Dynamic MRI of the upper airways in subjects with and without COPD

K. K. Gast[1], S. Ley[2], A. Biedermann[3], A. Rist[4], W. G. Schreiber[1], H-U. Kauzcor[5], C-P. Heussel[1]

[1]Klinik fuer Radiologie, Klinikum der Johannes Gutenberg-Universitaet, Mainz, Germany, [2]Oncological Radiology, German Cancer Research Center, Heidelberg, Germany, [3]3. Med. Klinik (Pulmonology), Klinikum der Johannes Gutenberg-Universitaet, Mainz, Germany, [4]Klink fuer Hals- Nasen- Ohrenheilkunde, Klinikum der Johannes Gutenberg-Universitaet, Mainz, Germany, [5]Oncologic Radiology, German Cancer Research Center, Heidelberg, Germany

Synopsis: To investigate differences in the dynamic behaviour of the upper airways between normal subjects and COPD patients, dynamic MRI of the upper respiratory tract was evaluated concerning airway diameter at three different levels during continuos respiration. Fifteen healthy volunteers and 23 COPD patients were included. Median respiratory narrowing of the upper trachea was significantly stronger in COPD patients (64%) than in volunteers (43%). This enhanced airway narrowing might hamper distribution of inhalation drugs even more than in volunteers. Models of drug distribution should include dynamic airway behaviour during respiration.

Objective:

Inhalation therapy of pulmonary diseases is influenced by inspiratory flow as well as the shape of the airway lumen. There are models which describe the tracheo-bronchial tree and allow for simulation of particle distribution in individually shaped airways from data of computed tomography (1). However, these models rely on static inspiratory data and thus, lack the representation of dynamic changes during respiration. Furthermore, they focus on the lower airways. Especially in lung disease, such as chronic obstructive pulmonary disease (COPD), dynamic changes may be different from those in healthy subjects and may influence particle deposition even more (2). The purpose of this study was to investigate differences in the respiratory movements of the upper airways between volunteers and COPD patients by dynamic MRI during continuous respiration. The respiratory movement shall be determined at different pharyngeal positions and at an upper tracheal level.

Materials and Methods:

Fifteen healthy life-long non-smoking volunteers and 23 patients with a diagnosis of COPD were included into the study. Inclusion criterion was a forced expiratory volume in 1s (FEV_1) >70% predicted (Median 85%) in volunteers and <70% predicted (Median 61%) in COPD patients, respectively. COPD patients had a median smoking history of 50 pack-years. All measurements were performed on clinical 1.5 T scanner (Magnetom Vision, Siemens Medical Solutions, Erlangen, Germany). A neck array coil as provided with the scanner was used for transmission and reception. An ultrafast spoiled gradient-echo pulse sequence with proton-density weighting and the following parameters was used for dynamic measurements during continuous respiration: TR 2.4ms, TE 1.2ms, flip angle 8°, FOV 300mm, matrix 128, slice thickness 8mm. The pulse sequence allowed for a temporal resolution of 150ms during a period of 13s. Measurements were performed in the oropharynx, at the base of the tongue, larynx and subglottic trachea. Slice orientation was selected such as to achieve an imaging plane perpendicular to the respective airway. Sagittal images were acquired additionally. Patients were instructed to breath continuously during MR acquisition. Series demonstrating swallowing were excluded from analysis. Minimal and maximal lumen diameters within pharynx and upper trachea were measured manually on a commercially available viewing station (Magic View, Siemens Medical Solutions, Erlangen, Germany).

Results:

The median respiratory pharyngeal narrowing was 70% (48-100%) in volunteers (Fig. 1) and 76% (37-97%) in COPD patients (Fig.2) (p=0.98). The upper trachea, however, demonstrated a significantly higher median collapse of 43% (20-83%) in volunteers compared with 64% (29-100%) in COPD patients (p=0.011). The movements of the soft palate showed no clear coherence to the respiratory cycle (Fig. 3).

Conclusion:

COPD patients showed a significantly stronger respiratory collapse of the upper trachea as compared to volunteers. This is mainly due to a loss of elastic fibres in the bronchial wall which is known to be associated with COPD. As drug deposition is strongly influenced by the actual diameter of the airway lumen, the knowledge of the dynamic behaviour of the trachea is important e.g. for modelling of ventilation and drug deposition. When tracheal respiratory collapse in COPD patients is enhanced, particles may be more prone to central deposition. As this study focuses on the upper airways, further investigation of the dynamic respiratory behaviour of the more distal airways is crucial.

References: (1) Ley S, Mayer D, Brook BS, van Beek EJ, Heussel C-P, Rinck D, Hose R, Markstaller K, Kauczor H-U. Radiological imaging as the basis for a simulation software of ventilation in the tracheo-bronchial tree. Eur Radiol 2002;12:2218-2228. (2) Stockley RA. New approaches to the management of COPD. Chest 2000;117:(2 Suppl): 58S-62S

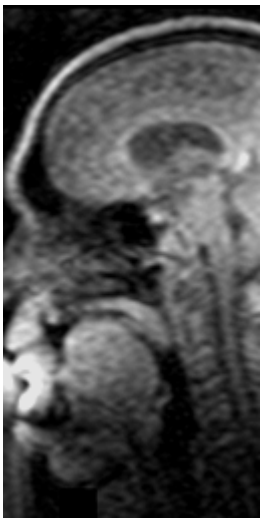

Fig.1

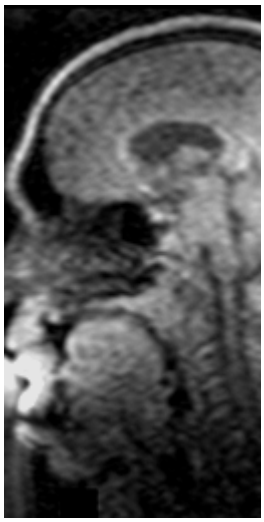

Fig.2

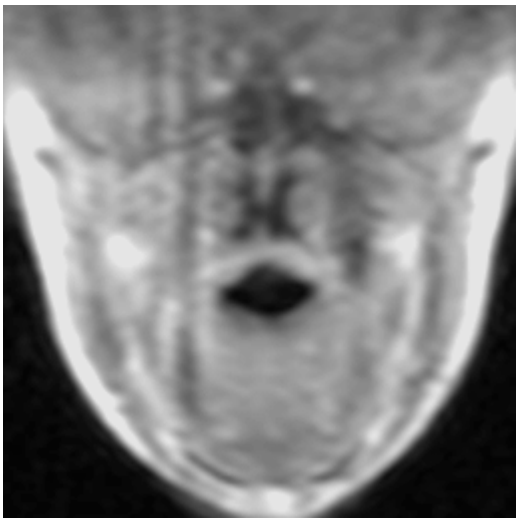

Fig. 3