Visualization of Human Sinus Ventilation by Radioactive Krypton Using the PARI SINUS™ Pulsating System

U. Schuschnig1, W. Möller2, G. Meyer3, K. Häussinger3, H. Mentzel1, J. Zimmerman1 and M. Keller1

1) PARI GmbH, Starnberg, Germany
2) GSF National Health Center for Environment and Health, Gauting, Germany
3) Asklepios Hospital for Respiratory Diseases, Gauting, Germany

Contact: u.schuschnig@pari.de (www.paripharma.com)

NACF Poster No. 283
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Introduction
- The paranasal sinuses are air-filled cavities in the bones of the skull surrounding the nose. They communicate with the nose via the ostia. Despite being non-ventilated hollow structure, it is possible to ventilate the sinus cavities by generating pressure differences between nasal and paranasal cavities [1]. Vibrating air flows or humming [2] can be used to generate such pressure gradients.
- The PARI SINUS™ is a novel device that targets drug delivery to the sinuses via a pulsating aerosol.
- The objective of this study was to develop a technique to visualize sinus penetration in both a nasal cast and human volunteers using dynamic 81mKr-gas ventilation imaging in combination with the PARI SINUS™ pulsating drug delivery system.

Materials and Methods
- The protocol was approved by the Ethical Committee of the Medical School of the Ludwig Maximilian University (Munich, Germany), and informed consent was obtained from each healthy subject (n=3).
- The SINUS™ compressor inlet was connected to the 81mKr gas generator output.
- The nebulizer was coupled to the right nostril and the left nostril was coupled via a flow resistor to output tubing (see Figure 1).
- During ventilation with the Kr-gas the subjects closed their soft palate, which allowed the transmission of pulsations by the SINUS system and prevented penetration into the lower respiratory tract.
- Images from a Dynamic gamma camera (DIACAM, Siemens, Erlangen, Germany) were recorded (0.5 sec frame time) during 10 to 15 seconds of ventilation with Kr, anterior and lateral left view (Figure 1, 2).
- Gamma camera images were resized and superimposed to the MRI images by adjusting the spatial resolution (Figure 5).

Results
- Figure 1: Dynamic gamma camera recording in anterior (left) and lateral (right) positions.
- Figure 2: 81mKr-gas ventilation of the nasal cavities of two volunteers during 10 sec breath holding in front of a planar gamma camera head (anterior) using the PARI SINUS™ without (w/o, left image) and with (w, right image) the pulsation system. The images show the superposition (sum) of all 60 recorded serial images. In addition the delivery and the exhaust tubing of the Kr-gas is shown.
- Figure 3: Activity profile along a horizontal region of interest (see inset) covering the nasal tract and the sinuses after nasal 81mKr-gas ventilation using the PARI SINUS™, with (w) and without (w/o) pulsation. The intensity profile shows the sum of intensity of all vertical pixels along the horizontal ROI.

Summary and Conclusions
- The Kr-gas ventilation images (with and without pulsation), superposition of activity distribution into a lateral MRI slice, and analysis of the activity profiles clearly demonstrate the efficiency of the PARI SINUS™ pulsation system to provide effective ventilation of the sinuses in healthy subjects.
- Using the PARI SINUS™ system there is a high probability that drugs can be delivered into the paranasal cavities to treat nasal diseases and to prevent the shift from an upper airway disease to the lower respiratory tract. Further studies are warranted to show this effect.

References