Size matters: an observational study investigating estimated height as a reference size for calculating tidal volumes if low tidal volume ventilation is required

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Abstract

Background: Acute lung injury is a life threatening condition often requiring mechanical ventilation. Lung-protective ventilation with tidal volumes of 6 mL/kg predicted body weight (PBW, based on sex and body height), is part of current recommended ventilation strategy. However, it is a common practice to visually estimate the body height of mechanically ventilated patients and use these estimates for ventilator settings. We aimed to determine if the common practice of estimating visual height to define tidal volume reduces the possibility of receiving lung-protective ventilation.

Methods: In this prospective observational study, 28 mechanically ventilated patients had their height visually estimated by 20 nurses and 20 physicians. All medical professionals calculated the PBW and a corresponding tidal volume with 6 ml/kg/PBW on the basis of their visual estimation. The patients' true heights were measured and the true PBW with a corresponding tidal volume was calculated. Finally, estimates and measurements were compared.

Results: 1033 estimations were undertaken by 153 medical professionals. Most estimates were imprecise and resulting data comprised taller body heights, higher PBW and higher tidal volumes (all $p \leq 0.01$). Using estimates for tidal-volume definition, patients are exposed to mean tidal volumes of 6.5 ± 0.4 ml/kg/PBW. 526 estimation-based tidal volumes (51.1%) did not provide lung-protective ventilation.

Conclusion: The common practice of visually estimating body height and using these estimates for ventilator settings is imprecise and potentially harmful because it reduces the chance of receiving lung-protective ventilation. Avoiding this practice increases the patient safety. Instead, height should be measured as a standard procedure.

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Protocol

Study design, patient selection

Step 1.

Objective: To determine if the common practice of estimating visual height to define tidal volume reduces the possibility of receiving lung-protective ventilation.

Design: Prospective, observational study

Setting: Twenty-four-bed intensive care unit of a tertiary hospital (University of Bochum, Herne, Germany).

Participants: Twenty-eight mechanically ventilated patients aged ≥18 years. Each patient had their height estimated by 20 nurses or respiratory therapists and 20 physicians.

Inclusion criteria: Age ≥18 years, mechanical ventilation on a pressure-controlled mode in the supine position

Exclusion criteria: Body height <150 cm or > 200 cm, amputation of lower limbs, colonisation with multi-resistant pathogens

Screening period: February to April 2016

Main outcomes measures: Medical professionals visually estimated the body height of mechanically ventilated patients. The authors asked them to calculate the predicted body weight (PBW) and a corresponding tidal volume with 6 ml/kg/PBW on the basis of their visual estimation. To determine the accuracy of these estimations, the patients' true heights were measured and the true PBW with a corresponding 6 ml/kg/PBW tidal volume was calculated by the authors. Finally, estimates and measurements were compared using descriptive analyses.

Ethical approval: The institutional review board approved the study protocol (15-5414-BR). The study has been performed in accordance with the Declaration of Helsinki and its later amendments and was retrospectively registered in the German Clinical Trial Register (DRKS), trial number DRKS00010899. Informed consent was obtained from all patients post hoc after extubation or from relatives.

Methods

Step 2.

Estimation of height, predicted body weight and tidal volumes (by assessors):

We asked medical professionals (= assessors) working in the ICU of our hospital (nurses, physicians, respiratory therapists) to visually estimate the body sizes of mechanically ventilated patients. Visual estimation of height was done in the supine position. All ventilated patients were sedated with sufentanil and midazolam or propofol (Richmond Agitation–Sedation Scale, −3/−4). Assessors were asked to define a predicted body weight (PBW) and a corresponding tidal volume with 6 ml/kg/PBW, using their estimated height as a reference.

Measurment of height, predicted body weight and tidal volumes (by the authors):

The authors mearsured the height using a measuring tape and calculated the precise PBW using the measured height and standard formula from the ARDSNet study:

Predicted BW (males) = 50 + 0.91 (cm of height − 152.4)

Predicted BW (females) = 45.5 + 0.91 (cm of height − 152.4)

Comparison of measurement versus estimations:

Using the estimated and calculated PBW, a corresponding tidal volume with 6 ml/kg/PBW was calculated by the authors. As a result, two data sets were generated: estimated magnitudes (height, PBW, tidal volumes) and measured magnitudes (height, PBW, tidal volumes).

As a final step, the authors divided each estimated tidal volume by the true PBW (calculated by the authors using measured height and the ARDSnet formula):

Estimated tidal volume (ml) / calculated PBW (kg) = exposed tidal volume (ml/kg/PBW)

In this way, we generated the equivalent and “real” tidal volume that the patient would be exposed to if visual estimation of body height was undertaken and used as a reference height for tidal volumes. We classified the estimated tidal volumes in a three-level categorical model (<6.5, 6.5–8.5, and >8.5 ml/kg/PBW).

Definition of variables

Step 3.

Height (cm):

measured body height in cm

Predicted body weight (PBW, kg):

Predicted BW (males) = 50 + 0.91 (cm of height − 152.4) in kg

Predicted BW (females) = 45.5 + 0.91 (cm of height − 152.4) in kg

Tidalvolume (ml):

PBW x 6 ml

Estimated body height (cm):

visually estimated body height

Estimated predicted body weight (kg):

PBW on basis of visual estimation

Estimated tdial volume (ml):

Estimated PBW x 6ml

Exposed tidal volume (ml/kg/PBW):

Estimated tidal volume / PBW

Statistical analysis

Step 4.

Categorical variables are summarised as proportions. Continuous data are described by mean or median values if they have a non-normal distribution, as well as by range and standard deviation (SD). The Mann–Whitney test and the paired sample t-test were used to compare continuous data. To study the relationship between true body height and distribution of estimated tidal volumes ≥6.5 ml/kg/PBW, the true body height was divided into several strata at 5-cm intervals. A threshold of

<175 cm was chosen as a variable for dichotomous classification.

To quantify the agreement between the measurement methods of visual estimation with the ‘gold standard’ of height measurement, a modified Bland–Altman plot was created.

A logistic regression model was build to identify assessors’ characteristics that could have an impact on the results of height estimation, with adjustment for sex, age, profession and years of work experience.