Comparative Analysis of Predictive Capability for Postoperative Lung Function among Dynamic Contrast-Enhanced MRI, CT and Nuclear Medicine study in Non-Small Cell Lung Cancer Patients

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Introduction: Despite advances in radiation therapy and chemotherapy, surgery is currently considered the best curative option for stage I lung cancer or Stage II or IIIA non-small cell lung cancer (NSCLC). Currently, a few guidelines and/ or algorithms recommended for prediction of postoperative lung function may be used to estimate the amount of functional lung tissue that would be lost with surgical resection in NSCLC patients. In these patients, radiological examinations including ventilation or perfusion scans, quantitatively assessed CT based on density-masked CT technique or qualitatively assessed CT based on anatomic estimation are considered to be useful for prediction of postoperative lung function (1, 2). As well as traditional or newly proposed nuclear medicine and CT methods, dynamic contrast-enhanced MR perfusion imaging (perfusion MRI) has also been put forward as useful for the prediction of postoperative lung function in NSCLC patients (3). However, no direct comparison of predictive capability among dynamic perfusion MRI, quantitative and qualitative CT, and nuclear medicine studies including perfusion scan, SPECT and fused SPECT with CT (co-registered SPECT/CT) has been performed as yet.

For the study presented here, we hypothesized that dynamic perfusion MRI could predict postoperative lung function in NSCLC patients as accurately as quantitative CT and/or co-registered SPECT/CT, and had better potential for this purpose than qualitative CT, perfusion scan and perfusion SPECT. The purpose of this study was to directly and prospectively compare predictive capabilities for postoperative lung function in NSCLC patients of the state-of-the-art radiological methods including perfusion MRI, quantitatively assessed CT and SPECT/CT with that of anatomical method (i.e. qualitatively assessed CT) and traditional nuclear medicine methods such as planar imaging and SPECT.

Materials and Methods: 229 consecutive pathologically diagnosed lung cancer patients considered candidates for lung resection (125 men, 104 women, aged 53 to 82 years; mean age, 71 years) prospectively underwent preoperative contrast-enhanced MDCT, dynamic perfusion MRI and perfusion scan with SPECT examination (Fig. 1), and had their pre-and postoperative forced expiratory volume per 1 sec (predicted percentage, %FEV_1) measured. Dynamic perfusion MRIs were acquired with a 3D spoiled gradient echo sequence using a 1.5T scanner. Postoperative FEV_1% (po%)FEV_1 was predicted from dynamic perfusion MRI (po%$FEV_{1\text{Perfusion MRI}}$) 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 (po%$FEV_{1\text{Quantitative CT}}$). Qualitatively assessed CT was used to predict poFEV_1% from the number of segments of total and resected lungs (po%$FEV_{1\text{Qualitative CT}}$), and perfusion scan (po%$FEV_{1\text{Planar imaging}}$), SPECT (po%$FEV_{1\text{Perfusion SPECT}}$) and co-registered SPECT/CT (po%$FEV_{1\text{Perfusion co-registered SPECT/CT}}$) to predict po%FEV1 from uptakes within total and resected lungs. Correlation and the limits of agreement between each actual and predicted poFEV_1% were statistically evaluated.

Results: All versions of po%FEV_1 showed significantly good correlation with their corresponding actual po%FEV_1 ($p<0.0001$). po%$FEV_{1\text{Perfusion MRI}}$ ($r=0.88$, $r^2=0.77$), po%$FEV_{1\text{Quantitative CT}}$ ($r=0.88$, $r^2=0.77$) and po%$FEV_{1\text{Co-registered SPECT/CT}}$ ($r=0.88$, $r^2=0.77$) showed better correlation with actual po%FEV_1 than did po%$FEV_{1\text{Qualitative CT}}$ ($r=0.85$, $r^2=0.72$), po%$FEV_{1\text{ Planar imaging}}$ ($r=0.83$, $r^2=0.69$) and po%$FEV_{1\text{ SPECT}}$ ($r=0.85$, $r^2=0.72$). The limits of agreement between actual po%FEV_1 and predicted po%FEV_1 are shown in Table 1. The limits of agreement for po%$FEV_{1\text{Perfusion MRI}}$ were smaller than those for po%$FEV1_{\text{Qualitative CT}}$, po%$FEV_{1\text{Planar imaging}}$ and po%$FEV_{1\text{SPECT}}$, and were almost equal to those for po%$FEV1_{\text{Qualitative CT}}$ and po%$FEV_{1\text{Co-registered SPECT/CT}}$.

Conclusion: State-of-the-art radiological methods comprising dynamic perfusion MRI, qualitatively assessed thin-section MDCT and perfusion SPECT/CT, can predict postoperative lung function more accurately than traditional methods according to anatomically based predictions and perfusion scans or SPECT in NSCLC patients. Dynamic perfusion MRI as well as qualitatively assessed CT and perfusion SPECT/CT may thus be able to play a complementary role in the prediction of postoperative lung function in routine clinical practice.

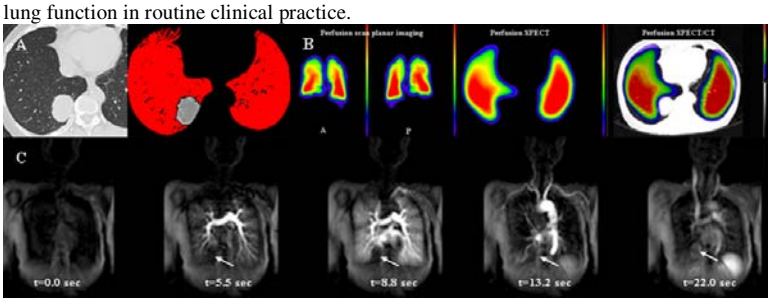

Figure 1. 72-year-old female patient with squamous cell carcinoma in the right lwer lobe.

A: Thin-section CT shows a mass in the right lower lobe, but no significant findings of emphysema in the right middle lobe. On quantitative CT, functional lung is shown in red, pulmonary emphysema in black, and lung cancer in white. There is slight emphysema in the right middle lobe and lingual segment. B: Perfusion scan shows reduced uptake of radioisotopes in the right lower lung field. Perfusion SPECT shows deficiency of radioisotopes due to lung cancer. On co-registered SPECT/CT, the SPECT image is well fused with CT, and simultaneously provides clear anatomical and functional information. Radioisotope deficiency due to lung cancer is also clearly shown. In addition, the reduced uptakes in the middle lobe and lingual segment are thought to be due to emphysema, which could not be visually assessed on the CT image. C: Dynamic perfusion MR images demonstrate heterogeneously enhanced lung parenchyma due to emphysema and a non-enhanced area due to lung cancer in the right lower lung field (arrow) for 5.5 sec and 8.8 sec. Enhancement of the lung cancer became gradually stronger during 13.2 sec and 22.0 sec.

Table 1. Mean difference and the limits of agreement of each method between actual and predicted postoperative lung functions.

	Mean difference (Mean ± Standard error)	Limits of agreement (%) (Mean ± 2Standard deviation)
Quantitative CT	4.7±0.4	4.7±14.2
Qualitative CT	6.0±0.5	6.0±17.4
Planar imaging	5.8±0.5	5.8±18.2
SPECT	5.5±0.5	5.5±16.8
Co-registered SPECT/CT	5.1±0.5	5.1±14.7
Dynamic perfusion MRI	4.4±0.5	4.4±14.2

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