Residência RP Pediátrica
Publicação Oficial da Sociedade Brasileira de Pediatria

Submitted on: 08/09/2021
Approved on: 12/14/2021

ORIGINAL ARTICLE

Adequacy of tidal volume supplied during invasive mechanical ventilation in preterm infants

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Keywords:
Intensive care units,
Infant,
Newborn,
Diseases,
Respiration,
Artificial,
Physical therapy
Mmodalities.

Abstract

Objective: To verify the adequacy of the tidal volume (VT) of the preterm newborn (PTNB) under mechanical ventilation according to the parameter adjustments made by the team and to compare it with the ideal tidal volume for the weight. **Method:** This is a cross-sectional study with a sample composed of PTNB with gestational age (GA) <37 weeks hospitalized in the Neonatal Intensive Care Unit of Hospital Agamenon Magalhães. Six VT measurements were collected for 60 seconds and the adequacy of the VT found was assessed by calculating the ideal tidal volume (VTi) using the formula Vti = 4ml / kg x current weight. **Result:** The sample of 16 premature infants, 68.7% had inadequate TV at the time of collection. PTNBs with GA above 30 weeks obtained a statistically higher TV (TV = 12.27 ± 2.22mL). When corrected for weight, those with GA <30 had a corrected VT of 9.34 ± 4.63 mL / Kg, not statistically significant, but mportante from a clinical point of view. **Conclusion:** It was found that PTNB below 30 weeks were exposed to VT greater than the ideal range for weight. With this, it is possible to identify the importance of continuous monitoring of the VT, favoring a better ventilatory assistance, minimizing lung injuries.

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Residência Pediátrica; 2023: Ahead of Print.
DOI: 10.25060/residpediatr-2023.v13n2-706

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INTRODUCTION

In recent decades, the survival rate of increasingly extremely premature infants has increased sharply, and this has led to a significant raise in the number of pathologies associated with prematurity, especially pulmonary disorders that can increase morbidity and mortality in these individuals[1-3]. Premature or preterm newborns (PTNB) are those who are born with a gestational age (GA) of less than 37 weeks and weighing less than 2500g[4].

The PTNB can present several complications after birth, due to their pulmonary, central nervous and cardiovascular system immaturity, predisposing them to difficulty ventilating their lungs, which can lead to respiratory failure. These immature lungs present deficits in surfactant production and increased intra-alveolar fluid, which makes it difficult to establish and maintain functional residual capacity (FRC) and gas exchange[5,6].

Among the respiratory disorders presented by PTNB, there is respiratory distress syndrome, apnea and infections, which lead to the need for invasive mechanical ventilatory support[7,8]. Although this intervention is essential for the survival of extremely premature infants, having a beneficial effect on lung function and establishing an improvement in gas exchange, this support also has its disadvantages and is linked to the high risk of MV-associated lung injury (VALI), and in the long term, to the development of chronic diseases such as bronchopulmonary dysplasia (BPD)[9].

The known mechanisms of VALI are barotrauma, volutrauma, atelectrauma and, more recently, biotrauma[10]. One of the most frequent in premature infants is volutrauma, which is caused by excessive tidal volume (tidal volume - TV) during MV, causing alveolar hyperdistention. This factor increases pulmonary inflammatory response, with recruitment of neutrophils and release of pro-inflammatory cytokines, leading to increased capillary permeability, leakage of fluid into the interstitium and enlargement of the alveolar-capillary membrane, causing pulmonary edema[11]. The use of low TV is recommended for preterm infants in order to minimize volutrauma, with a range between 3 and 5mL/Kg[12] being recommended.

In clinical practice, most ventilators in use in neonatal intensive care units (NICU) do not provide ventilatory modes with target volume, currently recommended in the literature for use in neonatal patients. The pressure-limited ventilation modes make the TV dependent on the patient's respiratory mechanics and the adjusted parameters (variation of pressure, flow and inspiratory time). In some ventilators, it is possible to monitor the volume through the respiratory function monitor[13,14]. However, it is still common for this monitoring during positive pressure ventilation to be estimated by the PTNB's chest expansion, an unreliable method because it is examiner-dependent[15].

In view of the above, the objective of the present study was to check the adequacy of PTNB tidal volume under mechanical ventilation according to the parameter adjustments made by the team and compare it with the ideal tidal volume for weight.

METHODS

This is a cross-sectional study, carried out at the Neonatal Intensive Care Unit of the Agamenon Magalhães Hospital (AMH), located at Estrada do Arraial, s/n, Casa Amarela, Recife – PE. Data were collected between March and November 2018, after approval by the research ethics committee of the aforementioned hospital, with CAAE number - 0227.0.236.000-11.

The study was carried out in preterm infants with gestational age < 37 weeks, of both sexes, admitted to the unit during the data collection period. The use of invasive mechanical ventilation for a period equal to or longer than 24 hours was considered as an inclusion criterion, excluding those PTNB with pathologies that extrinsically limited alveolar ventilation (air leakage syndromes - drained or not; pleural effusion and diaphragmatic hernia).

After signing the free and informed consent form by the parents or guardians of the newborn, the collection of anthropometric, demographic and clinical data obtained from the patient's medical records and cataloged in a form created by the researchers. Data related to ventilatory support were also collected, as well as the parameters used at the time of collection, by consultation at the bedside.

The INTERMED© neonatal proximal flow sensor was used to perform the collection, being coupled to the mechanical ventilator circuit, usually an Inter Neo, IX 5 or Inter 5 plus – INTERMED. Six measurements of tidal volume (TV) were collected during 60 seconds (one measurement every 10s). Subsequently, the average of these values was calculated. Ventilatory parameters that could interfere with TV were also noted: ΔP [inspiratory pressure – end-expiratory pressure (PEEP)]; flow and inspiratory time (IT). However, there was no variation in the flow and IT parameters, which were not considered for the statistical analysis. No adjustments were made by the researchers before or after monitoring.

To assess the adequacy of the TV found, the ideal tidal volume (iTV) was calculated for the current weight, using the average value in the range of 3 to 5 ml/Kg recommended for preterm infants in the literature, according to the formula: iTV= 4mL/Kgx current weight

For data evaluation, SPSS 13.0 software (Statistical Package for the Social Sciences) for Windows and Excel 2010 were used, with all tests being applied with 95% confidence. The results are presented in a table with their respective absolute and relative frequencies. Numerical variables are represented by measures of central tendency and measures of dispersion. For the comparison between two groups we used the Mann-Whitney test. For the evaluation between paired groups, the Wilcoxon test was used.

RESULTS

The AMH Neonatal ICU has 16 beds, but there are only 8 ventilators with tidal volume monitoring available, which limited the possibility of data collection, with the sample consisting of 16 PTNBs. The admission diagnosis of PTNBs included: respiratory distress syndrome (75%), early sepsis (62.5%), perinatal hypoxia (37.5%) and respiratory distress secondary to other causes (12.5%).

Table 1 describes general characteristics in relation to birth, in which it can be seen that more than 50% of the sample were born by vaginal delivery and were female. Regarding the need for surfactant replacement, it appears that 56.3% of the PTNB used this medication. As for the percentage of PTNB with adequate tidal volume at the time of collection, we found that only 5 newborns (31.3%) had tidal volume within the recommended range.

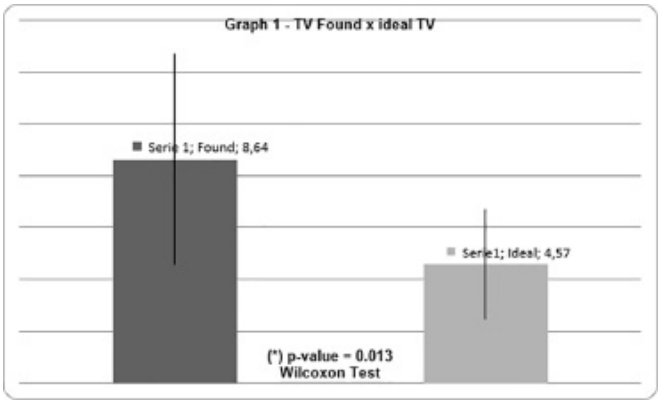
Table 1. Characteristics of premature newborns.

Variables		%
Sex		
Females	9	56,3
Males	7	43,8
Type of delivery		
C-Section	6	37,5
Vaginal	10	62,5
Apgar 5 min		
< 7	6	37,5
≥ 7	10	62,5
Surfactant		
Yes	9	56,3
No	7	43,8
TV found above the ideal TV		
Yes	11	68,7
No	5	31,3

None of the evaluated preterm infants presented hypoventilation with TV below the safe range of 3 to 5mL/kg.

Table 2 describes the characteristics of the sample in terms of demographic data and ventilatory support, in which we can see that the average GA of the newborns studied was extremely premature (< 30 weeks), who remained on average for 5 days in the mechanical ventilation, consisting of a more vulnerable population due to gestational age and exposure to MV during a period of greater susceptibility (first week of life) to lung injury associated with mechanical ventilation.

Graph 1 shows the comparison of the supplied tidal volume and the ideal tidal volume (calculated by the PTNB's current weight). We can see that the volume supplied was almost double the volume that should be reached to avoid injury due to alveolar hyperdistention, with both clinically and statistically significant difference (8.64 ± 4.08 versus 4.57 ± 2.12, p = 0.013).



Graph 1. Found VT x Ideal VT.

In table 3, the mean tidal volume found and the ideal one were compared and associated with the gestational age and with the ΔP used at the time of collection. We can see from the table that babies over 30 weeks of gestational age had a statistically higher TV (TV = 12.27 ± 2.22mL). When corrected for weight, babies with GA < 30 weeks had a higher corrected TV offer, of 9.34 ± 4.63 mL/Kg, not statistically significant, but an important variation from a clinical point of view , considering the greater lung immaturity in this range.

Table 2. Demographic profile and ventilatory support of premature newborns.

Variables	Mean ± SD	Median (Q1; Q3)	Minimum – Maximum
GA (weeks)	27.92 ± 3.50	26.00 (25.32; 30.96)	24.71 – 35.00
BW (g)	1179.00 ± 564.60	890.00 (840.00; 1603.75)	680.00 – 2650.00
Days of life	13.56 ± 10.15	7.50 (5.00; 24.50)	2.00 – 31.00
CGA (weeks)	29.73 ± 3.75	28.07 (26.78; 32.82)	26.14 – 38.14
Current weight (g)	1143.63 ± 530.08	895.00 (731.25; 1560.00)	660.00 – 2495.00
Days in MV	7.81 ± 6.94	5.00 (3.25; 12.50)	1.00 – 23.00

Table 3. Mean TV and ideal TV in relation to GA.

Variables	TV supplied (mL)	TV found in mL/Kg	Ideal TV (mL)
	Mean ± SD	Mean ± SD	Mean ±SD
GA (Weeks)			
<30	7.51 ± 3.22	9.34 ± 4.63	3.38 ± 0.82
≥30 weeks	12.27 ± 2.22	7.09 ± 2.12	7.19 ± 1.63
p-value *	*0.015*	*0.336*	*0.002*
Pressure variation used (cmH_2O)			
<14	10.11 ± 3.79	8.93 ± 4.60	5.12 ± 2.44
≥14	7.14 ± 2.80	8.16 ± 3.38	3.65 ± 1.04
p-value *	*0.082*	*0.914*	*0.329*

(*) Mann-Whitney Test.

When compared by the ΔP used (without specifying the gestational age), we can see that even a pressure variation considered low was capable of generating an excessive tidal volume.

DISCUSSION

In the present study, 68.7% of the evaluated preterm infants had tidal volumes higher than those recommended, reaching corrected average values for weight between 7 and 9mL/Kg. This demonstrates the difficulty in measuring, offering and/or maintaining an adequate tidal volume in neonatal patients. This fact occurs both due to the characteristics of the ventilator itself and the ventilation mode offered, as well as the respiratory physiology of the PTNB and the type of artificial airway used.

In neonatology, pressure ventilatory modes are classically used, which limit or control pressure (TCPL or PCV, respectively), but do not ensure tidal volume, causing a variation in this volume at each cycle[16]. Adult ventilators that can be used in neonatal patients have pressurization impairment in the presence of leaks, which can occur with some frequency in premature infants due to the use of uncuffed orotracheal tubes, giving the false impression of generating inadequate tidal volume and leading to the team to increase parameters, mainly ΔP[17].

Furthermore, the monitoring of this tidal volume, so commonplace in adult intensive care units, does not occur frequently in Neonatal ICUs, which is determined by clinical evaluation of peripheral oxygen saturation, chest expansion and X-rays. This has already been documented in the literature, that the evaluation of the expansion of 0.5 cm of the chest during inspiration to determine an adequate tidal volume is not reliable in predicting the adequacy of the adjusted parameter with the ideal current VT for the weight, since this form of evaluation is subjective and dependent on the examiner's experience[15].

In a similar study, carried out previously in the same unit for monitoring the TV, we noticed that 80% of the preterm infants had a TV above the recommended level[18]. Therefore, it is essential to use the flow sensor to check the volume in preterm infants.

Moderate assistance should be used to reduce lung injuries in the first minutes of life, as well as this care should be extended to the first week of life. Monitoring in neonates is advised by experts to minimize the possibility of harmful ventilation with inadequate TV given at birth. As current data suggest a range of 4-8 ml/kg is recommended for neonatal ventilation, there are few reports indicating which TVs are safe in preterm infants[19].

The current trend is to use target volume ventilation. In volume-directed ventilation, the ventilator monitors the TV with each inflation, thereby reducing the risk of volutrauma. Studies have described a reduction in TV change using volume-guided ventilation[20]. An ideal TV should be preserved for greater lung compliance, preventing overinflation[21]. However, the use of this ventilatory mode is not yet a reality in clinical practice, either due to the lack of ventilators capable of suppling it, or due to the lack of experience of the team with its handling and correction of possible asynchronies that occur during its use.

CONCLUSION

We have seen that 68.7% of the sample had a TV above the ideal variation range, with the average TV found being almost twice the ideal TV. None of the preterm infants had a TV below the recommended range. Regarding the TV found by gestational age, we noticed that premature infants with gestational age above 30 weeks had statistically higher TV values and premature infants with gestational ages below 30 weeks were exposed to an average TV of 9 mL/Kg.

Thus, we noticed the importance of continuous monitoring of this volume in intubated premature infants, whose ventilators did not supply ventilation mode at target volume. This monitoring favors better ventilatory assistance, enabling TV control supplied in order to minimize lung injuries resulting from the use of MV.

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