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Abstract

Background: Recent advances in stereotactic body radiation therapy (SBRT) technology for early-stage peripheral lung cancer have been remarkable and are becoming a viable alternative to surgery. However, the most important problem in performing SBRT correctly is minimizing the respiratory motion of the tumor.

Materials and methods: Thirty-eight patients treated with SBRT were evaluated to clarify factors affecting respiratory motion of early-stage peripheral lung cancer in the management of restrictive breathing technique (abdominal compression) to reduce respiratory tumor motion in SBRT. We investigated age, gender, body mass index (BMI), Brinkman index (BI), forced expiratory volume in 1 second (FEV 1.0), and type of ventilatory impairment as patient factors, and T-factor, stage, tumor-bearing lung lobe, and tumor pathology as tumor factors. Respiratory motion was assessed by volume differences between clinical target volume (CTV) and internal target volume (ITV). The degree of tumor motion due to respiration was compared using the formula of (ITV-CTV)/CTV as an index.

Results: In the results, univariate analyses showed that only age was a significant predictor of respiratory tumor motion ($p = 0.048$). In multi-variate analyses, only T factor was an independent significant predictor of respiratory tumor motion ($p = 0.045$), while there was a significant trend for age ($p = 0.061$), and tumor location ($p = 0.067$).

Conclusions: In late elderly patients or T1a tumor, respiratory motion in early-stage peripheral lung cancer was significantly large. However, it is not predictable by patient and

tumor characteristics. Therefore, respiratory motion of the tumor should be measured in all patients in some way.

Key words: SBRT; respiratory motion management; early-stage lung cancer

Introduction

In recent years, stereotactic body radiation therapy (SBRT) for early-stage lung cancer has become very popular due to advances in safe techniques [1–5]. SBRT is becoming an alternative treatment to surgery, especially for medically inoperable patients and the elderly [6–9]. We have previously reported the results of SBRT for early-stage peripheral lung cancer in 33 patients. We conclude that SBRT can be performed in elderly patients for the treatment of early-stage peripheral lung cancer with satisfactory therapeutic outcomes [10].

In SBRT for early-stage lung cancer, tumor motion during respiration cannot be ignored [11, 12]. Various methods have been developed to reduce the volume of the normal lung that gets irradiated. Methods that deal with the patient's respiratory motion can be broadly classified into five categories: motion-encompassing, respiratory-gating, breath-hold, forced shallow breathing with abdominal compression, and real-time tumor tracking [13].

In the absence of respiratory-gating equipment at our institution, a respiratory-gating technique with abdominal compression was adopted for SBRT in early-stage peripheral lung cancer. Therefore, we investigated the patient and tumor characteristics that influence respiratory tumor motion using the formula:

(internal target volume (ITV) – clinical target volume (CTV))/CTV

as an index.

Materials and methods

We conducted a retrospective analysis to determine the effect of patient and tumor characteristics on lung tumor respiratory motion in patients with early-stage peripheral lung cancer (Tis ~ T2bN0M0) treated with SBRT.

Patients were recruited from an institutional cohort database between September 2019 and December 2022. Thirty-eight patients underwent SBRT during the study period. All of the patients provided written informed consent to undergo SBRT. Because this was a retrospective analysis of clinical data, the Institutional Review Board was notified of the study, but approval was not required.

We evaluated age, sex, body mass index (BMI), Brinkman index (BI), forced expiratory volume in 1s (FEV1.0), and type of ventilatory impairment as patient factors, and T-factor, stage, tumor location (tumor-bearing lung lobe), and tumor pathology as tumor factors.

Respiratory tumor motion was assessed using the volume difference between the CTV and ITV. The degree of respiratory tumor motion was compared using the formula

$$(ITV - CTV)/CTV$$

as an index.

Table 1 shows the characteristics of the patient. Twenty-three males and 15 females were enrolled in the study. The median age and the mean age ± standard deviation (SD) were 82 and 81.5 ± 5.3 years, respectively (range 70–89 years). The mean age ± SD was 80.0 ± 5.5 years for the males and 83.8 ± 4.4 years for the females, indicating that the females were older. Regarding BMI, 24/38 patients (63%) were of normal weight (18.5 < BMI < 25). Fourteen patients (37%) were non-smokers, while 18 (48%) were heavy smokers, with a BI ≥ 600. Twenty patients (52%) had an FEV1.0 < 1.5 L. Regarding the type of ventilatory impairment, 21 patients (55%) had ventilatory impairment, of whom 3 had restrictive impairment, 12 had obstructive impairment and 6 had mixed impairment.

Table 2 shows the tumor characteristics. Tumors arising from the right upper and lower lobes were the most common (29% each). For T-factor, 2 patients had Tis, 3 had T1min, 2 had T1a, 13 had T1b, 10 had T1c, 7 had T2a, and 1 had T2b disease. The most common stage was stage IA_2 (32%), followed by stage IA_3 (26%). Only 13 (34%) patients were histopathologically diagnosed with tumors.

Patient immobilization and respiratory restriction

The respiratory restriction technique (abdominal compression) was used to reduce tumor motion during respiration. During computed tomography (CT) simulation, all patients were immobilized with a Vac-Lok™ pad and HipFiX. The cushion was placed at the level of the diaphragm to suppress respiratory motion. The pressure applied by the cushion was as high as the patient could tolerate.

Clinical target volume (CTV) and internal target volume (ITV) delineation

For treatment planning, CT without contrast enhancement during three respiratory phases (normal shallow breathing, shallow hold inspiration, and shallow hold respiration) to determine the ITV. CT was performed on 2 consecutive days to determine daily changes in the ITV.

The gross tumor volume (GTV) was delineated in the normal shallow breathing phase on the first day using the lung window. No margins were added for the microscopic extension (CTV = GTV). The ITV was determined from the remaining 5 respiratory phases using CT images acquired over the course of two days. The ITV was generated by combining the 6 phase-sorted GTVs.

.To eliminate interobserver variability, the target volumes were delineated on the CT images by the same two radiation oncologists using Pinnacle version 9.10 (Koninklijke Philips N.V., Amsterdam, The Netherlands). All patients were treated with an ITV-based strategy with an additional ITV-to-PTV margin of 3 mm.

Evaluation and statistical analyses

Age, BMI, BI and FEV1.0 were analyzed as continuous variables. Gender, type of ventilatory impairment, T-factor, stage, tumor location (tumor-bearing lung lobes), and pathological diagnosis were analyzed as categorical variables.

. Univariate analyses of possible variables affecting (ITV-CTV)/CTV were performed using unpaired two-tailed t-tests for categorical variables and regression analyses for continuous variables.

Multiple regression analysis was used to identify the interactions between different factors associated with tumor motion and ((ITV-CTV)/CTV). To analyze the relationship between patient and tumor values and (ITV-CTV)/CTV, we performed multilinear regression with patient and tumor values as predictor variables and (ITV-CTV)/CTV as the response variable. Age, BMI, BI and FEV1.0 were analyzed as continuous variables. Gender, type of ventilatory impairment, T-factor, and tumor location (tumor-bearing lung lobes) were analyzed as categorical variables. The values of these parameters are shown in Table 3. Histopathological type and clinical stage classification were excluded from multivariate analysis because 25/38 patients had no pathological diagnosis, and stage classification was almost the same as the T-factor, except for stage IA_1.

The mean age of the top 10 patients with the greatest respiratory tumor motion ((ITV-CTV)/CTV) was compared with the remaining 28 patients with less respiratory tumor motion by Welch's t-test.

Statistical significance was set at $p < 0.05$. All statistical analyses were performed with Microsoft Excel for Windows (version 2305) (Microsoft Corporation, Redmond, WA, USA).

Results:

Correlation between CTV and ITV

A very strong correlation was observed between the ITV and CTV ($y = 1.5041x + 2.2348$, $R^2 = 0.8303$, $p = 1.96173E-15$). The ITV also showed a very strong correlation with (ITV–CTV) ($y = 0.448x + 20.1525$, $R^2 = 0.7632$, $p = 8.23057E-13$). As shown in Figure 1A, (ITV/CTV)/CTV showed a correlation with CTV ($y = –0.0583x + 1.4618$, $R^2 = 0.1709$, $p = 0.0.009881$), but not with ITV ($y = –0.0103x + 1.2119$, $R^2 = 0.0145$, $p = 0.471007$).

Patient characteristics influencing respiratory tumor motion

Tumor respiratory motion, expressed as (ITV-CTV)/CTV, was significantly greater in elderly patients ($y = 0.043x – 2.4684$, $R^2 = 0.1037$, $p = 0.048664$) (Fig. 1B).

Although the mean respiratory motion of the tumor ± SD was greater in females than in males (1.321 ± 0.757 in females and 0.940 ± 0.678 in males), there was no statistically significant difference between the genders ($p = 0.115$) (Fig. 2A). The (ITV-CTV)/CTV was lower in underweight patients (BMI < 18.5) than in normal weight ($18.5 \leq$ BMI < 25) or obese patients (BMI ≥ 25), but the difference was not significant ($p = 0.301$) (Fig. 1C). There was no significant correlation between (ITV-CTV)/CTV and FEV1.0 ($p = 0.631$) (Fig. 1D), or Brinkman index ($p = 0.148$) (Fig. 1E). Type of respiratory impairment did not affect (ITV-CTV)/CTV (Fig. 2B).

Tumor characteristics affecting tumor respiratory motion

The mean (ITV-CTV)/CTV ratio was 2.041 for T1a tumors and 0.884 for T2a tumors. A significant trend was observed in both groups ($p = 0.0537$) (Fig. 2C).

There was no clear correlation between (ITV-CTV)/CTV and stage (Fig. 2D). Tumor location (lung lobe) did not affect (ITV-CTV)/CTV (Fig. 2E). No correlation was observed between the histopathological type and (ITV-CTV)/CTV (Fig. 2F).

Results of multi-regression analysis of factors affecting respiratory tumor movement.

The results of the multivariate analysis are summarized in Table 4. Only the T-factor was an independent significant predictor of (ITV-CTV)/CTV ($p = 0.045$), while other variables were not. However, there was a significant trend for age ($p = 0.061$) and tumor location ($p = 0.067$) to be significant predictors of (ITV-CTV)/CTV.

Characteristics of the top 10 patients with the greatest (ITV-CTV)/CTV

Table 5 summarizes the characteristics of the top 10 patients with the greatest respiratory tumor motion. All 10 patients were late elderly (> 80 years old), and their mean age ± SD was 85.1 ± 2.8 years. They were significantly older than the remaining 28 patients with less respiratory tumor motion at 80.2 ± 5.5 years ($p = 0.0012$).

Their BMI was greater than 20. Nine of the 10 patients were not only late elderly but also had some comorbidities. No consistent trend was observed between respiratory impairment, FEV1.0 or BI, and respiratory tumor motion.

In 8 of the 10 patients, the tumor was located in the upper lobe (Lt: 4 out of 5 patients, Rt: 4 out of 5 patients). There was no clear relationship between variables associated with tumor size, such as T-factor, stage, and CTV, and respiratory motion of the tumor.

Discussion

Until recently, surgery was the first-line treatment for early stage non-small cell lung cancer (NSCLC) and SBRT was recommended for medically inoperable patients [6–9]. Lagerwaard et al.'s data indicate that SBRT should be considered the treatment of choice for patients with stage I NSCLC who are at high risk of surgical toxicity [6]. Viani et al. reported the results of a recent meta-analysis that included 29,511 patients in a trial that compared the effectiveness of SBRT versus surgery for early-stage NSCLC. They concluded that surgery generally resulted in better 3-year overall survival and cause-specific survival than SBRT; however, publication bias and heterogeneity may have influenced these results. In contrast, SBRT produced local control similar to that of surgery [14]. Whether SBRT is an appropriate treatment option for patients who are candidates for surgery remains controversial [7]. However, recent advances in SBRT technology have been remarkable, and SBRT is increasingly considered to be a well-tolerated outpatient procedure with local tumor control rates reported to exceed 90%, making it an attractive alternative to invasive surgery and a viable alternative [15]. Tandberg et al. reported a comprehensive review of surgery versus SBRT for stage I NSCLC [8]. Chi also reported that there may be situations where SBRT is a reasonable alternative to surgery [7].

The most important factor for correctly performing SBRT in early-stage NSCLC is the minimization of respiratory tumor motion. Therefore, efforts are needed to reduce respiratory tumor motion (internal margins). American Association of Physicists in Medicine (AAPM) Task Group 76 reported on the management of respiratory motion in radiation oncology. The methods developed to reduce the effects of respiratory tumor motion in radiotherapy can be broadly grouped into five main categories, as mentioned in the Introduction: Nagata et al. reported that the methods dealing with the patient's respiratory tumor motion can be broadly divided into the breath- holding, restricted breathing (abdominal compression), and respiratory gating techniques [16]. Each method has its strengths and weaknesses, and each should be fully understood before being adopted in clinical practice.

Methods using fluoroscopy, CT, and magnetic resonance imaging (MRI) have been developed to evaluate the respiratory motion in lung tumors, and many reports have been published on the evaluation of tumor motion using each of these methods [6, 17–26].

In our study, we did not use a direct evaluation method, such as measuring the motion distance in three axial directions using images, but we considered the difference in volume between the ITV and CTV as an indirect indicator to evaluate the respiratory motion of peripheral lung tumors. Naturally, the difference will be larger in large tumors than in small ones ($y = 1.5041x + 2.2348$, $R^2 = 0.8303$, $p = 1.96173E\text{-}15$). Therefore, we hypothesized that the value obtained by dividing (ITV − CTV) by CTV ((ITV-CTV)/CTV) would be an objective index for evaluating respiratory motion in peripheral lung tumors of different sizes, regardless of whether the CTV was large or small, and we compared the magnitude of respiratory motion using (ITV − CTV)/CTV.

In the univariate analysis, only age was correlated with respiratory tumor motion, and the respiratory motion of peripheral lung tumors was significantly greater in the elderly than in the younger adults (p = 0.049). However, in the multivariate analysis, although the T-factor was the only factor that was significantly correlated with peripheral lung tumor respiratory motion (p = 0.045), significant trend correlations were observed between age and respiratory motion of the tumor (p = 0.061), and between tumor location (lobe) and respiratory tumor motion (p = 0.067).

Lung tumor motion is primarily driven by diaphragmatic motion [19, 27]. Therefore, many studies have already reported that unfixed tumors located in the lower lobe [19] or in the lower half of the lung [28, 29] show the greatest amount of motion, usually along the SI axis [13, 19,20]. Ross reported that tumors in the upper lobes showed minimal motion [24].

Lung tumors show remarkable mobility in all directions, but this does not correlate closely with the anatomical location [22, 23, 28, 29].

As females tend to perform thoracic breathing and males abdominal breathing, the association of sex with the type of breathing affects the respiratory motion of the tumor. In this study, although the mean respiratory motion of the tumor was greater in females than in males, there was no statistically significant difference between the sexes (p = 0.115).

Abdominal compression was used to suppress the respiratory motion of the lung tumor; however, the degree of abdominal compression is thought to depend on the patient's body type, such as BMI. It is thought that obese patients are more likely to be able to suppress respiratory motion. However, abdominal compression suppresses respiratory motion more during inspiration more in obese patients than in lean patients. However, because respiratory motion during expiration tends to be greater in lean patients, the difference due to BMI was unclear in this study.

Qi et al. showed that abdominal compression did not reduce the motion of peripheral lung tumors, and GTV motion was not significantly reduced in any of the three measured directions or in the 3D vector, regardless of the location of the tumor in the lung [30].

In this study, there was no clear relationship between pulmonary function tests such as FEV 1.0 or the type of ventilatory impairment. Several reports have already shown that the respiratory motion of lung tumors is not associated with pulmonary function test results [22, 28, 31]. Considering these reports and our results, it cannot be said that the respiratory motion of lung tumors is greater in patients with poor respiratory function. In contrast, Herman et al. reported that tumor motion was minimal in medically inoperable patients, mainly because of severe COPD [32].

Univariate analysis showed a significantly greater respiratory motion of the tumor in the elderly, and multivariate analysis also showed a significant trend. However, the pulmonary function tests results in the elderly were not necessarily impaired, and the cause could not be determined. It is possible that the elderly patients were not properly instructed to take repeated shallow breaths in the treatment room due to poor comprehension or hearing loss.

Conclusions

Various patient and tumor characteristics were evaluated to clarify the predictor of respiratory motion in early-stage peripheral lung tumors using (ITC-CTV)/CTV in the management of the restricted breathing technique (abdominal compression) to reduce tumor motion during breathing in SBRT. The results showed that although the respiratory motion in early-stage peripheral lung cancer was significantly correlated with the T-factor and patient age, it could not be predicted by the patient and tumor characteristics evaluated in the current study. Therefore, tumor respiratory motion should be assessed in all patients treated with SBRT. (ITC-CTV)/CTV may be an effective indicator of tumor respiratory motion.

Conflict of interests

The authors declare no conflict of interests.

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Table 1. Demographic characteristics

Variable	**No. of Pts. (%)**
Average age ± SD (Yrs.)	
Total	81.5 ± 5.3 (median:82)
Male	80.0 ± 5.5 (median:81)
Female	83.8 ± 4.4 (median:85)
Sex	
Male	23 (61%)
Female	15 (39%)

BMI	
Underweight	6 (16%)
Normal weight	24 (63%)
Obesity	8 (21%)
BI	
0	14 (37%)
1 ~ 399	2 (5%)
400 ~ 599	4 (10%)
600 ~1199	9 (24%)
1200 ~	9 (24%)
FEV1.0 (L)	
~ 1	7 (18%)
1 ~ 1.5	13 (34%)
1.5 ~ 2	8 (21%)
2 ~ 2.5	4 (11%)
2.5 ~	6 (16%)
Ventilatory impairment	
Normal	17 (45%).

Restrictive type	3 (8%).
Obstructive type	12 (31%)
Mixed type	6 (16%)

SD — standard deviation; BMI — body mass index; BI — Brinkman Index; FEV 1.0 — forced expiratory volume in 1 second

Table 2. Tumor characteristics

Variable	**No. of Pts. (%)**
Tumor location.	
Left lobe	
Upper	8 (21%)
Lower	5 (13%)
Right lobe	
Upper	11 (29%)
Middle	3 (8%)
Lower	11 (29%)
T factor	
Tis	2 (5%)
Tmin	3 (9%)

T1a	2 (5%)
T1b	13 (34%)
T1c	10 (26%)
T2a	7 (18%)
.T2b	1 (3%)
Stage	
0	2 (5%)
IA1	5 (13%)
IA2	13 (34%)
IA3	10 (26%)
IB	7 (18%)
IIA	1 (3%)
Pathology	
Adenocarcinoma	8 (21%)
Squamous cell carcinoma	3 (9%)
Non-small cell carcinoma	2 (5%)
None	25 (65%)

Table 3. Factors' values assigned in the stepwise multiple linear regression model

Variable	**Value**
Age	Primary value
Sex	Male = 0 Female = 1
BI	Primary value
BMI	Primary value
FEV1.0 [L]	Primary value
Ventilatory impairment	Normal = 0, Restrictive = 1, Obstructive = 2, Mixed = 3
Tumor location (Lobe)	LUL = 0, LLL = 1, RUL = 2, RML = 3, RLL = 4
T factor	Tis □ 0, Tmin = 1, T1a = 2, T1b □ 3, T1c = 4, T2a = 5, T2b = 6

BI — Brinkman Index; BMI — body mass index; FEV 1.0 — forced expiratory volume in 1 second

Table 4. Results of multivariate regression analysis of various factors affecting respiratory tumor motion

Regression statistics

Multiple R	0.591686
R Square	0.350093
Adjusted R Square	0.170808
SE	0.660129
Observations	38

	df	***SS***	**MS**	**F**	**Significance F**
Regression	8	6.807489	0.850936	1.952717445	0.089656976
Residual	29	12.637337	0.435770		
Total	37	19.444826			

	Coefficients	**SE**	**t Sat.**	**p-value**	**Lower 95%**	**Upper 95%**
Intercept	–1.122	2.292.	–0.489	0.628	–5.810	3.567
Age.	0.049	.0.025	1.951	0.061	-0.002	0.100.
Gender	–0.193	.0.428.	–0.451	0.655	–1.069	0.683

BI	–0.000	0.000	–0.675	0.505	0.001	0.000.
BMI	0.019	0.033	0.567	0.575	–0.049	0.087
FEV1.0 [L]	–0.305	0.295	–1.034	0.310	–0.908	0.298
Ventilatory impairment	–0.134	0.171	–0.781	0.441	–0.484	0.217
Tumor location (lobe)	–0.144	0.075	–1.909	0.067	–0.298	0.010
T factor	–0.188	0.090	–2.098	0.045	–0.371	–0.005

SE — standard error; BI — Brinkman Index; BMI — body mass index; FEV 1.0 — forced expiratory volume in 1 second

Table 5. Characteristics of top 10 patients with the highest (ITV-CTV)/CTV among the patients enrolled in this study

Age	**Sex**	**BMI**	**T factor**	**Stage**	**Tumor location**	**1sec rate**

(L)	**BI**	**Ventilation**						
88	F	23.1	2a	IB	lt-S3	0.98	1100	Normal
86	F	20.3	1c	IA3	rt-S1	0.79	0	Normal
81	F	25.3	1a	IA1	lt-S5	1.06	600	Normal
84	M	22.1	1b	IA2	lt-S1/2	2.26	1280	
Obstructive								
89	M	27.5	1c	IA3	lt-S1/2	2.75	150	Normal
82	M	24.5	1b	IA2	lt-S8	0.81	600	Mix
85	F	21.8	1min	IA1	rt-S2	1.43	0	Normal
89	F	27.6	1b	IA2	rt-S1	1.08	1000	
Obstructive								
83	M	23.3	1b	IA2	rt-S2	2.03	150	Normal
84	F	30.1	1b	IA2	rt-S10	1.35	0	Normal

CTV	**ITV**	**ITV-CTV**	**(ITV-CTV)/CTV**	**Histology**
3.94	11.88	7.94	2.02	Adenocarcinoma
3.17	11.16	7.99	2.52	Adenocarcinoma
1.42	5.29	3.87	2.73	–
1.21	4.62	3.41	2.82	–

6.91	20.95	14.04	2.03	–
5.92	17.13	11.21	1.89	–
1.96	5.03	3.07	1.57	–
1.64	4.22	2.58	1.57	–
1.12	3.30	2.18	1.95	–
2.06	5.88	3.52	1.71	-

Complications

Concurrent double cancer (cervical cancer), late elderly

No surgical endurance, low respiratory function, late elderly

Past history of malignant lymphoma, late elderly

COPD, late elderly

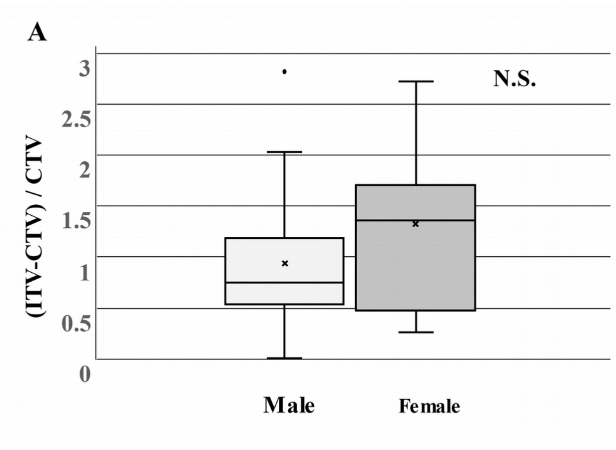
Cerebral infarction, late elderly

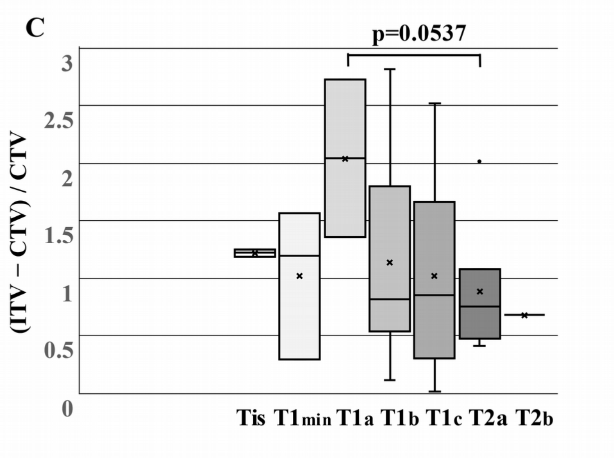
No surgical endurance, low respiratory function, hearing impairment, late elderly

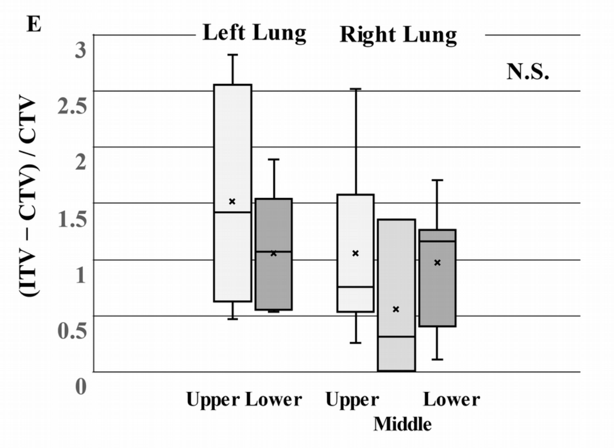
Late elderly
COPD, Late elderly
Renal dysfunction, late elderly
No surgical endurance, arial fibrillation, pulmonary hypertension, late elderly

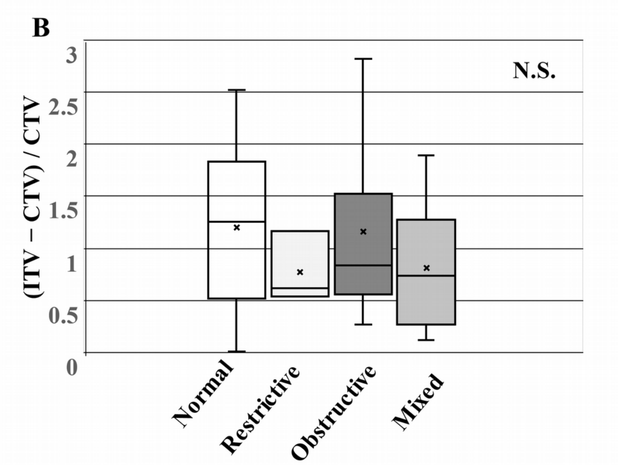
BMI — body mass index; BI — Brinkman Index; CTV — clinical target volume; ITV — internal target volume; COPD — chronic obstructive pulmonary disease

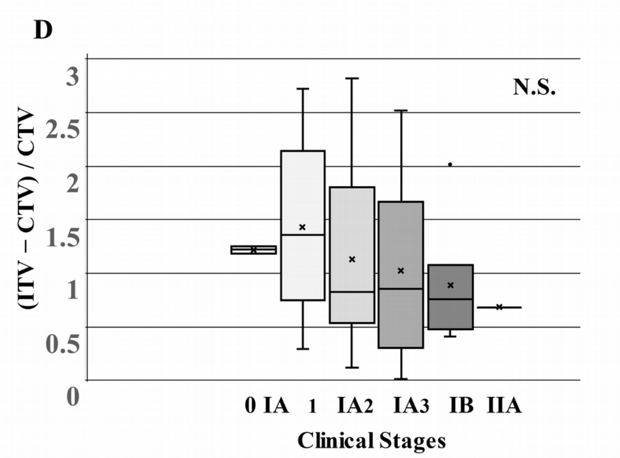
Figure 1. Box and whisker plots of the distribution of respiratory tumor motion assessed as (ITV-CTV)/CTV between different categories of values. CTV — clinical target volume; ITV — internal target volume. **A.** Sex; **B.** Types of ventilatory impairment; **C.** T-stages; **D.** Clinical stages; **E.** Tumor-bearing lung lobes; **F.** Histopathological types of tumors




C
p=0.0537
(ITV – CTV) / CTV
3
2.5
2
1.5
1
0.5
0
Tis T1min T1a T1b T1c T2a T2b


E
Left Lung
Right Lung
N.S.
(ITV – CTV) / CTV
3
2.5
2
1.5
1
0.5
0
Upper Lower Upper Lower
Middle


B
N.S.
(ITV – CTV) / CTV
0
0.5
1
1.5
2
2.5
3
Normal
Restrictive
Obstructive
Mixed


D
N.S.
(ITV – CTV) / CTV
0
0.5
1
1.5
2
2.5
3
0 IA 1 IA2 IA3 IB IIA
Clinical Stages

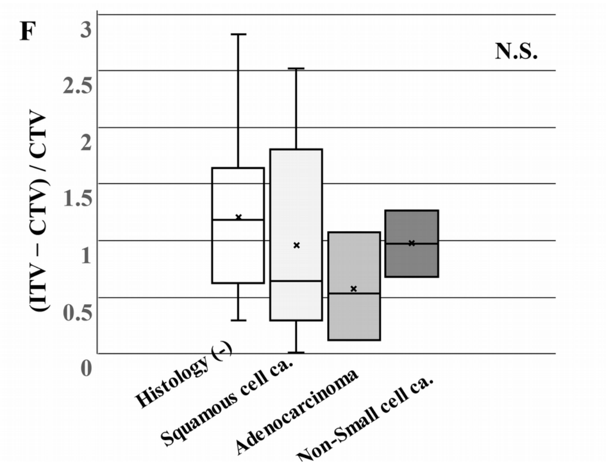
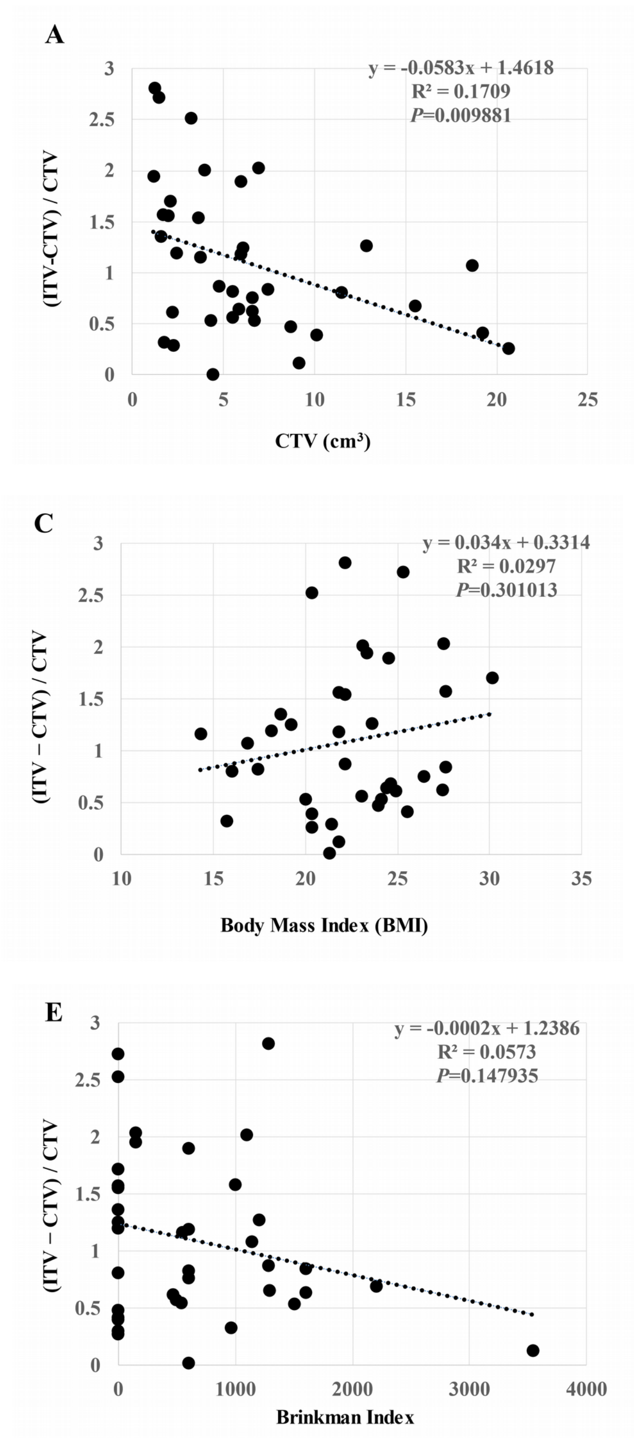
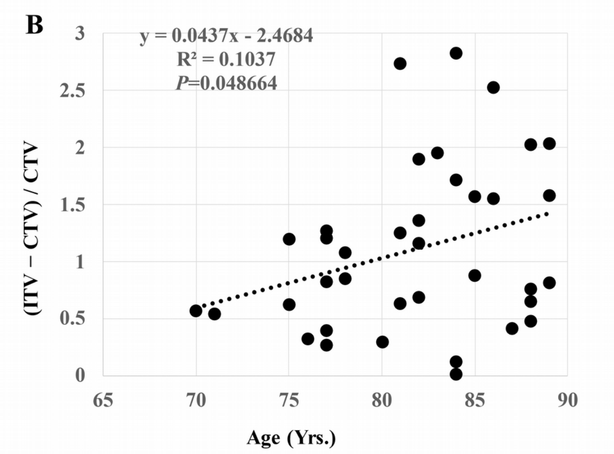

F
N.S.
(ITV – CTV) / CTV
0
0.5
1
1.5
2
2.5
3
Histology (-)
Squamous cell ca.
Adenocarcinoma
Non-Small cell ca.

Figure 2. Scatter plots of continuous distribution of respiratory tumor motion assessed as (ITV-CTV)/CTV and various categorized values. CTV — clinical target volume; ITV — internal target volume. **A.** CTV; **B.** Age; **C.** Body mass index (BMI); **D.** Forced expiratory volume in 1 second FEV1.0 (1 s volume); **E.** Brinkmann Index (BI)

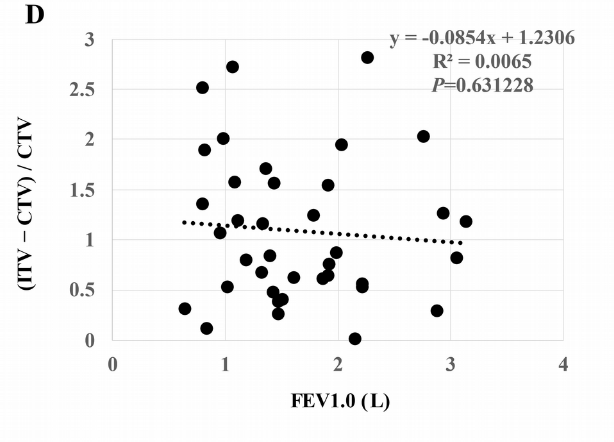


B



y = 0.0437x - 2.4684
R² = 0.1037
P=0.048664
3
2.5
2
1.5
1
0.5
0
65
70
75
80
85
90
(ITV – CTV) / CTV
Age (Yrs.)

D



y = -0.0854x + 1.2306
R² = 0.0065
P=0.631228
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
(ITV – CTV) / CTV
FEV1.0 (L)