# Assessment of oxygen transfer in patients with bronchial carcinoma for improvement of radiation therapy planning

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**Introduction:** Information about tumor oxygenation and lung function could be used for more efficient radiation therapy of human bronchial carcinoma. Currently, CT and PET are the only routinely used options for anatomical or functional assessment of the human lung as regards to radiation planning. Therefore, lung tumor treatment is mainly guided by theses two techniques, despite the fact that neither can assess the tumor oxygenation or the pulmonary function of the tumor surrounding lung parenchyma. One step towards improved radiation planning, therefore, could be the regional assessment of the oxygen transfer function (OTF), which is the calculated slope of the function $1/T_1 = 1/T_1(0) + OTF \cdot C_{gas}$, where $C_{gas}$ is the oxygen concentration of the inhaled gas and $T_1(0)$ is the intrinsic $T_1$ in the complete absence of oxygen [1].

**Subjects and Methods:** Four patients with non-small-cell-lung-cancer (NSCLC) were examined on a 1.5 T whole-body scanner (Vision, Siemens, Erlangen, Germany) with a peak gradient amplitude of 25 mT/m and slew rate of 83 T/m/s. For signal reception a four-element body phased array coil was used. $T_1$- parameter-maps of three different slices containing the lung and the tumor were acquired using a technique based on IR Snapshot FLASH [2]. Imaging parameters were as follows: TE = 1.4 ms, TR = 3.5 ms, FA = 7°, FOV = 400 $mm^2$, ST = 15 mm and an image matrix of 90 x 128. $T_1$-maps were acquired during a single breath-hold, first while breathing room air, and again after switching to carbogen (95% oxygen, 5 % carbon dioxide) after a waiting period of five minutes to avoid inflow effects [3]. Four ROIs were drawn, in the tumor, atelectasis, aorta, and healthy lung tissue, and the OTF for each was calculated.

**Results:** As a typical example, a $T_1$-map obtained while breathing room air (a) and the corresponding map while breathing carbogen (b) of one slice of patient 1 is depicted in Figure 1. The OTF of the four ROIs drawn in these slices are shown in Figure 1(c). The mean OTF values of all three slices and the mean $T_1$ values measured during breathing in room air of each patient are summarized in Table 1.

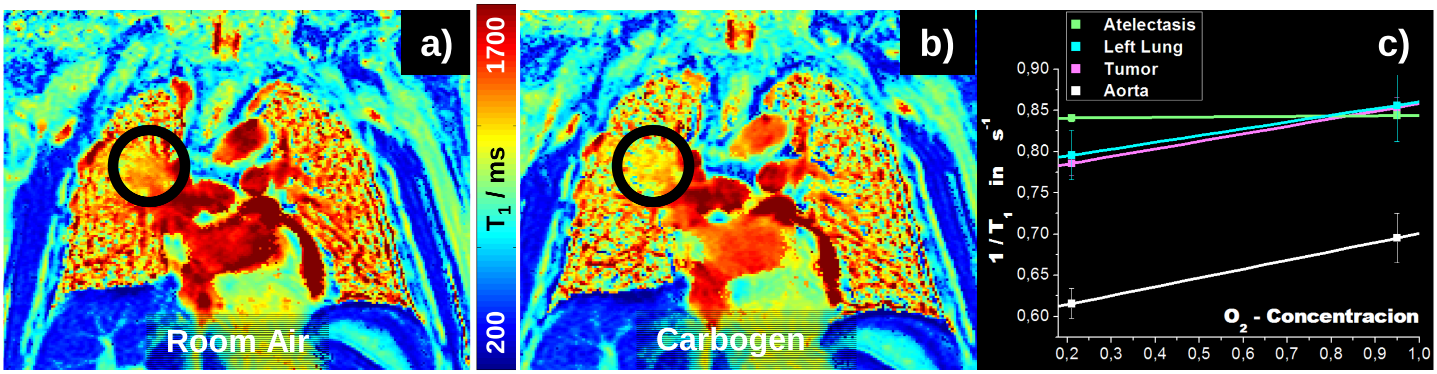


**Figure 1.** *$T_1$-maps of a coronal slice of patient 1 while breathing room air (a) and carbogen (b). The $T_1$ shortening by virtue of increased oxygenation in the tumor mass (black circles) can be seen and is quantitatively calculated and depicted as slope (OTF) in (c).*

| NSCLC-Pat. | $T_1$ Lung / ms | $T_1$ Tumor / ms | $T_1$ Atelec. / ms | OTF Lung / $s^{-1}$ | OTF Tumor / $s^{-1}$ | OTF Atelec. / $s^{-1}$ | OTF Aorta / $s^{-1}$ |
|---|---|---|---|---|---|---|---|
| 1 | 1257 ± 47 | 1272 ± 23 | 1189 ± 6 | 0.082 ± 0.019 | 0.083 ± 0.013 | 0.004 ± 0.001 | 0.113 ± 0.005 |
| 2 | 1173 ± 51 | 1183 ± 30 | 1171 ± 49 | 0.118 ± 0.040 | 0.058 ± 0.034 | 0.043 ± 0.025 | 0.107 ± 0.060 |
| 3 | 1256 ± 45 | 1394 ± 10 | 888 ± 2 | 0.136 ± 0.019 | 0.026 ± 0.007 | 0.012 ± 0.003 | 0.142 ± 0.013 |
| 4 | 1194 ± 7 | 966 ± 30 | 1009 ± 41 | 0.123 ± 0.027 | 0.014 ± 0.032 | -0.015 ± 0.035 | 0.128 ± 0.032 |

**Table 1.** *Measured mean $T_1$ values during breathing of room air of three and calculated mean OTF of four ROIs of each NSCLC-patient.*

**Discussion:** In this study, $T_1$ values of human NSCLC were quantitatively measured. As expected for tumors, a relatively wide range of $T_1$ values appears amongst the patients. In each patient, the tumor $T_1$ value is approximately the same as in the corresponding lung. The oxygen transfer to the tumors could be quantitatively assessed via OTF. Using carbogen as the breathing gas upon irradiating lung tumors does not always improve therapy results [4]; only tumors which have good oxygen transfer after breathing carbogen are likely to benefit from radiotherapy performed during inhalation of carbogen. In addition, local pulmonary function can be deduced via regional measurement of OTF [1]. Using this method, the functionality of the lung surrounding the tumor can be evaluated and the irradiation dose could be raised without further impairing healthy lung tissue if the OTF is low. Through a measurement of the OTF of the aorta, overall lung function can be derived, as the mixed arterialised blood is measured directly in this approach. The local pulmonary OTF in relation to the aortic OTF, therefore, offers an estimation of the contribution of a particular part of the lung to the overall oxygen transfer, as well as a quantification of the effect of local pulmonary shunts. In conclusion, the proposed method may have the potential to provide information about oxygen transfer in human lung tumors, and may therefore help to improve the effectiveness of radiation therapy.

**References:**

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