Hyperpolarized $^3$He and $^{129}$Xe Magnetic Resonance Imaging of Asthma Pre- and Post-Salbutamol

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Introduction

- Hyperpolarized gas magnetic resonance imaging (MRI) provides high spatial and temporal resolution images of lung function and structure.
- Hyperpolarized helium-3 ($^3$He) MRI is the most predominantly utilized noble gas, however, high cost and limited availability of $^3$He has restricted clinical translation.
- Xenon-129 ($^{129}$Xe) gas is relatively inexpensive and is substantially more abundant than $^3$He gas.
- However, the lower diffusion coefficient, increased viscosity and higher atomic weight of $^{129}$Xe may have an impact on the distribution of gas in the lung at baseline and following treatment.

Research Objective

- To quantitatively compare hyperpolarized $^3$He and $^{129}$Xe MRI measurements in asthma subjects pre- and post-salbutamol.

Methods

- Subjects: 7 asthmatics underwent $^3$He MRI, $^{129}$Xe MRI, spirometry in 2 subjects, against their mean (mean difference (±SD) was 0.79% (1.19%), lower limit -1.54% and upper limit 3.11%).

Image Acquisition

- MRI was performed on a whole body 3.0 Tesla Discovery 750MR (General Electric Health Care, Milwaukee, WI) MRI system with broadband imaging capability.

Image Analysis

- $^3$He and $^{129}$Xe ventilation defect percent (VDP) generated as ventilation defect volume (VDV) normalized to the thoracic cavity volume using image segmentation and registration software.

Statistical Analysis

- Three-way mixed design repeated measures ANOVA was used to determine the interactions between subjects, treatment (pre- and post-salbutamol), and gas ($^3$He and $^{129}$Xe) (SPSS 19.0).

Results

- Pulmonary function and $^3$He and $^{129}$Xe MRI measurements pre- and post-salbutamol.

Pulmonary function and $^3$He and $^{129}$Xe MRI measurements pre- and post-salbutamol.

<table>
<thead>
<tr>
<th>Subject</th>
<th>PRE-SALBUTAMOL</th>
<th>POST-SALBUTAMOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>He Helium</td>
<td>FeV1 %pred</td>
<td>76 (6)</td>
</tr>
<tr>
<td>Xe Xenon</td>
<td>FEV/FVC %</td>
<td>91 (12)</td>
</tr>
<tr>
<td>VCV %</td>
<td>67 (7)</td>
<td>104 (10)</td>
</tr>
<tr>
<td>TLC</td>
<td>105 (6)</td>
<td>123 (13)</td>
</tr>
<tr>
<td>RV</td>
<td>131 (10)</td>
<td>35 (4)</td>
</tr>
<tr>
<td>IC</td>
<td>105 (13)</td>
<td>117 (12)</td>
</tr>
<tr>
<td>FRC</td>
<td>110 (16)</td>
<td>93 (17)</td>
</tr>
<tr>
<td>Raw</td>
<td>192 (75)</td>
<td>132 (81)</td>
</tr>
</tbody>
</table>

Noble Gas MRI

- $^3$He VDP %: 7 (6) ± 5 (4) 0.06
- $^{129}$Xe VDP %: 8 (5) ± 5 (4) 0.01

Conclusion and Discussion

- In asthma subjects there was a strong correlation between $^3$He and $^{129}$Xe VDP pre- and post-salbutamol, although $^{129}$Xe VDP was significantly higher than $^3$He VDP.
- $^3$He and $^{129}$Xe MRI provided visually obvious improvement in gas distribution following salbutamol administration, although quantitatively the improvement was statistically significant in $^{129}$Xe VDP only.

These findings suggest differences between $^3$He and $^4$He MRI VDP in asthma at baseline and following treatment may reflect differences in the properties of the gases and physiological/anatomical abnormalities in asthma.

References


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