Dynamic Lung Volumetry with MR in Healthy Volunteers: Comparison with Spirometry

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Background and Purpose: Impaired respiratory mechanics are usually indirectly evaluated with spirometry. MR techniques permit direct visualization of dynamic chest wall and diaphragmatic motions with high spatial and temporal resolution (1-3). This ability is important for systemic understanding of pathophysiologic processes, because local changes of the lung volumes and compliance can only be detected by imaging techniques. However, continuous MR evaluation during respiratory maneuvers and strict correlation and validation to spirometric data was only performed with geometric modeling (4). The purpose of this study is to evaluate the ability of dynamic volumetric MR with parallel imaging technique in the assessment of respiratory mechanics in comparison with spirometric results.

Materials and Methods: Seven normal volunteers (2 males; 5 females, mean age 30 years) were included in this study. Dynamic volumetric MRI was acquired in coronal plane using balanced turbo field echo sequence (TE/TR: 1.89/0.94ms; M2D mode with 10 slices; flip angle: 50°; matrix: 112x112; field of view: 520x520 mm; reconstructed voxel size: 2.03 x 2.03 x slice thickness) with SENSE factor of 3. Slice thickness was adjusted to cover the whole lung in full inspiration (median 15 mm). Three images per second were acquired with temporal resolution of 0.335 sec. MR imaging was done during quiet breathing and forced inspiration/expiration, identical to the respiratory maneuvers for spirometry. Spirometry was performed with conventional standard technique in supine position. Tidal volume (V_T), forced vital capacity (FVC), and maximum expiratory volume of one second (FEV1). Using dedicated software developed in MATLAB (The Mathworks Inc., Natick, MA), both lungs were automatically segmented on the basis of threshold function and region growing method (figure 1). The lung volume in different time points were plotted to measure the same parameters obtained on spirometry (figure 2). The results of MR and spiromety were compared with Spearman's correlation (SC) and Interclass Correlation Coefficients (ICC). The parameters of left and right lung were compared also.

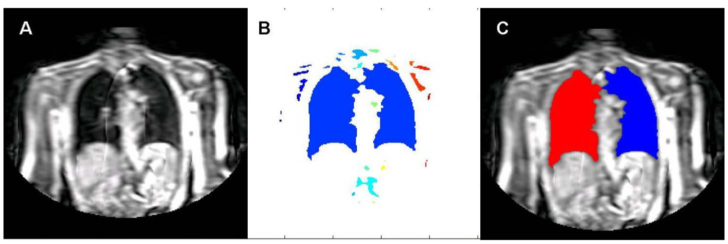

Figure 1. Semi-automatic detection of both lungs. (A) original image (B) extracted pixels after threshold application (C) Finally segmented both lungs overlaid on original image.

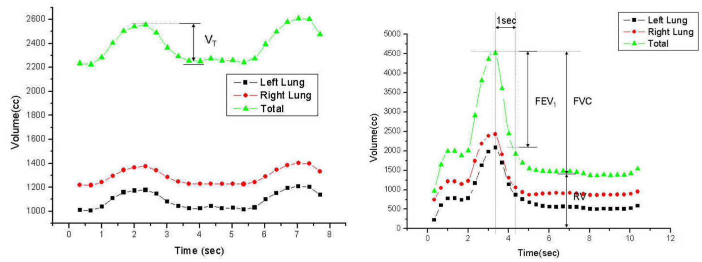

Figure 2. Measurement of V_T, FVC and FEV1 with time-volume curve obtained from MR images. Parameters of right and left lung can be measured separately.

Results and Discussion: All MR studies were performed successfully. Although there were artifacts related to parallel imaging technique, both lungs were successfully extracted in all subjects automatically. Figure 1 shows example of extracted lung on the software and figure 2 shows examples of time volume curved generated with MR data. Statistical analysis showed that measured FVC, FEV1 on both MR and spirometry were well correlated although parameters measured on MR were systematically lower than those on spirometry (Table 1). Moderate correlation of V_T is thought to be due to small number of study subjects and possible different breathing pattern between MR and spirometry. Comparison of left and right lung showed that all parameters are well correlated and parameters of right lung are larger than left lung (Table 2).

	MR (cc, mean ± SD)	Spirometry	Spearman's rho	Alpha of ICC
V_T	559 ± 130	617 ± 241	0.607	0.488
FEV1	2233 ± 636	3137 ± 577	0.786*	0.866*
FVC	3344 ± 1212	3651 ± 841	0.679	0.87*

Table 1. Comparison of MR and spirometry. *significant correlation ($p<0.05$)

	Left lung (cc, mean ± SD)	Right lung	Spearman's rho
V_T	263 ± 67	295 ± 72	0.75
FEV1	1044 ± 229	1188 ± 467	0.821*
FVC	1599 ± 278	1745 ± 983	0.857*

Table 2. Comparison of left and right lung.

Conclusion: This study shows that dynamic MRI using 3D bTFE with parallel imaging technique provide direct visualization of lung during breathing cycle. This technique is applicable to variable diseases with chest wall deformity or asymmetry, because no geometric assumption or modeling is used.

References: 1. Gierada DS, et al. Radiology 1995;194:879-884. 2. Kondo T, et al. Respirology 2000;5:19-25 3. Cluzel P, et al. Radiology 2000;215:574-583 4. Plathow C, et al. Invest Radiol 2004;39:202-209