

# “Ventilatory Alternans” in the Airways of Competitive Breath-hold Divers Evaluated with Hyperpolarized Helium MRI

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## Introduction

Competitive breath-hold divers have reached astonishing depths, exceeding 200 m. Independent of the diving response, these divers use glossopharyngeal breathing maneuvers, such as glossopharyngeal insufflation (GI, or lung packing) and exsufflation (GE, or reverse lung packing). Using hyperpolarized <sup>3</sup>He MRI, we studied pulmonary ventilation of world-class breath-hold divers performing these breathing maneuvers and here we report findings observed near FRC and following GE.

## Methods

Four competitive breath-hold divers (1 female, 3 males) were studied. We obtained dynamic MR images of <sup>3</sup>He during 1 liter inspirations from FRC, and from lung volumes approximately 0.5L below RV after GE maneuvers. Breath-hold ventilatory images were also obtained at these volumes, in addition to volumes exceeding TLC after GI maneuvers. Subjects were imaged supine.

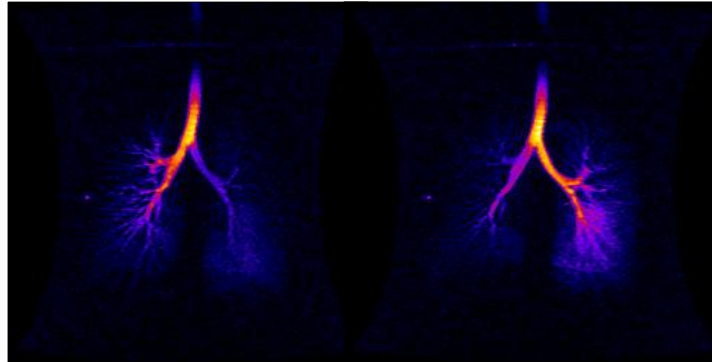


Figure 1. Dynamic hyperpolarized <sup>3</sup>He MR images at FRC showing the alternation of gas flow at a frame rate of 400 ms/frame.

## Results

Our major findings were from the dynamic imaging protocols during inspiration. At a frame rate of 400 ms/frame, the inspired gas was seen to progress through the trachea, main stem bronchi and airways up to the 6<sup>th</sup> generation. Of particular interest was an alternation of flow (here termed “ventilatory alternans”) of <sup>3</sup>He gas between

## Results (continued)

the left and right main stem bronchi and distal airways, occurring throughout the entire inspiration. The alternation period approximated 2 frames, consistent with a cardiogenic origin. From the imaged <sup>3</sup>He intensities, we estimate that at volumes near FRC the amplitude of this tidal fractionation was around 70% / 30%, alternating between the left and right lung, and was markedly less following GE.

## Conclusions

Hyperpolarized <sup>3</sup>He MRI reveals previously unreported alternation of gas flow between the left and right side airway trees. This observation suggests that this type of pendelluft may contribute to cardiogenic mixing and play a functional role in lung ventilation, especially near FRC. As such, these findings may apply to the general population.

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