T5.27

Ergonomics of Respirator Mask Wear

Arthur Johnson
University of Maryland College Park, College Park, MD

Respirator masks are worn to protect against airborne contamination in the environment. However, wearing respirators interferes with vision, communication, respiration, heat exchange, anxiety level, and personal procedures such as eating, drinking, scratching, etc. We have been testing the human performance effects of respirator wear and found some interesting effects. For instance, visual acuity of respirator lenses can severely affect the ability to perform console monitoring and hand-eye coordination tasks. Male-female differences were found, with males better at spatial tasks and females better at recognizing details. Vision after exercise has been shown to decrease, increase, and decrease again depending on the time. Respiratory resistances lead to hypoventilation in both inhalation and exhalation directions, with inhalation resistance more affective than exhalation resistance. Respirator dead volume does not cause hypoventilation, but does cause a decrease in exercise performance. Communications with respirators are also degraded, sometimes by up to 50% at interpersonal distances of 0.5 m.

T5.28

Variable Peak Pressure Ventilation Improves Lung Mechanics and Gas Exchange During Long Term Mechanical Ventilation in a Rodent Model of ARDS

Stephen Arold[1], Rene Mora[2], Kenneth Lutchen[1], Edward Ingenito[3], Bela Suki[1]
[1]Boston University, Biomedical Engineering, Boston, MA, [2]Brigham and Women's Hospital, Pulmonary, Boston, MA, [3]Harvard University, Boston, MA

Mechanical ventilation can generate shear stress which is thought to propagate pre-existing lung injury during acute lung injury (ALI). We have previously shown, in a rodent model of acute respiratory distress syndrome(ARDS), that random variations in peak inspiratory pressure, termed variable peak pressure ventilation (VPPV), reduce lung elastance (EL) and improves oxygenation (paO2) over conventional ventilation (CV) during short term mechanical ventilation. To further characterize the effects of VPPV, we ventilated 3 groups of guinea pigs with endotoxin induced lung injury for 3 hours at: 1) 8 cmH2O positive end expiratory pressure (PEEP), CV 2) 3 cmH2O PEEP, CV and 3) 3 cmH2O PEEP, VPPV. We measured lung mechanics and gas exchange periodically, and bronchoalveolar lavage (BAL) cell counts, phospholipid concentration, protein content, and surfactant function after 3 hours. While there were no differences in BAL cells, phospholipid or protein content, we found that after 3 hours of mechanical ventilation the VPPV group demonstrated the highest paO2, and lowest EL. Additionally, animals ventilated at 3 and 8 cmH2O PEEP with CV, developed hypercapnia and acidosis, which was notably absent during VPPV. In conclusion, VPPV may be a reliable and simple method of improving oxygenation and lung mechanics while possibly reducing lung injury, during mechanical ventilation with ALI.

T5.29

Probing Dynamic Lung Mechanical Properties in Emphysema Patients

Cortney Henderson[1], Edgardo Salcedo[1], Edward Ingenito[2], Stephen Loring[3], Marilyn Moy[2], Haytham Atileh[1], Kenneth Lutchen[1]
[1]Boston University, Biomedical Engineering, Boston, MA, [2]Brigham and Women's Hospital, Pulmonary Division, Boston, MA, [3]Beth Israel Deaconess Medical Center, Boston, MA

Lung volume reduction surgery (LVRS) does not improve lung function in all late-stage emphysema patients and methods that aid in patient selection and assessing response to surgery are needed. We developed a new method to estimate the resistance (Rdyn) and elastance (Edyn) of the lung between 0-8 Hz in emphysema patients. Such data reflect the pattern and level of obstruction in the lung. Emphysema patients cannot easily alter their breathing pattern. Our approach exploits spontaneous breathing (SB) and superimposed oscillations (SO) from 4-8 Hz on top of the patient's spontaneous breathing. For SB and SO, transpulmonary pressure and airway opening flow were measured from 4 healthy subjects and 5 patients with severe emphysema. A least squares analysis was used to estimate Rdyn and Edyn during inspiration only for the SB and high-pass filtered SO data. Rdyn and Edyn were higher in emphysema patients than in healthy subjects. Moreover, the patient's Edyn increased markedly with frequency beginning at very low frequencies (0-2 Hz). There is some evidence that the SB method underestimates Rdyn at frequencies less than 2 Hz. We conclude that Rdyn and Edyn data from 0-8 Hz have the potential to track the impact of LVRS on mechanical lung function. Moreover, in principal by combining computed tomography (CT) and ventilation/perfusion scans with Rdyn and Edyn data, one might establish whether physical distribution of lung disease correlates with mechanical heterogeneity. Supported by NIH and NSF.

T5.30

Transfer Function Analysis of Respiration of Laboratory Animals

Jeffrey Reynolds, Brian Stolarik, Kimberly Friend, David Frazer
NIOSH/HELD/Engineering and Control Technology Branch, Morgantown, WV

A transfer function analysis technique was developed to measure the resistance-compliance time constant (RC) of the lungs of laboratory animals. The change in volume of the thorax with respect to time (thoracic flow) was taken as the system input, and the flow from the nares was taken as the output. Fourier analysis was used to calculate the transfer function from thorax to nares. These data were fit to a parametric model yielding the RC time constant. In order to determine the transfer function, it is necessary that the system input contain enough energy at frequencies of interest to sufficiently excite the system. Spectra of thoracic flow were examined, and were shown to contain a noise component that decreases monotonically with frequency, in addition to a periodic component. Furthermore, the thoracic flow spectra indicate energy over a wide band of frequencies. Coherence was calculated from input to output in order to test system linearity and the input excitation. Coherence was shown to be good well beyond the fundamental breathing frequency for each animal. The coherence values were also shown to be useful in frequency weighting when the measured response was applied to the model.

T5.31

Higher Order Spectral Analysis for Excitation Characterization in Cough Sounds

Kimberly Friend, Travis Goldsmith, Walter McKinney, Jeffrey Reynolds, Sharon Watkins, David Frazer
NIOSH/HELD/ECTB, Morgantown, WV

Higher order spectral analysis is used to separate the sound source excitation and transmission path during a cough using an autoregressive model based on third order statistics. Volunteer subjects awaiting pulmonary function testing at the West Virginia University Hospital were recruited to perform a voluntary cough maneuver. Cough sound pressures were recorded by a previously described system [1]. Because the respiratory tract changes shape with respect to the excitation with time, it can be modeled as a time-varying filter, H(z), with fixed parameters over short time intervals. In order to determine H(z), the cough sound samples were processed through an all-zero digital filter created with an autoregressive routine based on third order cumulants [2]. The inverse filter was used to separate the excitation source producing the cough sound pressure wave. Coughs were recorded and analyzed from patients diagnosed with obstructive and restrictive lung disease, as well as healthy control subjects.
1. Goldsmith, WT, JS Reynolds, WG McKinney, KA Friend, D Shahan, DG Frazer. A System for Recording High Fidelity Cough Sound Measurements. Proceedings 3rd International Workshop on Biosignal Interpretation, 1999; 178-81. 2. Hadjileontiadis, LJ, and ST Panas. Higher Order Statistics: A Robust Vehicle for Diagnostic Assessment and Characterization of Lung Sounds. Technology and Health Care. Vol. 5 (1997): 359-374.

T5.32

Alveolar pH Changes and Trans-Alveolar Transport

Lars Olson[1], Richard Effros[2], G. Hogan[2], W. Lin[2]
[1]Marquette University, Milwaukee, WI, [2]Medical College of Wisconsin, Pulmonary and Critical Care Medicine, Milwaukee, WI

A method for assessing lung alveolar pH changes was devised to study transport across the alveolar epithelium and to study how alveolar pH can be modified by extra-alveolar conditions. Isolated lungs were perfused with a balanced salt solution. The airways were filled with perfusate containing 0.2mg/ml fluorescein isothiocyanate dextran, M.W. 2×106 g/mole (FITC). Lung epifluorescence was detected using a trifurcated optical fiber bundle. Two bundles were used to transmit the excitation wavelengths 420 nm and 490 nm, where FITC is pH insensitive and sensitive, respectively. Light reflected from the lung in the third bundle went through an emission filter of 515 nm and was measured with a photomultiplier tube. The device was calibrated using both cuvettes and lung infusions containing FITC. Lungs were perfused with ammonium chloride containing perfusate for 1 minute followed by washout. Perfusates either contained a buffer that did not leave the vascular space or bicarbonate. With each perfusate, an alkalinization of the alveolar space was initially observed. However, with the bicarbonate buffer perfusate, a subsequent acidification of the alveoli was also observed. This implies that this method can detect pH changes caused, putatively, by transport of ammonia, bicarbonate and protons across the alveolar epithelium.

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Editors:
Nitish V. Thakor, Ph.D.
Department of Biomedical Engineering
Johns Hopkins University

Francis A. Spelman, Ph.D.
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University of Washington

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