Original Article

Comparative evaluation of hemodynamic and respiratory parameters during mechanical ventilation with two tidal volumes calculated by demi-span based height and measured height in normal lungs

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Abstract

Background: Appropriate determination of tidal volume (VT) is important for preventing ventilation induced lung injury. We compared hemodynamic and respiratory parameters in two conditions of receiving VTs calculated by using body weight (BW), which was estimated by measured height (HBW) or demi-span based body weight (DBW).

Materials and Methods: This controlled-trial was conducted in St. Alzahra Hospital in 2009 on American Society of Anesthesiologists (ASA) I and II, 18-65-years-old patients. Standing height and weight were measured and then height was calculated using demi-span method. BW and VT were calculated with acute respiratory distress syndrome-net formula. Patients were randomized and then crossed to receive ventilation with both calculated VTs for 20 min. Hemodynamic and respiratory parameters were analyzed with SPSS version 20.0 using univariate and multivariate analyses.

Results: Forty nine patients were studied. Demi-span based body weight and thus VT (DTV) were lower than Height based body weight and VT (HTV) ($P = 0.028$), in male patients ($P = 0.005$). Difference was observed in peak airway pressure (PAP) and airway resistance (AR) changes with higher PAP and AR at 20 min after receiving HTV compared with DTV.

Conclusions: Estimated VT based on measured height is higher than that based on demi-span and this difference exists only in females, and this higher VT results higher airway pressures during mechanical ventilation.

Key Words: Critical care, demi-span, tidal volume, ventilation

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INTRODUCTION

Mechanical ventilation is commonly indicated for respiratory failure.[1] It is an essential component of the care of patients with acute respiratory distress syndrome (ARDS).[2]

For many patients, typical initial settings include a tidal volume (VT) of 8 mL/kg of ideal body

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weight (IBW),[3] but in acute lung injury (ALI) and ARDS, initial smaller VTs (6 mL/kg of IBW) is recommended.[4]

Patient and ventilator asynchrony exists if the phases of breath delivered by the ventilator do not match that desired by the patient[5] and can cause dyspnea, increase the work of breathing, and prolong the duration of mechanical ventilation.[6]

Traditionally weight has been used for calculation of VT (6-12 cc/kg). According to ARDS net formula body weight (BW) should be calculated as a measure of height and measuring standing height is essential for calculating VT. A number of common disabilities and disease processes make it difficult to accurately measure standing height in many patients. Therefore, various formulae based on bones that do not change length have been developed. These methods include knee height, forearm length, and demi-span.[7]

Demi-span is measured as the distance from the middle of the sternal notch to the tip of the middle finger in the coronal plane [Figure 1]. Height is then calculated from a standard formula. Demi-span may be easier to obtain in patients with lower limb dysfunction. For patients with severe contractures, forearm length may more practical. Some studies showed demi-span measurement is a useful estimate of height in people (particularly women) aged ≥ 65 and also in adult population.[7]

Estimating height from demi-span

Deane *et al.*,[8] conducted a prospective audit of delivered VTs (mL/kg) calculated using recorded BW and compared these to the volumes calculated using predicted BW. This study showed that predicted BW was significantly less than recorded BW. Consequently, larger VTs was delivered on mL/kg basis when calculated using predicted BW than recorded BW. This was particularly so for women, who received higher volumes than men when using predicted BW.

Hirani and Mindell[9] examined differences between measured height and demi-span equivalent height (DEH) among people age >65 and investigate the impact on body mass index (BMI) of using DEH. Results showed that the height measurement was lower than the DEH from age group 70 to 74 years onwards in men and in each age group in women.

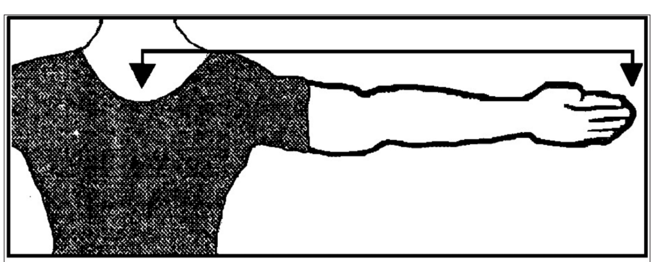

Figure 1: Estimating height from demi-span

Hickson and Frost[7] compared three commonly used clinical measurements that can estimate height and analyze their agreement with current height. The results showed that demi-span and half arm-span could be measured in the largest proportions of the population; however, agreement analysis demonstrated very poor agreement between standing height and all the methods of estimation.

The concept of the present report is on calculating VT, which is an important factor in the mode of the ventilator with significant effects on final outcome of the patient; on one hand, there is ventilator-associated lung injury and on the other hand there is low respiratory function and adverse cardiovascular effects. Therefore, methods of VT calculation need to be evaluated further.

MATERIALS AND METHODS

In a double-blind, controlled, clinical trial, after approval of Institutional Ethical Committee, and obtaining informed patient consent, 49 patients whom were candidate for elective surgery on the extremities under general anesthesia and mechanical ventilation were entered to study in a simple non-random consecutive sampling. Sample size calculated according to $Z_{1-\alpha/2}$, $Z_{1-\beta}$, and d, which respectively measured 1.96, 0.84, and 0.4 × S in pilot study.

Inclusion criteria were age between 18 and 65 years old, ASA I and II (Class one and two of American Society of Anesthesiologist classification), without history or sign and symptoms of acute or chronic respiratory disorder and no history for smoking. Patients who received blood products, intravenous fluids more than 10 mL/kg/h for any reason or showed signs of bronchospasm or laryngospasm during study or need any other drug or treatment (according to orders of their physicians) were excluded from study. Patients were fasted from midnight and took 2 mL/kg isotonic solution during fasting time and they had similar induction and maintenance protocol for anesthesia management during study. According to proposal of study, hemodynamic changes in 30% range of base remained untreated and in out of this range should be treated with their physician after recording the case and exiting them from study.

Height and weight were measured in standing position before patients lay on the operating room (OR) table and height was calculated using demi-span method while patient has laid on the OR table according to these formula:

Demi-span based calculated height for females (in cm) = (1.35 × Demi-span in cm) +60.1

Demi-span based calculated height for females (in cm) = (1.40 × Demi-span in cm) +57.8

Then, BW was calculated according to ARDS-net formula by using standing measured height and demi-span calculated height:

Females: Predicted BW (kg) =45.5 + 2.3 ($height_{(inch)}$ − 60)

Males: Predicted BW (kg) =50 + 2.3 ($height_{(inch)}$ − 60)

VT was calculated as 10 mL/kg of BW, so we had two calculated VT for each participant.

After calculation of VTs, participants were randomized into two groups using random table list generated by random allocation software.

Thereafter, monitoring measures including airway pressure, pulse oximeter, capnograph, non-invasive blood pressure, and electrocardiography were started and general anesthesia was applied. After intubation, mechanical ventilation started while using VT which was calculated previously. In the first group, participants were ventilated by Demi-span based VT for 20 min and then by measured height based VT for 20 min and in the second group vice versa. After the last measuring, patients leaved to manage according to orders of their physicians.

Blindness: This study was double-blinded as the patient was not aware of the intervention group and also the data gathering was carried out by a research co-operator who was not aware of the groups.

Expiratory VT, respiratory rate (RR), peak airway pressure (PAP) plateau airway pressure (PlAP), lung static compliance (S-Comp), lung dynamic compliance (D-Comp), minute ventilation (MV), SPO_2 (percent saturation of hemoglobin by oxygen) and end-tidal of CO_2 ($EtCO_2$), arterial O_2 content (O_2 Cont) and airway resistance (AR), systolic blood pressures (SBP), diastolic blood pressures (DBP), and mean blood pressures (MBP), and heart rate (HR) were measured (or calculated) 5 min after intubation and every 5 min in each of two next 20 min.

Data were analyzed by *t*-test, Chi-square, and multivariate analyses in SPSS statistical software version 20. The statistical significance criterion was set at $P < 0.05$.

RESULTS

During the study period, 49 patients including, 32 males (65.3%) and 17 females (34.6%) with mean age of 29.8 ± 13.3 years were entered the study. Patients didn't have any BP change out of the 30% range of base values during study, and did not have statistically significant difference in fluid intake between two groups.

In all patients, Demi-span based body weight (DBW) was lower than exact body weight (ExBW) ($P = 0.014$) and also lower than measured height based body weight (HBW), ($P = 0.028$) but no significant difference was observed between HBW and ExBW ($P = 0.328$). In male patients, DBW was lower than HBW ($P = 0.005$). ExBW didn't has significant difference with HBW ($P = 0.207$) and DBW ($P = 0.524$). In female patients, both the DBW and HBW was lower than ExBW ($P < 0.05$) but no significant difference to each other ($P = 0.761$) [Table 1].

Differences between the ExBW and HBW (Ex-HBW) and between ExBW and DBW (Ex-DBW) were significantly higher in female than male patients (12.4 ± 12.6 vs. −3.1 ± 11.2 and 11.8 ± 9.5 vs. 1.5 ± 11.1 Kg, $P = 0.001$ and 0.011, respectively) [Figure 2].

Putting all these results together show that calculating BW based on the measured height or based on demi-span are similar to the ExBW in male but not in female patients. Accordingly, we did a multivariate analysis to see, which factors influences Ex-HBW and Ex-DBW. Linear Regression Analysis showed that female gender ($t = 4.S$, $P < 0.001$) and age ($t = 3.9$, $P < 0.001$) significantly predicted discrepancy between ExBW and HBW, but for DBW, only gender ($t = 3.1$, $P = 0.004$) and not age ($t = 1.8$, $P = 0.072$) predicted discrepancy between ExBW and DBW.

Comparison of VT based on HBW (HTV) and VT based on DBW (DTV) is showed in Table 2 and Figure 3.

Table 1: Comparison of body weight based on two methods

	Mean±SD			*P* value
	ExBW	HBW	DBW	
All (*n*=49)	68.1±11.2	65.7±11.9	62.9±7.7	ExBW versus HBW=0.328 ExBW versus DBW=0.014
Male (*n*=32)	69.0±12.6	72.1±8.4	67.5±5.2	ExBW versus HBW=0.207 ExBW versus DBW=0.524
Female (*n*=17)	66.4±8.5	54.0±7.6	54.5±3.2	ExBW versus HBW=0.006 ExBW versus DBW=0.001

ExBW: Exact body weight, HBW: Height body weight, DBW: Demi-span body weight

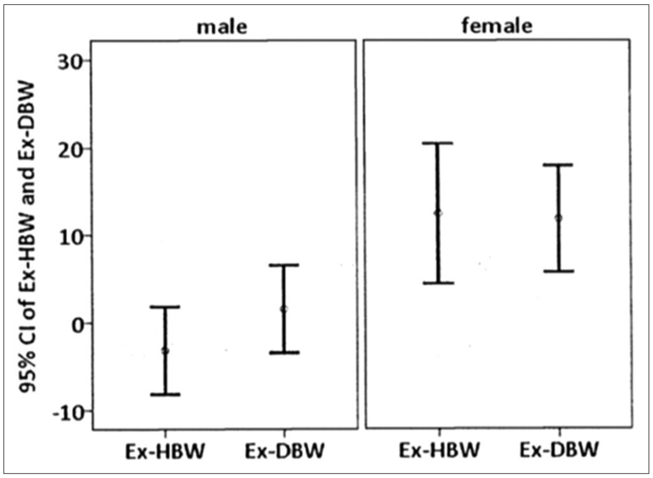

Figure 2: Differences between the exact body weight (ExBW) and height body weight (HBW) (Ex-HBW) and between ExBW and demi-span body weight (Ex-DBW) according to gender

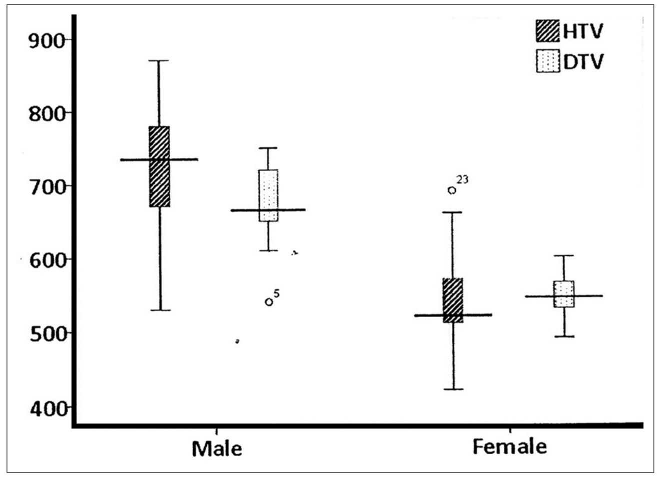

Figure 3: Comparison of tidal volume based on height body weight and TV based on demi-span body weight according to gender

Table 2: Comparison of tidal volume based on two methods

	HTV	DTV	*P*
All, *n*=49	657.6±119.5	629.4±77.5	0.028
Males, *n*=32	721.8±84.3	675.0±52.1	0.005
Females, *n*=17	540.0±76.9	545.8±32.8	0.761

HTV: Tidal volume based on measured height, DTV: Tidal volume based on demi-span

As patients entered two different protocols; receiving HTV then DTV or DTV then HTV measurements were repeated between the two groups (protocols), means and *P* values were mentioned in Figure 4.

DISCUSSION

The aim of the present study was to evaluate the effects of height calculation based on demi-span method for VT calculation in ARDS-net formula on respiratory and cardiovascular function during mechanical ventilation in normal lungs during general anesthesia. As the results showed, BW calculated based on demi-span was lower than BW calculated based on measured height and this difference was statistically significant in male but not in female patients ($P = 0.005$). These results were similar with results of Deane *et al.*,[8] which showed that "predicted BW" (calculated from demi-span) was lower than "recorded weight" (defined as a weight measured by scales or a dietitian-estimated weight) and the difference was prominent in men.

Following BW, in our study, VT based on demi-span was lower than VT based on measured height but this difference remained only in male patients. These results shows that BW calculation in female patients can be carried out either based on measured height or demi-span but in male patients, it must be carried out with cautious. This result was in contrast to study by Deane *et al.*,[8] which showed that mean VTs calculated from "predicted BW" (demi-span) were greater than those calculated from recorded BW. The difference between our results and results of their study might be related to the definition of the recorded BW. In our study, we calculated BW based on measured height but Deane *et al.*,[8] defined "recorded BW" as a weight measured by scales or a dietitian-estimated weight.

In this study, trend of changes in blood pressures (SBP, DBP, MBP) were similar between patients receiving VT based on BW calculation by two methods. The only difference in hemodynamic parameters was observed in HR at 5 min after VT based on measured height, which was lower than HR after VT based on demi-span and difference exist only for male and not for female patients. More detailed analysis showed that bradycardia was observed in 14.7% of the measured time while receiving VT based on measured height and in 17.6% of the measured time while receiving VT based on demi-span, which does not reflect a clinical difference.

Similarly, regarding ventilation parameters (RR, SaO_2, PAP, PlAP, $EtCO_2$, O_2 content, S-Comp, D-Comp, MV, and AR), almost all parameters had similar trend of changes between patients receiving VT based on BW calculation by two methods. The only difference was observed for PAP and AR. Indeed, after crossing the groups a difference was observed in PAP and AR changes with a slightly higher PAP and AR at 20 min after receiving VT based on measured height compared with that of after receiving VT based on demi-span which shows that higher VT resulted in higher PAP and higher AR after 20 min under mechanical ventilation.

Studies showed that obesity is a risk-factor for poor outcome in mechanical ventilation, with studies demonstrating an association with increased mortality

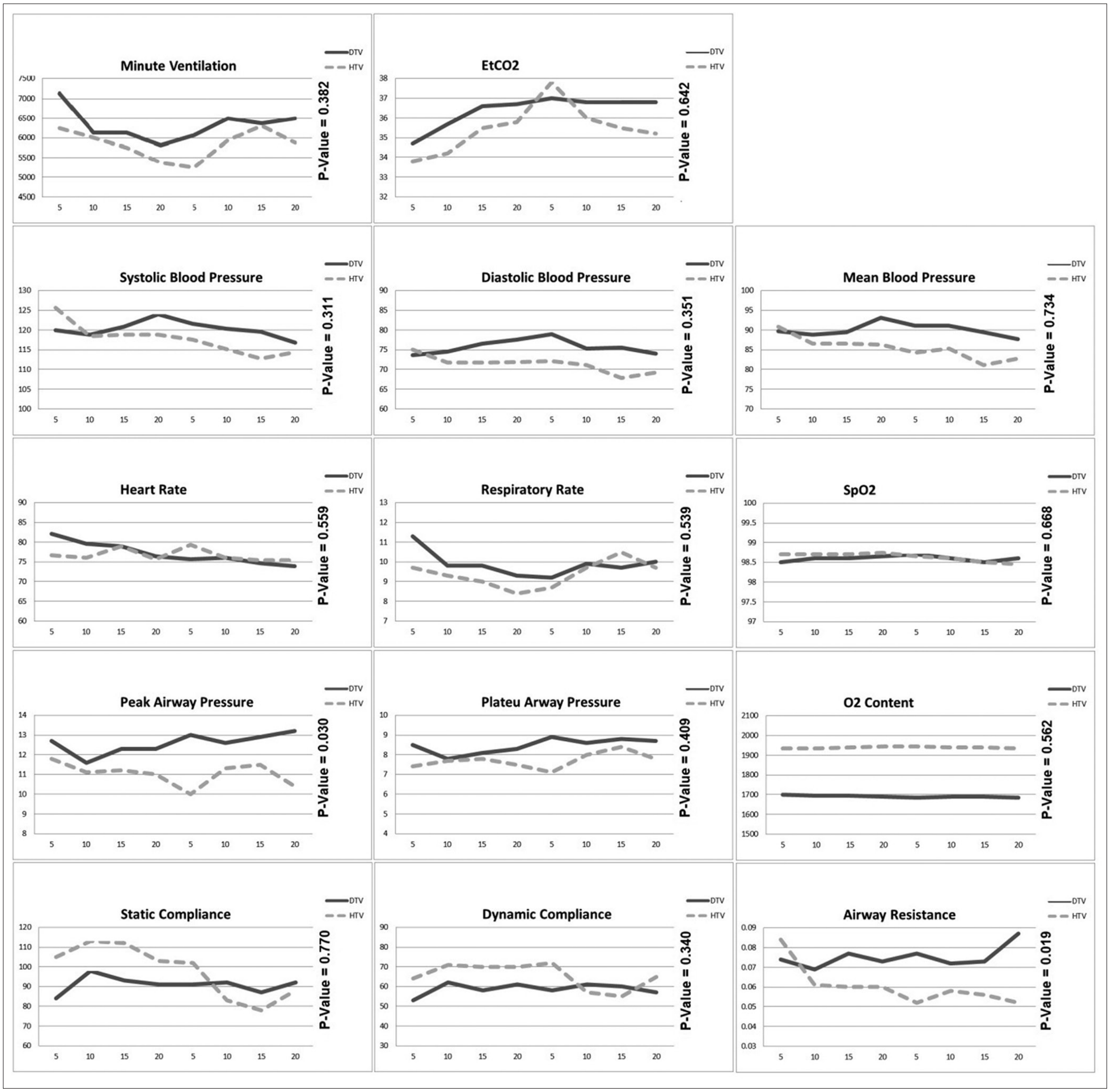

Figure 4: Comparison of hemodynamic and respiratory parameters at 5, 10, 15, and 20 min of study

or morbidity.[10,11] A retrospective review found obese patients received higher VTs than patients with normal BMI, and that, when obese patients were ventilated on a predicted BW protocol, there was no association between BW and mortality.[12] Given that BW based on demi-span was less than BW based on measured height, it is conceivable that overestimation of weight could be especially problematic for obese patients, leading to ventilation with inappropriately large VTs.

The results of the present study showed that estimation of BW and thus, calculation of VT based on measured height is higher than that based on demi-span and this difference exists only in females. This difference has few effects on hemodynamic and ventilation status that was a higher PAP and higher AR while after receiving higher VTs (i.e., based on measured height).

REFERENCES

1. Grasso S, Mascia L, Ranieri VM. Respiratory care. In: Miller RD, editor. Miller's Anesthesia. 7th ed. Philadelphia: Churchill Livingstone; 2010. p. 2880.
2. Cortés I, Peñuelas O, Esteban A. Acute respiratory distress syndrome: Evaluation and management. Minerva Anestesiol 2012;78:343-57.
3. Tunnicliffe B. Mechanical ventilation. In: Smith FG, editor. Core Topics in

Critical Care Medicine. 1th ed. New York: Cambridge University Press; 2010. p. 215.

4. Lipes J, Bojmehrani A, Lellouche F. Low Tidal Volume Ventilation in Patients without Acute Respiratory Distress Syndrome: A Paradigm Shift in Mechanical Ventilation. Crit Care Res Pract 2012;2012:416862.
5. Thille AW, Rodriguez P, Cabello B, Lellouche F, Brochard L. Patient-ventilator asynchrony during assisted mechanical ventilation. Intensive Care Med 2006;32:1515-22.
6. Haas CF, Bauser KA. Advanced ventilator modes and techniques. Crit Care Nurs Q 2012;35:27-38.
7. Hickson M, Frost G. A comparison of three methods for estimating height in the acutely ill elderly population. J Hum Nutr Diet 2003;16:13-20.
8. Deane AM, Reid DA, Tobin AE. Predicted body weight during mechanical ventilation: Using arm demispan to aid clinical assessment. Crit Care Resusc 2008;10:14.
9. Hirani V, Mindell J. A comparison of measured height and demi-span equivalent height in the assessment of body mass index among people aged 65 years and over in England. Age Ageing 2008;37:311-7.
10. Goulenok C, Monchi M, Chiche JD, Mira JP, Dhainaut JF, Cariou A. Influence of overweight on ICU mortality: A prospective study. Chest 2004;125:1441-5.
11. Bercault N, Boulain T, Kuteifan K, Wolf M, Runge I, Fleury JC. Obesity-related excess mortality rate in an adult intensive care unit: A risk-adjusted matched cohort study. Crit Care Med 2004;32:998-1003.
12. O'Brien JM Jr, Welsh CH, Fish RH, Ancukiewicz M, Kramer AM. National Heart, Lung, and Blood Institute Acute Respiratory Distress Syndrome Network. Excess body weight is not independently associated with outcome in mechanically ventilated patients with acute lung injury. Ann Intern Med 2004;140:338-45.

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