Use Of Ulna Length To Predict Protective Lung Tidal Volume In Adult Egyptians

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Research Article

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Abstract

Background: Ventilation with low tidal volume (VT) is advised for critically ill patients to protect against ventilator-induced lung injury and provide better clinical outcomes. Previous studies showed poor compliance with using height to predict the VT. Ulna length has been used successfully to predict protective low VT. Our study aims to evaluate the ability of ulna length measurement to predict accurate protective lung VT in Egyptian people in reference to their standing height.

Methods: we included adult healthy volunteers with age ≥ 18 years in this study. The height of each subject was measured while standing upright against a wall. Then, the left ulna was measured with a measuring tape from the olecranon to the mid-point of the styloid process. From ulna length, height was estimated, and protective lung VT was calculated using predicted body weight (PBW).

Results: We enrolled 102 participants in this study. The agreement between the calculated VT from standing height and ulna length was analyzed with Bland Altman analysis and showed a bias of (-5.7) ml, and limits of agreements (±1.96 SD) -91 ml to 76 ml. in females, When the calculated VT of ulna length was compared to PBW from height, the predicted mean tidal volume was 6.2 ml/kg (95% confidence interval CI 4.5-7.8 ml/kg). in males, by using ulna length, the predicted mean VT was 6.1 ml/kg (95% CI 4.8-7.4 ml/kg).

Conclusion: Ulna length can be used to predict protective lung VT in Egyptian people when compared to their standing height.

Trial registration: NCT04644458 ClinicalTrials.gov 09/26/2021

Background

Protective lung ventilation with low tidal volume became the standard of care for acute respiratory distress syndrome (ARDS) after the release of ARDS network guidelines. This recommendation is thought to decrease mortality and improve patient outcomes [1]. Ventilation with low tidal volume is also advised for ventilation of critically ill patients with healthy lungs to protect against ventilator-induced lung injury and provide better clinical outcomes [2-4]. The concept is extended to include intraoperative mechanical ventilation, as protective lung ventilation may decrease postoperative pulmonary complications [5,6].

Tidal volume calculation is based on predicted body weight (PBW). Predicted body weight is determined by the patient standing height and gender [1]. As the relationship between Patient lung volume and height is well established, accurate height measurement is essential for the correct prediction of patient tidal volume [7]. Use of actual body weight will result in excessive tidal volume especially in women and obese patients [8,9].

Previous studies showed poor compliance with the recommendation of use height to predict tidal volume [10,11]. This is thought to be due to absent prior height documentation or difficulty precisely measuring patient height, especially in emergency settings [12,13]. Instead, recumbent height and visual estimation are usually used methods in practice. This inappropriately predicts tidal volume [14,15].

Other measurements were suggested to estimate patient height like knee height and ulna length [16]. Ulna length provides an attractive substitution for easy and accurate prediction of height in bedridden patients [16,17]. Furthermore, Ulna length is used successfully to predict protective low tidal volume [18,19].

Our study aims to evaluate the ability of ulna length measurement to predict accurate protective lung tidal volume in Egyptian people in reference to their standing height.

Methods

After approval of the local ethical committee and informed consent, we included adult healthy volunteers with age ≥ 18 years in this study. Individuals with growth retardation or limb bone deformity were excluded from the study. The height of each subject was measured while standing upright against a wall. Then, the left ulna was measured with a measuring tape from the olecranon to the mid-point of the styloid process as shown in **Fig.1**. From ulna length, height was estimated as advised by Malnutrition Advisory Group, British Association of Parenteral and Enteral Nutrition (BAPEN), Malnutrition Universal Screening Tool MUST [20].

Protective lung tidal volume was calculated as 6 ml/kg using predicted body weight (PBW) as follow:

PBW= 50*0.91 (centimeters of height – 152.4) in males and 45.5*0.91(centimeters of height – 152.4) in females. We aim to evaluate the ability of ulna length to predict accurate protective lung tidal volume in Egyptian people in reference to their standing height.

Each measurement was performed only once for each subject. Data are presented as mean ±SD or number (%). The Bland-Altman method analyzed the agreement between calculated tidal volumes from standing height and ulna length.

Results

We enrolled 102 participants (41 females, 61 males) in this study. The mean age of participants was (47.9 ± 14.3) years and (minimum-Maximum) age was (18–81) years. Their measurements data are presented in table (1).

Table (1)

Measurements data for all participants.

	Mean ± SD*	(Minimum-Maximum)
Weight (kg)	79.9 ± 18.9	(45–150)
Height (cm)	168.4 ± 9.4	(146–187)
Ulna length (cm)	25.6 ± 2	(19–30)

SD = standard deviation

Calculated tidal volumes from standing height and ulna length are presented in table (2).

Table (2)

calculated tidal volumes (ml) for all participants.

	Mean ± SD	(Minimum-Maximum)
VT (height)	376.6 ± 59.7 ml	(238–389) ml
VT (ulna)	382.5 ± 51.2 ml	(249–489) ml
VT (tidal volume), SD (standard deviation)		

The agreement was analyzed with Bland Altman analysis and showed a bias of (-5.7) ml, and limits of agreements (± 1.96 SD) -91 ml to 76 ml as shown in Fig. 2

41(40.2%) females participated in the study. The mean age of female participants was (43 ± 15.6) years and (minimum-Maximum) age was (18–81) years. Their measurements data are presented in table (3). When the calculated tidal volume of ulna length was compared to predicted body weight from height, the predicted mean tidal volume was 6.2 ml/kg (95% confidence interval CI 4.5–7.8 ml/kg).

Table (3)

Measurements data for female participants.

	Mean ± SD	(Minimum-Maximum)
Weight (kg)	77.1 ± 20.7	(45–150)
Height (cm)	162.1 ± 6.2	(146–176)
Ulna length (cm)	24.7 ± 2.1	(19–28)
SD (standard deviation)		

Calculated tidal volumes (ml) from standing height and ulna length are presented in table (4).

Table (4)

calculated tidal volumes (ml) for female participants.

	Mean ± SD	(Minimum-Maximum)
VT (height)	325.9 ± 33.6 ml	(238–402) ml
VT (ulna)	335.9 ± 33.9 ml	(249–385) ml
VT (tidal volume), SD (standard deviation)		

The agreement was analyzed with Bland Altman analysis and showed a bias of (-2) ml, and limits of agreements (± 1.96 SD) -102 ml to 104 ml as shown in Fig. 3

61(59.8%) males participated in the study. Their mean age was (51.3 ± 12.4) years and (minimum-Maximum) age was (24–73) years. Their measurements data are presented in table (5).

Table (5)

Measurements data for male participants.

	Mean ± SD	(Minimum-Maximum)
Weight (kg)	81.8 ± 17.5	(50–145)
Height (cm)	172.7 ± 8.8	(149–187)
Ulna length (cm)	26.3 ± 1.7	(22–30)
SD (standard deviation)		

Calculated tidal volumes (ml) from standing height and ulna length are presented in table (6).

Table (6)

calculated tidal volumes (ml) for female participants.

	Mean ± SD	(Minimum-Maximum)
VT (height)	410.6 ± 48 ml	(281–498) ml
VT (ulna)	413.8 ± 34.2 ml	(331–498) ml
VT (tidal volume), SD (standard deviation)		

The agreement was analyzed with Bland Altman analysis and showed a bias of (-9) ml, and limits of agreements (± 1.96 SD) -85 to 67 ml as shown in Fig. 4.

By using ulna length, the predicted mean tidal volume was 6.1 ml/kg (95% CI 4.8–7.4 ml/kg).

Discussion

Guidelines suggest using predicted body weight to determine lung-protective tidal volume for positive pressure mechanical ventilation [21, 22]. Fisher et al. found that excessive tidal volumes with more than 8 ml/kg predicted body weight occurred in many patients admitted to intensive care units [23].

Estimation of predicted body weight requires measurement of patient standing height which may be difficult in clinical practice. Visual estimation and recumbent length measurement are not accurate enough for predicted body weight [24, 25].

A variety of measurements were used to estimate height [26–28]. There were many attempts to replace height measurements with measurements of ulna length. Routine Measurement of ulna length is easy in hospitalized patients, including recumbent patients and those on a chair [29].

Previous studies showed that forearm length was well correlated with height [24, 30]. Forearm length was used as an alternative to height in elderly patients [31]. While another study showed different results when predicting height from ulna length in adults of different ethnic groups [32].

Moller et al. concluded that ulna length can be used as an estimate of body height to predict low tidal volume [33]. Lehr et al, found that forearm measurement is useful for protective mechanical ventilation in a Caucasian ICU population [17]. In another study, forearm length is associated with a 15% error of predicted body weight [16].

This study found agreement between ulna length and standing height to predict lung-protective tidal volume for both males and females. All participants had predicted tidal volume less than 8 ml/kg of predicted body weight.

Rivers et al., 2015 used an ulnar tidal volume ruler to estimate protective lung ventilation in healthy volunteers. They concluded that left ulna length can be useful to accurately calculate lung-protective tidal volume. According to their results, the predicted mean tidal volume was 5.7ml/kg for males and 5.8 ml/kg for females. They did not include individuals aged more than 65 years [34].

Singh et al. concluded that forearm length overestimates predicted body weight and tidal volume in Indians and Africans. They used supine height as a comparison [35].

Our findings should be tested in clinical practice on a larger number of patients.

Conclusion

Ulna length can be used to predict protective lung tidal volume in Egyptian people when compared to their standing height.

Declarations

Ethical approval and consent to participate:

This study complies with Sohag university faculty of medicine institutional ethical guidelines and with the declaration of Helsinki. Written informed consent was obtained from all the participants.

Consent for publication:

Not applicable

Availability of data and material:

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests.

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Authors Contribution:

All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by **H M** and **B R**. The first draft of the manuscript was written by **H M** and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Figures

Figure 1

the left ulna length from olecranon to the styloid process

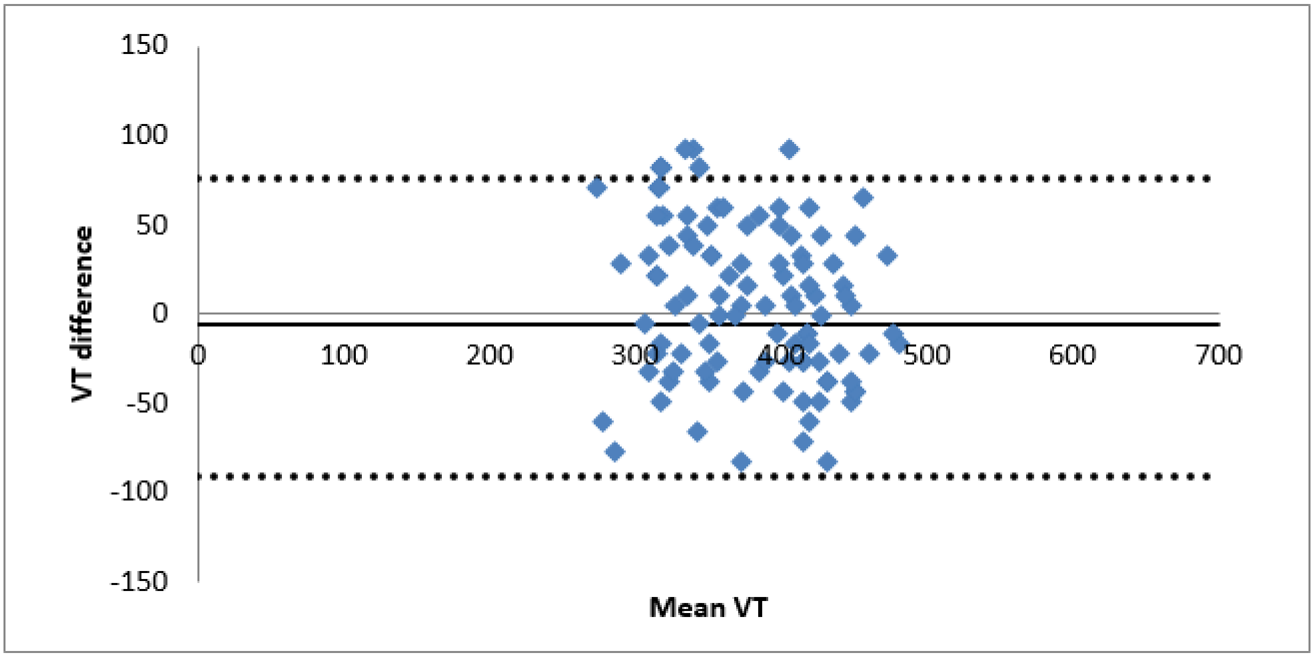

Figure 2

Bland Altman plot for all participants. VT (tidal volume).

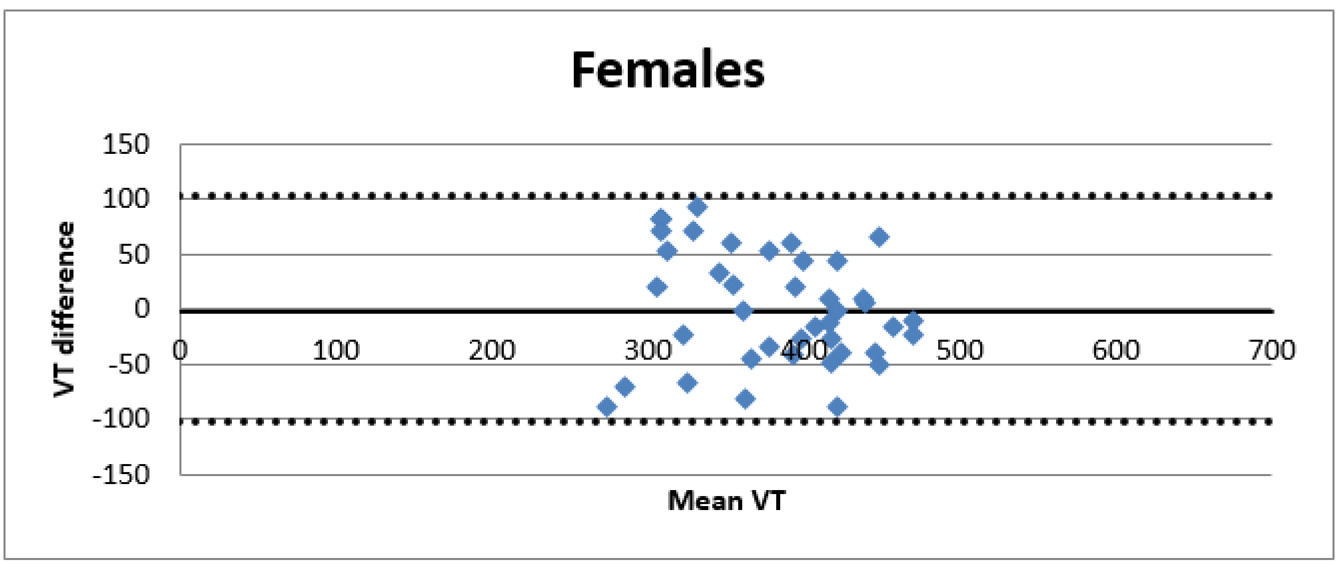

Figure 3

Bland Altman plot for female participants. VT (tidal volume).

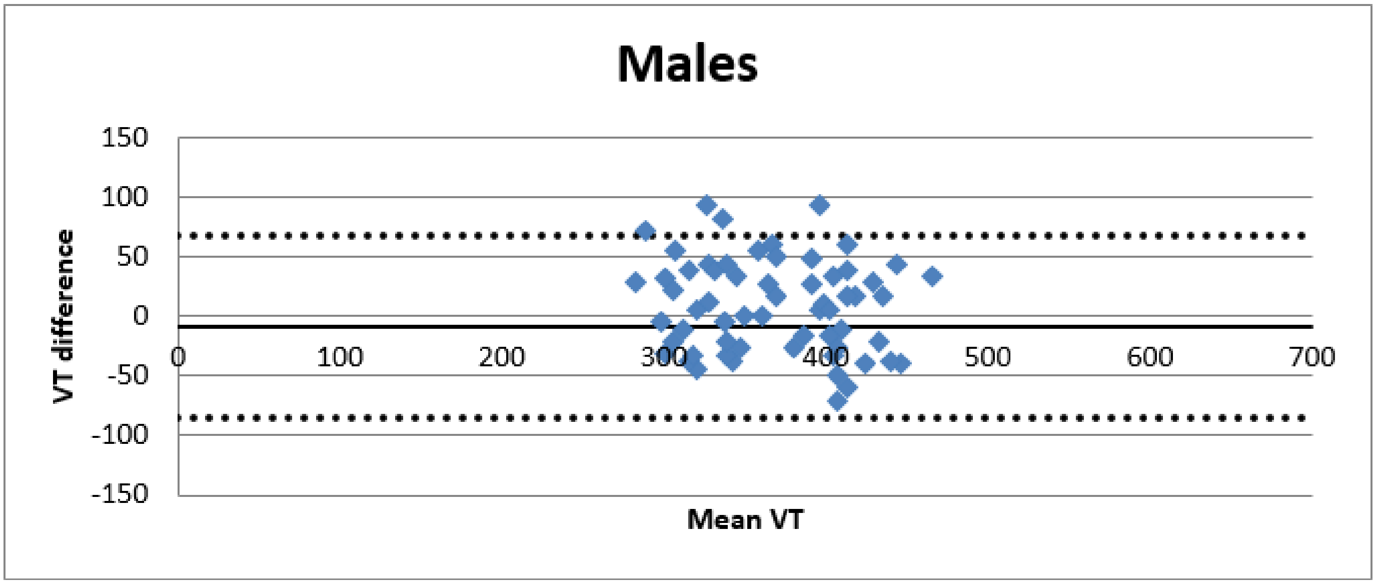

Figure 4

Bland Altman plot for male participants. VT (tidal volume).

By using ulna length, the predicted mean tidal volume was 6.1 ml/kg (95% CI 4.8-7.4 ml/kg).