Online Data Supplement

Observational study of the effect of obesity on lung volumes

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Patients and Methods

Anthropometric Data

Age and gender were recorded. Height, using a wall mounted stadiometer (range 600-2100mm), and weight, using a medical scale (capacity 300kg), were measured. Body-Mass-Index (BMI) was calculated as weight (kg) / height $(m)^2$. Neck, waist and hip circumference were measured using a standard medical tape measure. Waist-to-hip ratio was calculated as waist (cm) / hip (cm). The thickness of the skin was assessed using a caliper to measure a double skin fold at the level of the umbilicus. The sagittal diameter at the level of the umbilicus was obtained with the help of a spirit level and a bed-mounted ruler in supine posture. Change of the sagittal diameter was recorded when inflating the lungs to TLC.

Lung Function Measurement

The patients underwent standard spirometry and lung volume measurement using the multibreath helium dilution method according to international guidelines (1, 2). Spirometry was performed on a Vitalograph Gold Standard® (Vitalograph®, Buckingham, UK). We measured lung volumes using a closed-circuit multi-breath helium dilution method on a Jaeger Masterscreen PFT system (Cardinal Health Ltd, Basingstoke, UK) which included a software-based integrator (JLAB software version 4.0). Predicted values were derived from published data for Caucasians (2).

Dynamic Compliance

Dynamic compliance, as used in this study, was calculated as the volume change divided by oesophageal pressure (Poes) change during a normal inspiration (ΔVolume (L) / Δ Poes (cmH_2O)). Both parameters were measured when flow was zero, as derived from a pneumotachograph. Oesophageal pressure was taken as a surrogate marker for pleural pressure (3).

Pressure Measurement

We used commercially available, single-use balloon catheters (Cooper Surgical, Trumbull, CT, USA) to measure Poes and Pgas (4). In combination with appropriate volumes of air inside the balloon catheters (0.5ml of air in the oesophageal and 2.0ml of air in the gastric balloons) (5-7). Correct placement of the oesophageal balloon catheter was confirmed as described by Baydur *et al* (8) when seated and supine. The correct placement of the gastric balloon was confirmed by pushing the abdomen slightly from the outside, performing sniff and cough manoeuvres and comparing the signal to the oesophageal balloon recordings. Breathing through a flanged mouthpiece (Hans Rudolph, KA/USA), mouth pressure (Pmouth) was obtained. Inspiratory Poes, and similarly the transducted inspiratory Pmouth are surrogate markers for intrathoracic pressure and indices of global inspiratory muscle contraction (9). Transdiaphragmatic pressure (Pdi) is a measure of diaphragm specific contraction

(10) and was recorded online, derived from the electronic subtraction of oesophageal from gastric pressure (Pdi=Pgas-Poes). Transpulmonary pressure (P_L) was also calculated (P_L=Pmouth-Poes).

Electromyogram (EMG) of parasternal intercostal and external oblique muscles

The EMG of the parasternal intercostals and abdominal muscles were recorded using surface electrodes (Kendall Arbo®, Tyco Healthcare®, Neustadt, Germany) from standard positions. For recording the EMG of the parasternal intercostals (EMG_{para}) electrodes were placed on each side of the sternum 3cm from the midline in the second intercostal space (11, 12). For the purpose of recording the EMG from the external oblique unilaterally ($EMG_{abdomen}$, recorded from the right side) one electrode was placed in the middle of a vertical line connecting the lower rib cage with the anterior superior iliac spine, with the subject standing. A second electrode was placed approximately 4-5cm anterior to that location, as described by Lasserson *et al* (13). The recordings of the spontaneous EMG, and the respiratory pressures, were sampled at 2kHz, and EMG data were filtered (band-pass filter 30 Hz - 1,000 Hz).

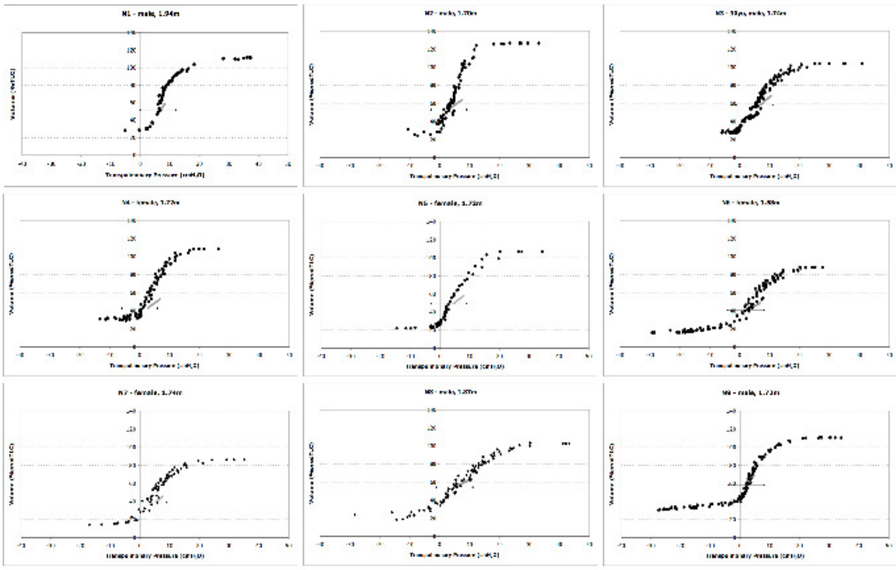
Maximal inspiratory mouth pressure (PImax)

Maximum inspiratory pressures were measured from functional residual capacity in the standard way (14, 15), with the patient seated, wearing a nose-clip and using a flanged mouthpiece (P.K. Morgan Ltd®, Rainham, UK). Repeated efforts were made, until consistent results were achieved, and the numerically largest (i.e. most negative) pressure noted. The average of the pressure was measured over one second (14).

Sample Size Calculation

We used published data from a previous study with obese subjects to calculate sample size (16). The probability was 80 percent (P=0.8) that the study would detect a treatment difference at a two-sided 0.05 significance level with a total of 18 subjects (in two arms), if the true difference between the pressures (end-expiratory oesophageal pressure, Poes, ee) was 6.0 cmH_2O. This was based on the assumption that the standard deviation of the response variable (Poes, ee) was 4.2 cmH_2O.

Results



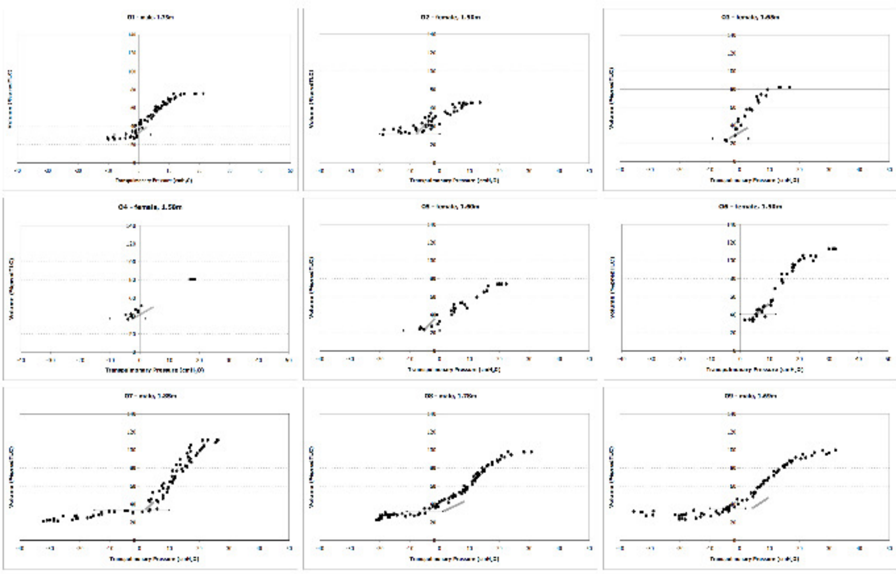
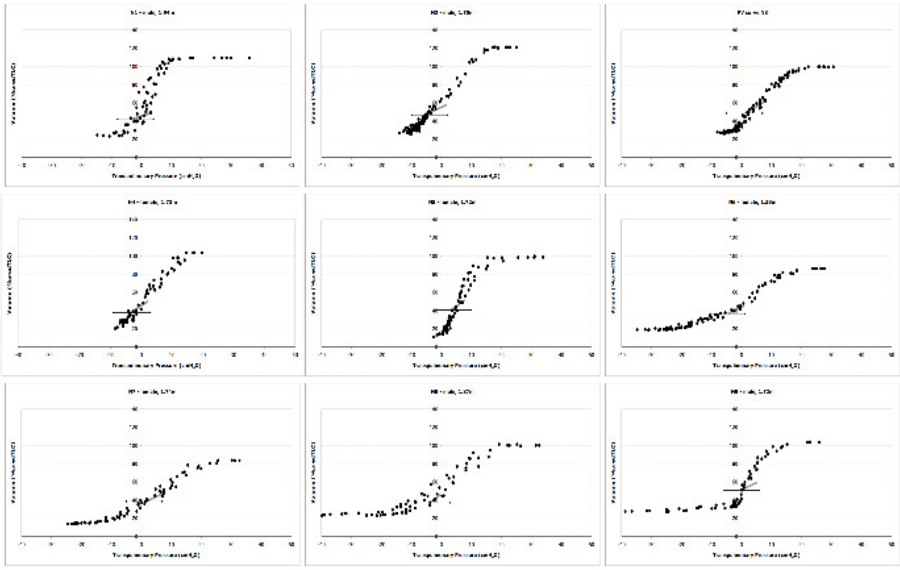


Figure E1: Pressure-Volume curves in seated normal (upper panel) and obese (lower panel) subjects were adjusted to percent predicted TLC to account for gender and height. The slope is steeper in the non-obese subject, determining compliance. Obese subjects breathe at lower FRC levels and when corrected for lung volume, age and gender there is a similar dynamic compliance in obese and non-obese subjects. Transpulmonary pressures during tidal breathing become more negative the more restricted the patient is. Obese subject ´O4´ did not produce satisfactory breathing manoeuvres over the entire expiratory range and only the maximal and minimal pressures were noted. Horizontal bars indicate FRC, short diagonal gray bars indicate tidal breathing.



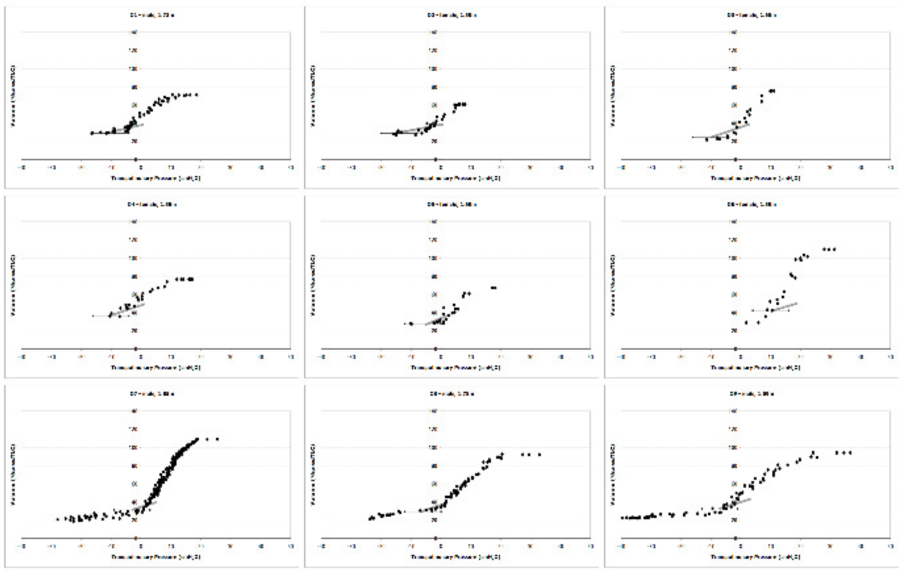


Figure E2: Pressure-Volume curves in supine normal (upper panel) and obese (lower panel) subjects were adjusted to percent predicted TLC when seated, as there are no reference values for supine posture related TLC, to account for gender and height. Obese subjects breathe at low FRC. Subjects ´O2-O5´ had suboptimal breathing manoeuvres and their PV curves should be interpreted with caution.

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