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EFFECT OF ALVEOLAR RECRUITMENT MANEUVER ON PULSE PRESSURE VARIATION: A CASE REPORT

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Abstract: This research aimed to evaluate the effect of the alveolar recruitment maneuver and the identification of the ideal PEEP on the Pulse Pressure Variation (PPV) in a patient with acute respiratory failure under mechanical ventilation. To verify the ideal PEEP, the Open Lung Approach (OLA) alveolar recruitment maneuver was performed, and the PPV was evaluated at each stage of the recruitment protocol. The PPV presented a lower percentage in the plateau stages below 30ml/cmH2O and in the best Static Compliance of the Respiratory System (Csr). Optimal PEEP, in addition to promoting the opening of collapsed units, minimizes the occurrence of atelectrauma and possibly the dynamic overdistension of the respiratory system, reducing pulmonary vascular resistance, cardiac work and the use of vasoactive drugs.
Keywords: Alveolar recruitment, Open LungAprroach, Pulse Pressure Variation.

INTRODUCTION

Mechanical Ventilation (MV) is an artificial way to maintain oxygenation and/or ventilation in patients with acute or chronic respiratory failure, reducing the work of the respiratory muscles, reversing or preventing ventilatory failure. due to muscle fatigue, in addition to enabling specific therapeutic procedures [1.]

The recruitment maneuver is one of the procedures in mechanical ventilation capable of increasing the lung surface and opening previously collapsed alveolar units through the use of high pressure levels in the respiratory system for short periods of time, which can be performed with progressive increases in PEEP. [2.]

One of the most used PEEP strategies today is the Open Lung Approach (OLA) which aims to find the individualized PEEP that promotes the best Static Compliance of the Respiratory System (Csr) or the best Elastance of the Respiratory System (Esr) [3.] However, high levels of PEEP can reduce venous return and increase pulmonary vascular resistance, in addition to significant cardiac impairment [4.]

In this regard, hemodynamic monitoring becomes essential to quantify cardiovascular responses, especially in patients under invasive ventilatory support, due to the fact that variables such as heart rate, cardiac output, systolic blood pressure, diastolic blood pressure, venous return, among others they will be subject to changes as a result of the underlying pathology [6] and the effects of MV[14.]

Thus, the verification of the Pulse Pressure Variation (PPV) becomes important, because in addition to assessing responsiveness to fluid therapy, it also has significance in predicting hemodynamic effects of therapies using PEEP[5]. The aim of this study was to verify the effects of the alveolar recruitment maneuver on pulse pressure variation in mechanically ventilated patients.

Keywords: Mechanical ventilation; PEEP titration; pulse pressure variation.

GOALS

General Objective: To assess pulse pressure variation in response to PEEP titration or applicability of the PEEP table (ARDS Network).

Specific objectives

- Evaluate pulse pressure variation in response to PEEP titration and applicability of ARDS Network tabulated PEEP.

- Compare the pulse pressure variation response in PEEP titration applications and in the ARDS Network.

- To analyze and compare the hemodynamic effects in response to the use of titrated PEEP and the ARD Network.

JUSTIFICATION

The use of both PEEP titration and tabulated PEEP are routine applications in ICUs, especially in patients who have significant ventilatory changes or when diagnosed with Acute Respiratory Distress Syndrome (ARDS), these therapeutic approaches can corroborate hemodynamic changes as which sometimes require the use of vasoactive drugs, due to increased blood pressure.

METHOD

This is a case report, carried out in the Intensive Care Unit of a public hospital in Brusque-SC. One individual participated in the study (female, 62 years old, 85kg, 1.55m), hospitalized for acute respiratory failure, submitted to MV PCV mode, with initial parameters: pressure of 14, PEEP.7, vt.0.390, flow. 55, FR. 17, thread 2.0.48%, peak pressure. 23, plateau. 17, C.sr.36ml/cmH2O; Driving Pressure.10cmH2O/l/s; arterial blood gas analysis 1 hour after orotracheal intubation. Ph.7.47, PaCO2.38, PaO2.122.1, HCO3.21.0, BE.1.8, Ratio PaO2/FiO2.254, DA-a.201.

On the 2nd day of MV, the patient presented worsening of the ventilatory and hemodynamic condition, requiring an increase in ventilatory parameters and the use of vasopressor drugs for stability, the drugs used were: Noradrenaline 25 ml/h and Vasopressin 10 ml/h. ventilations were: pressure 19, PEEP.10, VT.0.514, flow.46, RR. 20, FiO2.0.48%, peak pressure. 29cmH2O, plateau. 27cmH2O, Driving pressure.17.0cmH2O/l/s; arterial blood gases: Ph.7.58, PaCO2.28.7, PaO2.81.6, HCO3.27.6, BE.6.6, PaO2/FiO2.170 ratio, DA-a.246. Access was performed to check invasive blood pressure (IBP) in the right upper limb and coupled to the Mindray Umec12 multiparameter monitor.

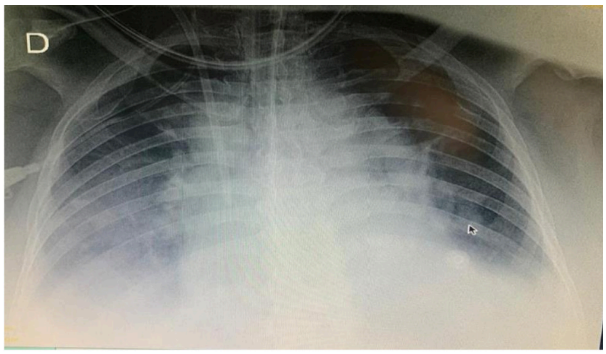

Figure 1: Chest X-ray after the second day of hospitalization.

After the implantation of the AIP, a radiographic image was performed, which showed bilateral opacity, mainly in bases with consolidative characteristics, in addition to an increase in the cardiac area and the mediastinum. Then, the pulse pressure variation was measured according to the following criteria:

Absence of respiratory stimulus;

Invasive mechanical ventilation in controlled mode with tidal volume ~8ml/Kg and PEEP of 5 cmH2O;

Hemodynamic stability due to a variation in heart rate and blood pressure of less than 10% in the 15 minutes before the start of the protocol.

After performing the protocol, pulse pressure values were collected and calculated according to the formula: PPV = (PPmax – Ppmin) / ([PPmax + PPmin]/2) [7,] its value being 3.5%. This value refers to a patient not responsive to fluid therapy.

After checking the PPV, the fluid that was at 40ml/h was reduced to 21ml/h, but the dosage of vasopressor drugs was maintained to maintain blood pressure, then, by common agreement between the team, the recruitment maneuver was performed. pulmonary OLA, strictly following the protocol:

The volume ventilation mode (VCV), with the square flow curve, VT at 5ml/kg predicted (0.240ml); PEEP of 25 cmH2O, FIO2 of

1.0 and RR to maintain PaCO2 between 35 and 60 mmHg. During titration from ideal PEEP to RR, VT and inspiratory flow were not changed, only PEEP was progressively reduced from 25 cmH2O to 8 cmH2O, with steps of 2cmH2O for 30 seconds at each PEEP level. At the end of the 22nd of each PEEP stage, the PPV was evaluated and at the end of the thirtieth second, the Csr and plateau.

After completion of the protocol, the best PEEP stage was found at which PEEP was found, with PEEP maintained at 2cmH2O above the best Csr found [3]. After a period of 60 minutes, the PPV was reassessed with the parameters already established by the recruitment protocol.

RESULTS AND DISCUSSION

In the table 1 below, the measurement of PPV is represented in the protocol form with 4.7%, value obtained with PEEP of 5cmH2O, vt~8ml/kg, but Cst at 14ml/cmH2O, this value showed a reduction of 25.6 % when PEEP was 10cmH2O and Cst was 23ml/cmH2O, in the pre -recruitment period, the PPV presented variations at each stage of the titration, and at the maximum peak recruitment pressure, the PPV had an increase of approximately 29 86% of its initial value from the protocol measurement, and 47.77% when it started the ideal PEEP assessment protocol.

During recruitment, there was no change in both tidal volume and respiratory rate, as the values of ventilatory mechanics were measured at each stage of PEEP, the PPV showed a gradual reduction, however, the points with the lowest percentage of PPV were where presented the best Csr and the lowest plateau, and in the last stage of the PEEP titration the PPV returns to increase by 50% when the Csr falls by 20%. The effect of the recruitment maneuver showed a reduction of more than 100% of the PPV

PEEP	Mr.	Plateau	drivingpressure (PEEP-PEEP)	Driving Pressure (vt / Csr)	VPP
Pre-recruitment PEEP 10cmH2O	23	27	17	22.3	3.5%
PEEP for verification of PPV 5cmH2O	14	12	9	48.5	4.7%
25cmH2O	------	------	------	------	3.4%
30cmH2O	------	------	------	------	4.9%
35cmH2O	------	------	------	------	6.7%
23cmH2O	24	35	12	10.0	3.1%
20cmH2O	28	32	12	8.57	2.6%
17cmH2O	29	29	12	8.27	1.8%
14cmH2O	30	26	12	8.0	1.8%
11cmH2O	30	23	12	8.0	1.7%
8cmH2O	24	20	12	10.0	3.4%
Ideal PEEP 11cmH2O + 2cmH2O = 13cmH2O	30	24	11	13.3	1.7%
Optimal PEEP after 60 minutes 13 cmH2O	29	24	11	13.8	1.6%

Table 1. PPV variation during the entire alveolar recruitment maneuver.

percentage and maintaining this result for a prolonged time as shown in the table below:

Protocol for measuring PPV	4.7%
pre-recruitment VPP	3.5%
VPP after recruitment	1.7%
VPP 1 hour post-recruitment	1.6%

Table 2. PPV ratio before, immediately after the recruitment maneuver and 1 hour after the procedure.

After 1 hour of the maneuver, the PPV was verified, in which there were no significant variations.

The main findings of this study suggest that static compliance and ideal PEEP had greater effects on the reduction of PPV in relation to tidal volume, as low VTs have little ability to change both alveolar pressure and intrathoracic pressure, therefore, pulse pressure[8]. However, when it comes to lung compliance, the transmission of pressure in the airways can be reduced, especially in cases where Crs is >30ml/cmH2O [8,] contradictorily, this fact can be seen in the study in which patients ventilated with tidal volume greater than 8ml/kg and with Cst. Higher than 30ml/cmH2O had a high PPV, while the other group with a tidal volume greater than 8ml/kg and a Csr less than or equal to 30ml/cmH2O had a low PPV, demonstrating that the reduction of Csr may play a more important role than properly the tidal volume [9.]

In the case of PEEP, its use is known to induce a reduction in systolic volume [11] which is correlated with the patient's volume status, especially with regard to volume responsiveness [10] the study by Santos et al. reported that the combination of pulmonary recruitment and a PEEP titration may, in addition to extending lung protection, not have deleterious effects on the right ventricle, this is due to the fact that PEEP was titrated by the best Csr. [13]

Despite the analyzed data referring to the influence of PEEP and Csr as parameters to reduce airway pressure and consequently in the variation of pulse pressure, another important data is DrivingPressure, as the cyclical effect of mechanical ventilation on the cardiac system may be reduced as it becomes smaller.[12]

OLA does not have negative effects on pulmonary vascular mechanics, this fact is related to PEEP being titrated by the best Csr and absence of pulmonary collapse, in addition to the fact that Driving Pressure <15cmH2O reduces the possibility of developing acute right ventricular failure.[13]

Thus, it is worth mentioning two situations to be questioned: first: Does the pulmonary recruitment maneuver have the capacity to reduce the use of vasoactive drugs in the intensive care unit? Second: Is a lung recruitment maneuver necessary to predict fluid responsiveness?

Thus, further studies are necessary for its verification and further analysis of the effects of the recruitment maneuver on the reduction of vasoactive drug use and post-recruitment fluid responsiveness in critically ill patients.

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