing sufficient surgical margin, and hilar lymph node dissection. In addition, the recurrence patterns and long-term outcomes after segmentectomy remain unclear. To select the most appropriate surgical procedure and postoperative follow-up, clarification of these issues is required.

The primary objective of this study was to elucidate recurrence patterns and survival outcomes after intentional segmentectomy for early stage NSCLC. As a secondary aim, we attempted to identify predictors of time to recurrence (TTR) after intentional segmentectomy.

Materials and Methods

Study Design and Population

This study is a retrospective review of patient data from a prospectively maintained database. The Institutional Review Board of Hiroshima University Hospital approved this study. The requirement of informed consent from individual patients was waived because of the study's retrospective nature.

We enrolled 248 patients who underwent segmentectomy for primary lung cancer at Hiroshima University Hospital between April 1, 2007 and December 31, 2016. All patients underwent HRCT and FDG-PET/CT for preoperative staging according to the TNM Classification of Malignant Tumors, 8th edition, and the pathologic diagnosis followed the World Health Organization classification.[9,10] Tumor location, tumor size, and consolidation to maximum tumor diameter (C/T) ratio were assessed based on HRCT findings. Our surgical indication for intentional segmentectomy was clinical stage 0 or IA patients with a ground glass opacity-dominant tumor $\leq$ 3 cm or a solid-dominant tumor $\leq$ 2 cm on preoperative HRCT. Patients with incompletely resected tumors on macroscopic findings (R2) were excluded.

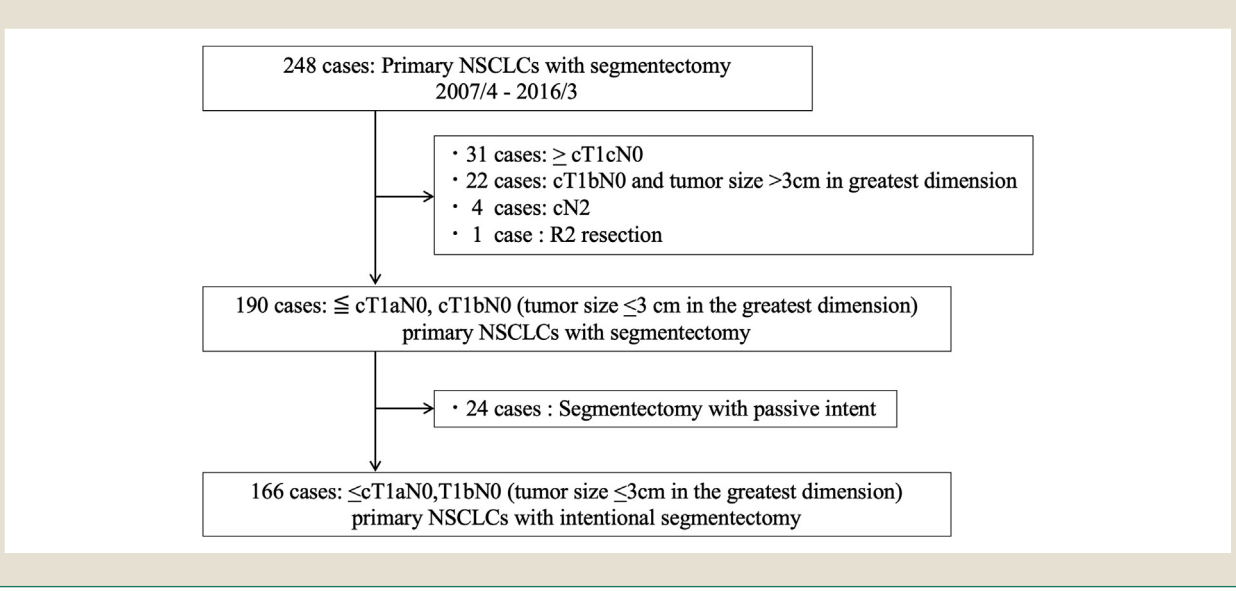
Of the 190 patients who meet our surgical indication, an additional 24 patients were excluded because of compromised segmentectomy owing to poor general or respiratory condition. The remaining 166 patients treated by intentional segmentectomy were analyzed to elucidate recurrence patterns and identify predictors of TTR after segmentectomy for early stage lung cancer (Figure 1).

Surgical Procedure and Postoperative Therapy

Radical segmentectomy was performed via a 4- to 8-cm thoracotomy by hybrid video-assisted thoracic surgery using both direct vision and television monitor visualization.[11] Electric cauterization of the segmental planes was usually performed without a stapler and accompanied by routine systematic dissection or sampling of the hailer and mediastinal nodes. If a resection margin of $>$ 2 cm or equal to the tumor diameter could not be ensured, the resection line was moved to the adjacent segment. Surgical margins were also assessed in resected specimens; the procedure was converted to lobectomy if they were inadequate. All patients routinely underwent systematic hilar and mediastinum lymph nodal dissection. Lymph nodes in frozen sections were assessed, and conversion to lobectomy or completion lobectomy was considered if lymph node metastasis was ide3ntified pathologically.

Simple segmentectomy was defined as a procedure with resection of only 1 intersegmental plane, such as lingual or superior segmentectomy, whereas complex segmentectomy was defined as a procedure with resection of 2 or more intersegmental planes, such as

Figure 1 Schema of the Study Population. A Total of 166 Patients Underwent Intentional Segmentectomy for Peripheral Small NSCLC. All Patients Were Preoperatively Staged According to the TNM Classification of Malignant Tumors, 8th Edition



Abbreviation: NCSLC = non–small cell lung cancer.

Table 1 Characteristics of Patients Who Underwent Intentional Segmentectomy

Variables	Value, n (%) Segmentectomy (n = 166)
Median age, y (IQR)	67.0 (61.0-72.0)
Gender	
Male	86 (51.8)
Female	80 (48.2)
Nodule location	
Right upper lobe	47 (28.3)
Right lower lobe	43 (25.9)
Left upper lobe	47 (28.3)
Left lower lobe	29 (17.5)
Median nodule diameter on CT, mm (IQR)	14.3 (12.0-17.3)
Median C/T ratio, % (IQR)	0.61 (0.26-1.0)
≤0.5	67 (40.4)
>0.5	99 (59.6)
Median solid tumor size on CT, mm (IQR)	9.0 (3.8-12.7)
Median SUVmax (IQR)	1.2 (0.8-1.8)
Clinical TNM	
TisN0M0	25 (15.1)
T1 miN0M0	26 (15.7)
T1aN0M0	42 (25.3)
T1bN0M0	73 (44.0)
Median surgical time, min (IQR)	170.5 (140.8-204.3)
Median bleeding, mL (IQR)	45.0 (22.0-84.3)
Resected segment	
Simple	72 (43.4)
Complex	94 (56.6)
Median pathologic size, mm (IQR)	15.0 (11.0-18.0)
Median surgical margin, mm (IQR)	15.0 (10.0-25.0)
Histologic type	
Adenocarcinoma	151 (91.0)
In situ	26 (17.2)
Lepidic	40 (26.5)
Acinar	4 (2.6)
Papillary	76 (50.3)
Micropapillary	1 (0.7)
Solid	3 (2.0)
IMA	1 (0.7)
Adenosquamous carcinoma	2 (1.2)
Squamous cell carcinoma	11 (6.6)
Large cell carcinoma	2 (1.2)
Pleural invasion	
Absent	158 (95.2)
Present	8 (4.8)
Vascular invasion	
Absent	151 (91.0)
Present	15 (9.0)
Lymphatic invasion	
Absent	150 (90.4)
Present	16 (9.6)
Median follow-up time, mos (IQR)	49.3 (35.2-73.4)

Abbreviations: CT = computed tomography; C/T ratio = consolidation to maximum tumor diameter ratio; IMA = invasive mucinous adenocarcinoma; IQR = interquartile range; SUVmax = maximum standardized uptake value.

anterior segmentectomy. Adjuvant chemotherapy was administered to patients with pathologic stage IA3 or more advanced disease.

Follow-up Evaluation

All patients who underwent lung resection were followed up starting from the day of the surgery. For the first 2 years, postoperative follow-up comprised a physical examination and chest radiograph every 3 months and a chest and abdominal computed tomography (CT) examination every 6 months. In subsequent years, physical examination and chest radiograph were performed every 6 months, and a chest CT was performed every year. Recurrence was determined by radiographic features or histologic evidence. We classified tumor recurrence into 3 subgroups: (1) local recurrence was defined as surgical stumps or preserved lobe; (2) regional recurrence was defined as an ipsilateral lobe other than the preserved lobe, ipsilateral thoracic cavity, hilum, or mediastinum lymph node; and (3) distant recurrence was defined as extrathoracic organs and metastasis to the lobe on the other side.

Statistical Analysis

Data are presented as numbers (in percentage) or median values, unless otherwise stated. TTR was defined as the elapsed time from the date of segmentectomy until recurrence or last follow-up. Recurrence-free survival (RFS) was defined as the elapsed time from the date of segmentectomy until recurrence, death from any cause, or last follow-up. Overall survival (OS) was also defined as elapsed time from the date of segmentectomy until death from any cause or last follow-up. The durations of TTR, RFS, and OS were analyzed using the Kaplan-Meier method, and differences were assessed using the log-rank test. Independent predictors of TTR after segmentectomy were determined using univariable and stepwise multivariable analysis with Cox proportional hazards models that included the preoperative and intraoperative clinical factors of C/T ratio, maximum standardized uptake value (SUVmax) on FDG-PET/CT, and resected segments (complex vs. simple). A P value less than .05 was considered statistically significant. Receiver operating characteristic (ROC) curves of the C/T ratio were used to determine the criteria required to predict factors of TTR. Frequencies of categorical variables were compared using the χ^2 test, and small samples were analyzed using the Fisher exact test. All data were analyzed using JMP software, Version 14 (SAS Institute, Cary, NC).

Table 2 Resected Segments in 166 Segmentectomies

Right	n = 90	%	Left	n = 76	%
Simple			Simple		
S6	23	25.6	S6	16	21.1
S7 + 8 + 9 + 10	2	2.2	S1 + 2 + 3	22	28.9
			S4 + 5	7	9.2
			S8 + 9 + 10	2	2.6
Complex			Complex		
S1	17	18.9	S3	5	65.8
S2	12	13.3	S8	3	3.9
S3	6	6.7	S9	1	1.3
S7	3	3.3	S10	1	1.3
S8	4	4.4	S1 + 2	12	15.8
S9	1	1.1	S1 + 2a + 3	1	1.3
S1 + 2	5	5.6	S6 + 8	1	1.3
S1a + 2	1	1.1	S6 + 9 + 10	1	1.3
S1 + 3	2	1.3	S8 + 9	2	2.6
S1b + 3	1	1.1	S9 + 10	2	2.6
S2 + 3a	1	1.1			
S3 + 6	1	1.1			
S6 + 10	1	1.1			
S6 + 9 + 10	1	1.1			
S7 + 8 + 9	1	1.1			
S8 + 9	4	4.4			
S9 + 10	4	4.4			

Abbreviations: a = posterior subsegment; b = anterior subsegment; S1 = apical; S2 = posterior; S3 = anterior; S4 = lateral; S5 = medial; S6 = superior; S7 = medial basal; S8 = anterior basal; S9 = lateral basal; S10 = posterior basal.

Results

Table 1 summarizes the characteristics of the 166 patients analyzed in this study: 25 (15.1%) were cTisN0M0, 26 (15.7%) were cT1 miN0M0, 42 (25.3%) were cT1aN0M0, and 73 (44.0%) were cT1bN0M0 according to the TNM Classification of Malignant Tumors, 8th edition. The median whole nodule diameter was 14.3 mm (interquartile range [IQR], 12.0-17.3 mm), and the median C/T ratio was 61% (IQR, 26%-100%); the median solid tumor size was 9.0 mm (IQR, 3.8-12.7 mm), and the median SUVmax was 1.2 (IQR, 0.8-1.8). Most patients showed no evidence of pathologic pleural, lymphatic, or vascular invasion. Adenocarcinoma was the predominant histology, followed by squamous cell carcinoma. The median follow-up time for all surviving patients was 48.8 months. There were postoperative complications, including 8 grade III cases including 3 bronchopleural fistula, 1 thoracic empyema, 3 prolonged air leakage, and 1 pleural effusion. One grade IV complication owing to bronchopleural fistula, was observed. There were no deaths associated with perioperative complications. Detailed segmentectomy procedures are shown in Table 2, and the characteristics of patients with recurrences are shown in Table 3. Recurrences after segmentectomy occurred in 6 (3.6%) of 166 patients. Local-only recurrences occurred in 2 (1.2%) patients, whereas regional with local recurrences occurred in 2 (1.2%) patients. Distant-only recurrence occurred in 1 (0.6%) patient involving the bone and brain, whereas distant with regional recurrence occurred in 1 patient involving the bilateral lung, mediastinal lymph node, and cervical lymph node. The median TTR of patients with recurrences was 14.3 months (IQR, 6.2-48.6 months). Although most recurrences occurred within 30 months, 1 patient developed local recurrence 105 months after intentional segmentectomy (Figure 2). In the 2 patients with recurrences at the surgical stump, surgical margin was 0.5 mm in a patient who developed recurrence at 105 months, and 30 mm in another patient with recurrence at 30 months.

As additional treatment, completion lobectomy was included in the 2 cases by pathologic findings—one case for lymph node metastasis and positive surgical margin and the other for lymph node metastasis. Though we found 3 more cases with positive pathologic lymph node, completion lobectomy was not included because the patient did not consent. Furthermore, completion lobectomy was also performed in both cases of local-only recurrence. One patient was free of recurrence 112 months after completion lobectomy, whereas the other patient died from intercurrent disease. No cancer-related death was observed in the 2 patients who underwent completion lobectomy after local recurrence. The 5-year RFS and 5-year OS were 93.1% (95% confidence interval [CI], 87.9%-96.1%) and 93.5% (95% CI, 87.7%-96.4%), respectively.

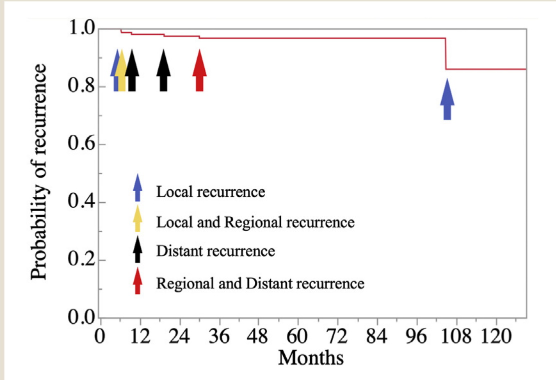
The univariable and multivariable analyses of TTR are presented in Table 4. The C/T ratio (%) (hazard ratio [HR], 1.1; 95% CI, 1.01-1.22; $P = .02$) was identified as a significant independent prognostic factor for TTR after intentional segmentectomy. We generated an ROC curve and found that the optimal cutoff value of

Table 3 Clinicopathological Features of Recurrent Cases After Intentional Segmentectomy

Age/Gender	Resected Segment	C/T Ratio	SUVmax	Solid Tumor Size, mm	c Stage	Recurrent Pattern	Recurrent Site	p Stage	Histologic Type	TTR, mos	Followed Treatment	Outcome
65/M	Right S6	0.86	3.3	12.9	cT1bN0M0 cStageIA2	Local	Surgical stump	pT1bN0M0 pStageIA2	Adenocarcinoma (Papillary > Acinar)	105	Completion lobectomy	Alive
65/M	Light S4 + 5	1	3.7	16	cT1bN0M0 cStageIA2	Local	Surgical stump	pT1bN0M0 pStageIA2	Adenosquamous cell carcinoma	6	Completion lobectomy	Death (intercurrent disease)
77/M	Right S6	0.87	1.8	12.2	cT1bN0M0 cStageIA2	Local Regional	Ipsilateral lung Mediastinal LN	pT1aN2M0 pStageIIIA	Adenocarcinoma (Papillary > AIS)	19	CT	Alive
74/M	Right S2	1	3.6	13	cT1bN0M0 cStageIA2	Local Regional	Ipsilateral lung Mediastinal LN	pT1bN0M0 pStageIA2	Squamous cell carcinoma	9	CRT	Death
75/F	Right S6	1	2.9	16	cT1bN0M0 cStageIA2	Distant	Bone Brain	pT1bN2M0 pStageIIIA	Adenocarcinoma (Solid > Acinar)	6	CRT	Death
76/M	Right S9 + 10	1	3.4	13.8	cT1bN0M0 cStageIA2	Regional Distant	Bilateral lung Mediastinal LN Cervical LN	pT1bN0M0 pStageIA2	LCNEC	30	BSC	Alive

Abbreviations: AIS = adenocarcinoma in situ; BSC = best supportive care; CT = chemotherapy; C/T ratio = consolidation to maximum tumor diameter ratio; CRT = chemoradiotherapy; LCNEC = large-cell neuroendocrine carcinoma; LN = lymph node; SUVmax = maximum standardized uptake value; TTR = time to recurrence.

Figure 2 Kaplan-Meier Probability of Recurrence Curves of All Intentional Segmentectomy Cases



the C/T ratio using the Youden index was 86.0% (sensitivity 100%, specificity 68.8%) (see Supplemental Figure 1 in the online version). The patient population was then subdivided based upon this value.

TTR differed significantly between patients with a C/T ratio ≥ 86.0% (5-year TTR, 90.6%) and ≤ 85.0% (5-year TTR, 100%; $P < .001$) (Figure 3A) There were no recurrences in patients with a C/T ratio ≤ 85.0% on preoperative HRCT. In addition, RFS differed significantly between patients with a C/T ratio ≥ 86.0% (5-year RFS, 86.5%) and ≤ 85.0% (5-year RFS, 96.4%; $P = .02$) (Figure 3B). However, OS did not differ significantly between the two groups (C/T ratio ≥ 86.0%, 5-year OS, 87.7% vs. C/T ratio ≤ 85.0%, 5-year OS, 96.4%; $P = .24$) (Figure 3C).

Discussion

The present study elucidated the recurrence patterns after intentional segmentectomy in patients with clinical stage 0 or IA NSCLC who could tolerate lobectomy. Local recurrences, such as surgical stumps of lung parenchyma and intrapulmonary metastasis of the preserved lobe—although rare after lobectomy—are great concerns after segmentectomy. Recurrences occurred in only 6 (3.6%) of 166 patients in this study, specifically 4 (2.4%) loco-regional recurrences and 2 (1.2%) local-only recurrences. Previous studies of patients with various backgrounds have reported loco-regional recurrence rates of 1.7% to 19.5% after segmentectomy.[6,7,12,13] Nomori et al reported 3 (1.7%) loco-regional recurrences out of 179 patients, including 2 recurrences in the surgical stump and 1 recurrence in the preserved lobe, after segmentectomy for T1a/1bN0M0 NSCLC according to the TNM Classification of Malignant Tumors, 7th edition.[12] Nishio et al reported 23 (19.5%) loco-regional recurrences out of 118 patients for T1aN0M0 NSCLC with a C/T ratio > 50%.[13] Thus, the recurrence rate in the present study was equal to or better than that in previous reports. Additionally, some reports have indicated that late local recurrence can occur more than 5 years after segmentectomy.[12,13] In our study, 1 patient developed local recurrence 105 months after segmentectomy and underwent subsequent completion lobectomy, suggesting that longer follow-up is needed to detect late local recurrence. Regarding completion lobectomy for recurrent

Table 4 Univariable and Multivariable Cox Proportional Hazard Regression Model Analysis for Time to Recurrence

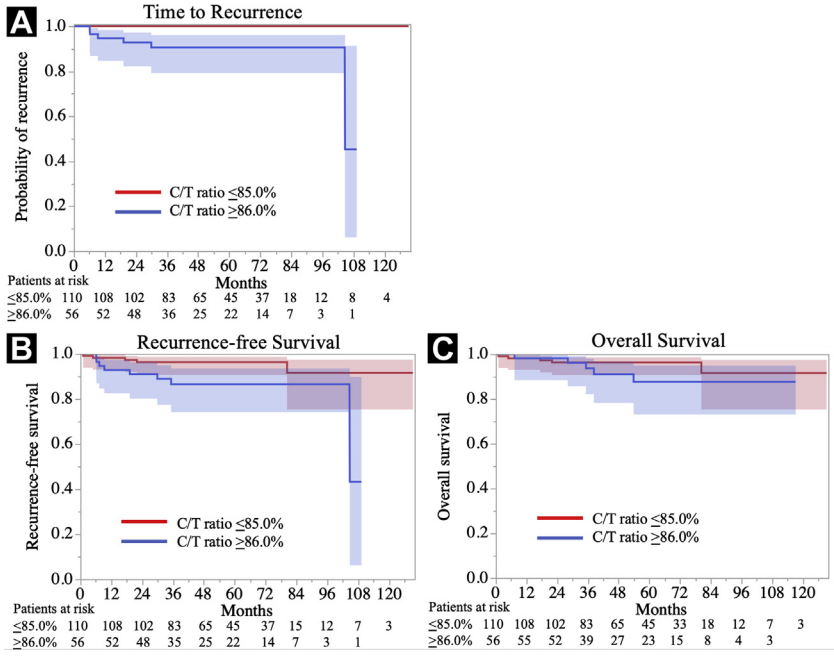
Variables	Time to Recurrence			
	Univariable		Multivariable	
	HR (95% CI)	*P*	HR (95% CI)	*P*
Age	0.99 (0.91-1.09)	.80		
Gender (male vs. female)	4.59 (0.74-87.9)	.29		
C/T ratio, %	1.07 (1.02-1.20)	.001	1.07 (1.01-1.22)	.02
Solid tumor size on CT, mm	1.31 (1.08-1.70)	.003		
SUVmax	2.03 (1.27-3.23)	.005	1.60 (0.86-2.76)	.13
Resected segment (complex vs. simple)	0.40 (0.06-2.07)	.28	0.22 (0.03-1.30)	.10

Abbreviations: CI = confidence interval; CT = computed tomography; C/T ratio = consolidation to maximum tumor diameter ratio; HR = hazard ratio; SUVmax = maximum standardized uptake value.

lung cancer, although our study and previous studies have indicated its feasibility and safety, it can be delicate surgery owing to severe adhesion, so the risk of pneumonectomy should be considered.[14,15] As an alternative treatment to surgery for local recurrent lung cancer, stereotactic ablative body radiotherapy with limited toxicities can be considered in high-risk patients or those with inoperable tumors.[16] The therapeutic strategy for recurrent lung tumor after segmentectomy should be discussed on a case-by-case basis, and more investigation is needed.

Regarding prognostic factors for early lung cancer, we previously reported that solid tumor size on preoperative HRCT had a high predictive value for pathologic invasiveness and RFS.[17] In other reports, SUVmax on FDG-PET/CT and solid tumor size were good clinical predictors of the malignant grade of lung adenocarcinoma with regard to pathologic invasiveness and negative pathologic nodes.[18,19] Despite the tendency of recurrence in cases with high SUVmax and larger solid tumor size, there was also a significantly higher risk of recurrence in patients with a C/T ratio $\geq$ 86.0% after intentional segmentectomy in this study. Among the 6 cases of recurrence, all tumors had a C/T ratio equal to or greater than 86.0% on HRCT, and there were no recurrences in patients with a C/T ratio $\leq$ 85.0%, suggesting that C/T ratio $\leq$ 85.0% tumors are good candidates for segmentectomy—even those with solid-dominant features on HRCT. However, for accurate evaluation of the efficacy of segmentectomy for lung cancer with a higher C/T ratio, we must wait for the final results of prospective randomized studies comparing segmentectomy versus lobectomy for early stage NSCLC (eg, the Japan Clinical Oncology Group [JCOG] 0802/West Japan Oncology Group [WJOG] 4507L and Cancer and Leukemia Group B [CALGB] 140503).[20,21] The target populations

Figure 3 Time to Recurrence, Recurrence-free Survival, and Overall Survival Curves for Patients Who Underwent Intentional Segmentectomy Based on the C/T Ratio Predictive of a High Risk of Recurrence. A, in the Overall Population, 5-year Probability of Recurrence Rates of 9.4% and 0.0% Were Identified for Patients With C/T Ratios ≥ 86.0% and ≤ 85.0%, Respectively (*P* < .001). B, in the Overall Population, 5-year RFS Rates of 86.5% and 96.4% Were Identified for Patients With C/T Ratios ≥ 86.0% and ≤ 85.0%, Respectively (*P* = .02). C, in the Overall Population, 5-year OS Rates of 87.7% and 96.4% Were Identified for Patients With C/T Ratios ≥ 86.0% and ≤ 85.0%, Respectively (*P* = .20)



Abbreviation: C/T = consolidation to maximum tumor diameter.

in these studies include more aggressive lung cancers, so they will be able to reveal the efficacy of segmentectomy versus lobectomy for early stage lung cancer with a higher C/T ratio.

Lastly, this study is subject to several limitations. First, this was a retrospective review of a prospective database from a single institution, although we could clearly distinguish intentional segmentectomy from compromised segmentectomy and unify the method of postoperative follow-up in a prospective manner. Second, this was a single-arm study, and we did not compare segmentectomy with standard lobectomy. Third, because the observation period was not that long, it is possible that there will be more recurrences in the future. Thus, further investigations with a longer observation period and larger sample size are needed.

Conclusion

Long-term survival is expected after intentional segmentectomy for selected patients with clinical stage 0 or IA NSCLC, particularly for tumors with a C/T ratio $\leq$ 85.0%. However, patients with a higher C/T ratio tumor appear to be at greater risk of postoperative recurrence after segmentectomy.

Clinical Practice Points

- At present, lobectomy is recommended as standard surgical procedure for early NSCLC, based on the results of a randomized trial performed in 1955. However, segmentectomy has the potential to replace lobectomy as a standard surgical procedure because of several benefits, such as reducing postoperative complication, preserving respiratory function, and improving patient's quality of life. Moreover, recent several reports have indicated the feasibility of segmentectomy in terms of OS. The present study primarily aimed to elucidate recurrence patterns and survival outcomes after intentional segmentectomy for early stage NSCLC and identify predictors of TTR after intentional segmentectomy.
- A total of 6 (3.6%) of 166 patients developed recurrences. Two (1.2%) patients who developed local-only recurrences subsequently underwent completion lobectomy; no cancer-related deaths were seen for these patients. Although most recurrences occurred within 30 months, 1 patient developed local recurrence 105 months after intentional segmentectomy. In multivariable analysis, C/T ratio was an independent predictive factor for TTR, and all tumors had a C/T ratio $\geq$ 86.0% on HRCT.
- Our results indicate favorable survival after intentional segmentectomy for early stage NSCLC, and longer follow-up is needed to detect late local recurrence. Patients who have a tumor with a higher C/T ratio appear to be at higher risk of recurrence after intentional segmentectomy and patients who have tumors with a C/T ratio $\leq$ 85.0% are good candidates for segmentectomy.

Disclosure

The authors have stated that they have no conflicts of interest.

Supplemental Data

Supplemental figure accompanying this article can be found in the online version at https://doi.org/10.1016/j.cllc.2019.06.004.

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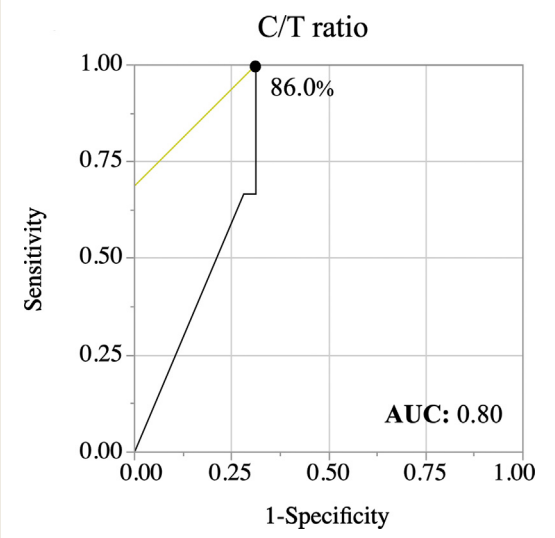
Supplemental Data

Supplemental Figure 1 **Receiver Operating Characteristic AUC for Detecting Time to Recurrence for C/T Ratio. The Optimal Cutoff Value of the C/T Ratio for Time to Recurrence Was 86.0% (n = 166; AUC = 0.80; 95% Confidence Interval, 0.70-0.90; *P* = .01)**



Abbreviations: AUC = area under the curve; C/T = consolidation to maximum tumor diameter.