Lung Volume and Continuous Positive Airway Pressure Requirements in Obstructive Sleep Apnea

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Online Data Supplement

Lung volume measurements

Changes in end expiratory lung volume (EELV) were determined using a standardized formula previously validated against the Kono-Mead least squares method (E1, E2): Average values for changing anteroposterior (AP) diameter of the chest wall and abdomen were determined for each subject (from magnetometer recordings) during quiet breathing through a pneumotachograph, while in the supine position for at least three minutes. The changes in chest wall and abdomen AP diameter were averaged over twelve breaths and combined with the pneumotachograph data. Each change in AP diameter values was then entered into the following equation describing the relationship between tidal volume and chest/abdominal excursion: TV = X (4 RC + AB). Tidal volume (TV) is determined using X, a coefficient determined in the calibration procedure for a given individual. All calibration maneuvers were performed with subjects instrumented, lying supine in the rigid shell.

We took special care to prevent any direct effect of the iron lung pressure on the neck and upper airway. We accomplished this using a form-fitting piece of Plexiglas, which prevented movement of the nylon webbing on the subject's neck as pressure became positive. This kept the webbing just above the shoulders avoiding pressure on the neck. In addition when the pressure in the iron lung was decreased (to increase lung volume), the webbing was shifted slightly inside the chamber, which would only further decrease the neck area potentially exposed to the pressure in the lung.

Data Analysis

The above-mentioned signals were recorded on both, a 16 channel polygraph (Grass model 78) and a personal computer. Each signal (EEG, EOG, EMG, EKG, $etCO_2$, abdominal and rib cage magnetometers, flow, tidal volume, mask and epiglottic pressure) was analyzed using signal-processing software (Spike 2, CED Ldt. Cambridge, UK). End expiratory lung volume (EELV) changes at the various extrathoracic and CPAP levels were determined at end-expiration. We used a Kolmogorov-Smirnov test to determine if the required CPAP levels were normally distributed in each condition. We used a one way repeated measure ANOVA with a post hoc Tukey test to determine if there was a significant difference between the three conditions (baseline, increased and decreased lung volume). We used a paired t-test to compare CPAP requirement for all the 17 patients between baseline and the +1 liter condition.

Linear regression using mixed models was performed to estimate the effect of lung volume on CPAP pressure while correctly accounting for the correlation of intra-individual data. The equation modeled was:

$P_{ij} = (b + b_i) + (m + m_i)*(V_{ij}) + e_{ij}$

Where P_{ij} = CPAP required for the ith subject and jth initial volume setting (– 0.75L, baseline, + 1L)

V_{ij} = Final lung volume for the ith subject and jth initial volume setting

b = mean intercept

b_i = offset in intercept for ith subject

m = mean slope

m_i = offset in slope for the ith subject

e_{ij} = random error in the ith subject and jth initial volume setting

Thus b and m represent the fixed effects in this model and b_i, m_i, and e_{ij} are the random effects. These parameters were estimated using Proc MIXED in SAS version 8.2 (Cary, NC).

For each measurement means ± standard error are presented. A p value < 0.05 was considered significant.

References

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E2. Konno K, Mead J. Measurement of the separate volume changes of rib cage and abdomen during breathing. J Appl Physiol. 1967;22(3):407-22.