Three-dimensional computed tomographic volumetry precisely predicts the postoperative pulmonary function

Surgical resection remains the principal treatment for early stage lung cancer, although new chemotherapeutic agents and molecular-targeted drugs have been developed. In order to conduct pulmonary resection safely, it is necessary to ensure that the patient's postoperative pulmonary function remains above acceptable levels. The prediction of the residual pulmonary function after lung resection has conventionally been performed using the segment-counting method. However, the segment-counting method is based solely on the number of remaining pulmonary segments, and differences between the volumes of each segment are ignored. These issues are expected to interfere with the prediction of the postoperative residual pulmonary function. The purpose of the present study was to compare the accuracy of the postoperative residual pulmonary function predicted using three-dimensional computed tomographic (3D-CT) volumetry with that predicted using the conventional segment-counting method in lung cancer patients, especially those with a poor pulmonary function.

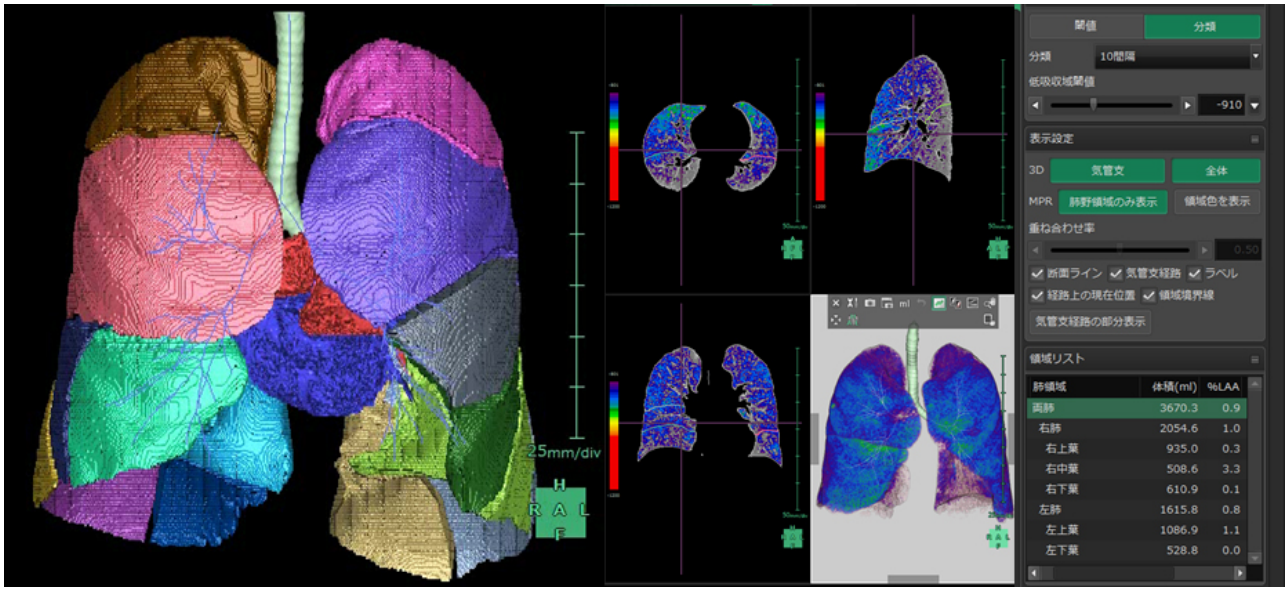

Fig. 1. The bronchial territories were extracted from three-dimensional lung models by specifying the target segment or lobe, and the volume of each territory was calculated concurrently. The volumes of the respiratory tract, blood vessels, tumors, and other parenchymal structures, such as tissue affected by atelectasis or organizing lesions, were calculated semi-automatically or selectively. The proportion of the lungs occupied by low-attenuation areas was calculated by highlighting the areas with attenuation values of less than –910 HU. The total lung volume, except for the volume of the lung tissue that does not participate in breathing, was described as the functional lung volume (FLV).

All patients scheduled to undergo lung cancer resection, pulmonary function tests, and CT were enrolled in this study. The postoperative residual pulmonary function was predicted based on the segment-counting and the 3D-CT volumetry methods (Fig. 1). The postoperative residual pulmonary function was predicted using the formula as described below.

Predicted postoperative pulmonary function = (1 – A / 19) × preoperative measured pulmonary function.

In the segment-counting method, A represents the total number of unobstructed segments in the resection lobe and 19 is the total number of segments in the whole lung. In the 3D-CT volumetry method, A represents the functional lung volume (FLV) of the resection portion of the lung, and the total number of segments is replaced by the total volume of the FLV of the whole lung.

The predicted postoperative values were compared with the results of postoperative pulmonary function tests after 6 months.

The total number of patients in this study was 53. There were 30 non-COPD patients (56.6%) and 23 COPD patients (43.4%). We initially examined whether or not there were marked variation in the proportional volume of each segment. The volume of each segment was calculated using the 3D-CT volumetry method. As a result, the proportional volume measurements obtained with the 3D-CT volumetry method differed significantly between each segment (Fig. 2). The relationships between the measured and estimated numerical variables were determined using the correlation coefficient. All of the linear correlation coefficients obtained with the 3D-CT volumetry method tended to be higher than those acquired with the segment-counting method. And the variations between the predicted and actual measured values were smaller with the 3D-CT volumetry method than with segment-counting method. Similarly, the differences and variations between the predictions obtained with two prediction methods were analyzed separately in the COPD and non-COPD groups. The differences and variations between the actual measured and predicted values obtained with the 3D-CT volumetry method tended to be smaller than those acquired with the segment-counting method in both the COPD group and non-COPD group. The differences and variations between the actual measured and predicted values obtained with two prediction methods tended to be larger in the COPD group than in the non-COPD group.

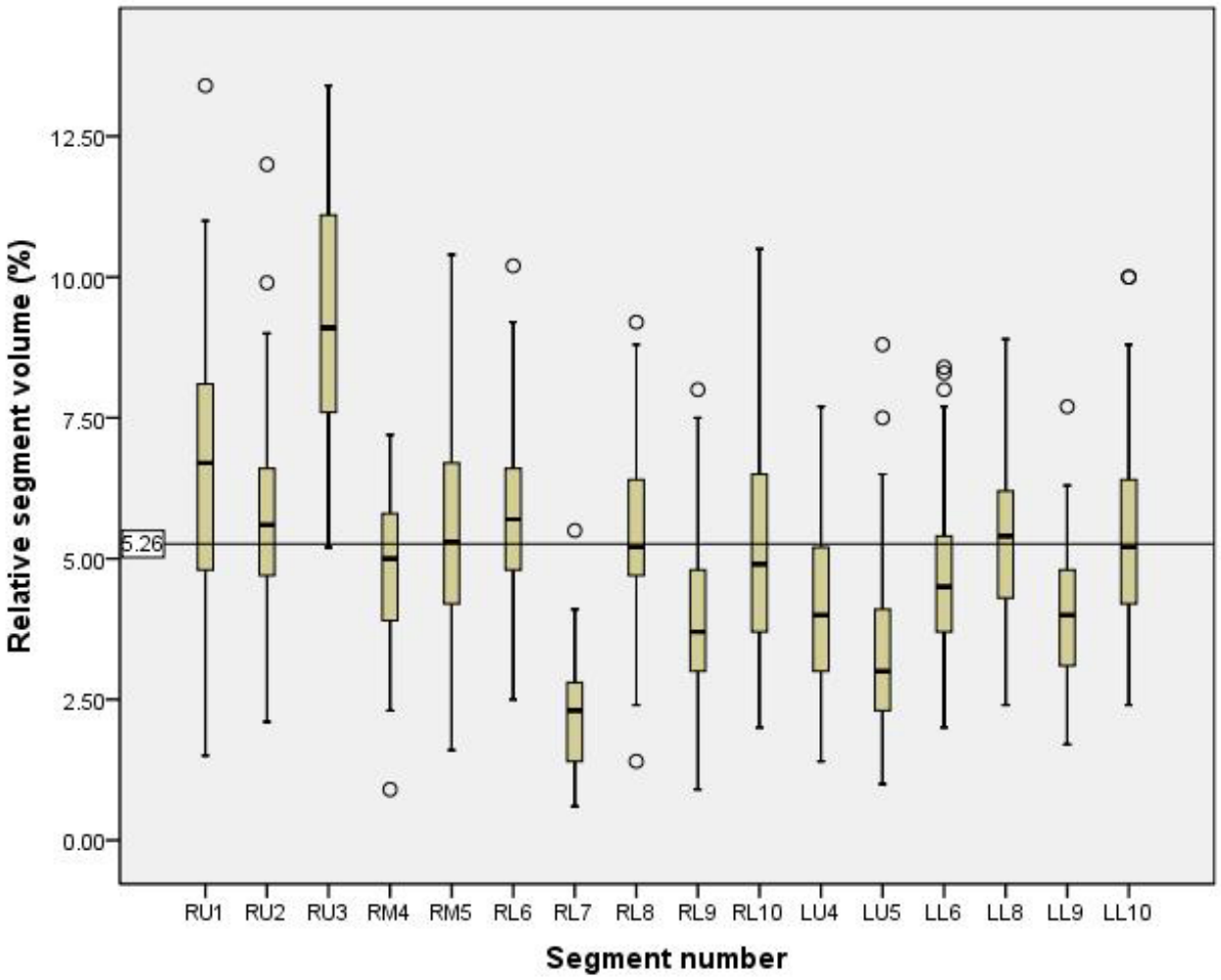

Fig. 2. The proportional volume of each segment is shown as a box and whisker plot. The central line indicates 1/19 ×100 = 5.26%, which is the volume ratio of 1 segment according to the segment-counting method. Significant differences were determined using the Kruskal–Wallis test.

From our study, the segment volume can vary between segments and individuals; therefore, predictions of the residual pulmonary function obtained with the segment-counting method may be inaccurate. And the 3D-CT-volumetry method is able to predict the residual pulmonary function more accurately than the segment-counting method, as the actual volume loss can be calculated, which may facilitate the selection of appropriate candidates for lung cancer surgery and reduce the risk of surgical complications, especially in patients with a relatively poor pulmonary function, such as those with COPD.

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