Comparative Analysis of Predictive Capability of Dynamic Perfusion MRI, Quantitatively and Qualitatively Assessed CT, and Perfusion SPECT for Postoperative Lung Function in Lung Cancer Patients

Y. Ohno[1], H. Koyama[1], M. Nogami[1], D. Takenaka[1], N. Aoyama[2], H. Kawamitsu[2], T. Yoshikawa[1], and K. Sugimura[1]

[1]Radiology, Kobe University Graduate School of Medicine, Kobe, Hyogo, Japan, [2]Radiology, Kobe University Hospital, Kobe, Hyogo, Japan

Introduction: Despite advances in radiation therapy and chemotherapy, surgical resection remains the treatment of choice for resectable non-small cell lung cancer. In current medical practice, perfusion scan and/ or SPECT combined with spirometry are the most widely utilized radiological examination for evaluation of patients whose pulmonary function, on the basis of spirometry findings alone, may not be sufficient to tolerate resection (1). However, poor spatial resolution, especially problematic for differentiating lobes and segments, remains a major limitation of this method. As another alternative approach for evaluating surgical risk in lung cancer patients, quantitative or qualitative evaluation by CT based on lung attenuation or anatomy has been proposed (1, 2).

More recently, it has been found that 3D dynamic contrast-enhanced perfusion MR imaging (perfusion MRI) is useful for evaluation of regional pulmonary perfusion and prediction of outcome for lung cancer patients (3, 4). However, the number of patents in these studies was limited, and predictive capability of perfusion MRI for postoperative lung function was not compared with that of quantitatively and qualitatively assessed CT. For the study presented here, we therefore planned a large prospective cohort for direct comparison of this capability of dynamic perfusion MRI, quantitatively assessed CT, qualitatively assessed CT, and perfusion SPECT. The purpose of our study was to determine prospectively the efficacy of dynamic contrast-enhanced perfusion MRI for prediction of postoperative lung function in patients with lung cancer in comparison with the other three modalities.

Materials and Methods: 150 lung cancer patients (87 men and 63 women) underwent dynamic perfusion MRI, multi-slice CT, perfusion SPECT, and FEV_1% measurements before and after lung resection. Dynamic perfusion MRIs were acquired with a 3D spoiled gradient echo sequence using a 1.5T scanner. Postoperative FEV_1% ($poFEV_1$%) was predicted from dynamic perfusion MRI ($poFEV_1\%_{Perfusion\ MRI}$) of semi-quantitatively assessed blood volumes within total and resected lungs. Quantitatively assessed CT was used to predict $poFEV_1$% from the functional lung volumes by means of commercially available software ($poFEV_1\%_{Quantitative\ CT}$). Qualitatively assessed CT was used to predict $poFEV_1$% from the number of segments of total and resected lungs ($poFEV_1\%_{Qualitative\ CT}$), and perfusion SPECT to predict poFEV1% from uptakes within total and resected lungs ($poFEV_1\%_{Perfusion\ SPECT}$). Correlation and the limits of agreement between each actual and predicted $poFEV_1$% were statistically evaluated.

Results: Representative case is shown in Figure 1. Actual $poFEV_1$% showed stronger correlation with $poFEV_1\%_{PerfusionMRI}$ ($r=0.87$, $p<0.0001$) and $poFEV_1\%_{Quantitative\ CT}$ ($r=0.88$, $p<0.0001$) than with $poFEV_1\%_{Qualitative\ CT}$ ($r=0.83$, $p<0.0001$) or $poFEV_1\%_{Perfusion\ SPECT}$ ($r=0.83$, $p<0.0001$). The mean difference and the limits of agreement of each method is shown in Figure 2. The limits of agreement of $poFEV_1\%_{PerfusionMRI}$ (5.3±11.8 %) were smaller than those of $poFEV_1\%_{Qualitative\ CT}$ (6.8±14.4 %) or $poFEV_1\%_{Perfusion\ SPECT}$ (5.1±14.0 %), and almost equal to those of $poFEV_1\%_{Quantitative\ CT}$ (5.0±11.6 %).

Conclusion: Dynamic perfusion MRI can predict postoperative lung function more accurately than qualitative CT or perfusion SPECT, and is at least as important as quantitative CT for lung cancer patients.

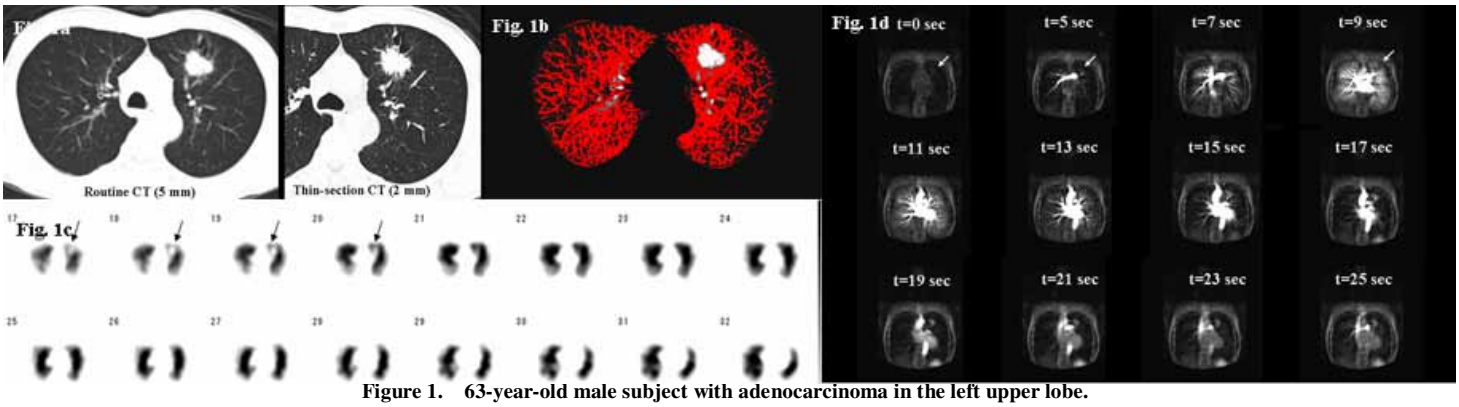

Figure 1. 63-year-old male subject with adenocarcinoma in the left upper lobe.

a: Routine transverse CT and thin-section CT show low attenuation areas in both lungs; the tumor mass can be seen. b: On quantitative CT, functional lung is shown in red, pulmonary emphysema in gray, and lung cancer in white. c: Perfusion SPECT demonstrates heterogeneous uptake but not by the lung cancer (black arrow). d: Dynamic perfusion MRI shows heterogeneous but well enhanced pulmonary parenchyma in both lungs not including lung cancer (arrow) during 5sec and 13 sec. Lung cancer is also enhanced after 13 sec.

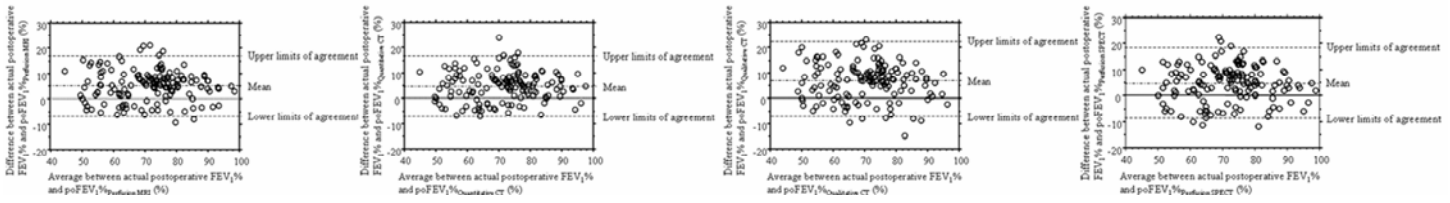

Figure 2. The mean of difference and the limits of agreement between actual postoperative FEV_1% and each version of $poFEV_1$%.

a: For $poFEV_1\%_{Perfusion\ MRI}$, the limits of agreement were 5.3±11.8 % and small enough for clinical purposes. b: For $poFEV_1\%_{Quantitative\ CT}$, the limits of agreement were 5.0±11.6 %, and almost equal to those for $poFEV_1\%_{Perfusion\ MRI}$. c: For $poFEV_1\%_{Qualitative\ CT}$, the limits of agreement were 6.8±14.4 % and larger than those for $poFEV_1\%_{Perfusion\ MRI}$ and $poFEV_1\%_{Quantitative\ CT}$. d: For $poFEV_1\%_{Perfusion\ SPECT}$, the limits of agreement were 5.1±14.0 % and larger than those for $poFEV_1\%_{Perfusion\ MRI}$ and $poFEV_1\%_{Quantitative\ CT}$.

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