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Analysis of epidemiological profile and ventilator parameters of postpartum women submitted to mechanical ventilation guided by electrical impedance tomography

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ABSTRACT

Introduction: Pregnancy-related diseases have aggravated the situation of postpartum women, who end up using Mechanical Ventilation (MV) when admitted to Intensive Care Units (ICU). Although MV has benefits, it is associated with deleterious effects that can be minimized with the use of Electrical Impedance Tomography (EIT). **Objective:** The aim was to analyze the epidemiological profile and ventilatory parameters of mothers, which developed HELLP Syndrome, sepsis and/or Acute Respiratory Distress Syndrome (ARDS), under MV and monitored with EIT. **Methods:** The study was observational, cross-sectional, retrospective and prospective conducted between March and September 2018, using data collection forms filled from the database and sociodemographic, obstetric and ventilatory records of postpartum women admitted to adult ICU. **Results:** The sample consisted of 13 postpartum women, 8 with sepsis (61.5%), 7 with HELLP syndrome (53.8%) and 4 with ARDS (30.8%). Five patients (38.5%) evolved with more than one of these conditions. Regarding the ventilatory parameters evaluated, VT 378.9 (±103.9) mL were observed and mean values found for PEEP 9.8 (±1.9) cmH_2O and driving pressure 11.1 (±1.4) cmH_2O are below recommendations in the literature, predicting lower mortality and morbidity index. **Conclusion:** The relevance of the driving pressure assessment in the MV setting was demonstrated, a parameter assessed by the EIT and directly related to static lung compliance (Cstat), PEEP, VT and optimization of regional pulmonary ventilation. It is highlighted the need for future research with greater clinical significance regarding the profile of postpartum women about the increasingly frequent diseases in this population.

Keywords: postpartum period; electric impedance; respiration, artificial; Respiratory distress syndrome, adult; sepsis; HELLP Syndrome.

INTRODUCTION

According to the World Health Organization[1], in 1990, about 585,000 women died due to diseases related to pregnancy and/or complications during childbirth. These data are closely related to the countries' socio-economic development; 95% include underdeveloped countries, unskilled group Brazil is inserted.

The pregnant-puerperal cycle is marked by intense anatomical, physiological and biomechanical changes to adapt the maternal organism to fetal development during pregnancy and by the rapid involution of the body to conditions prior to pregnancy, during the puerperium[2].

Therefore, a clear approach is needed on the main repercussions caused to parturients due to pregnancy-related diseases, of which the specific Hypertensive Disease of Pregnancy, the HELLP Syndrome (Hemolysis, Elevated Liver enzymes, Low Platelet count) and the Sepsis, with pulmonary repercussions, as well as the secondary installation of other non-specific pathologies in this group, such as the Acute Respiratory Discomfort Syndrome (ARDS), which can considerably aggravate the situation of postpartum women admitted to Intensive Care Units (ICU)[3-5].

In this context of worsening of the clinical condition of patients in the ICU, among the main therapeutic interventions used to minimize damage, there is mechanical ventilation (MV), a process of external maintenance of the ventilatory function of patients unable to sustain it spontaneously, showing itself as an important tool in the treatment of critically ill patients. However, despite being a necessary and beneficial intervention, its use is associated with deleterious effects on lung tissue, which may contribute to the worsening of patients[6,7].

However, it is currently possible to reduce these effects through the use of protective ventilatory strategies and, in this context, driving pressure has become increasingly discussed and evaluated. This is a ventilatory variable obtained by the equation (Plateau Pressure - Positive end-expiratory pressure), which, with the proper adjustment, was associated with longer survival in recent randomized clinical studies[8-10].

Thus, driving pressure can be assessed and monitored by electrical impedance tomography (EIT), a non-invasive technique that can be performed at the bedside, free of radiation, and which mainly allows the visualization/quantification in real-time of the distribution ventilation and pulmonary perfusion, ensuring the effectiveness of the management of the patient[11,12].

Another important factor evaluated by EIT is static lung compliance (Cst), facilitating the identification of alveolar collapses, when present, in some regions of the lung (decreased Cst), as well as reduced alveolar hyperdistension in other regions (causing increased Cst), during, for example, decremental titration of positive end-expiratory pressure (PEEP) in patients with ARDS[13,14].

Thus, this study aimed to describe the epidemiological profile and compare ventilatory parameters of puerperal women with ARDS, HELLP syndrome and sepsis, submitted to mechanical ventilation using electrical impedance tomography.

METHODS

This is a retrospective and prospective cross-sectional observational study, which is part of the project entitled "Pulmonary Assessment of Patients on Invasive Mechanical Ventilation through Electrical Impedance Tomography", underway at the Foundação Santa Casa de Misericórdia do Pará (FSCMP), under approval by the Research Ethics Committee (CEP) No. 2,251,640 and Clinical Trials under approval No. NCT03715647.

The research began after approval by CEP/FSCMP No. 2,517,703. Complies with the Research Standards Involving Humans (466/12 and 580/18) of the National Health Council.

The sample of this research and the inclusion criteria consisted of data from puerperal women admitted to the adult ICU of the FSCMP, from September 2017 to September 2018, which evolved with the diagnoses of ARDS, HELLP Syndrome or sepsis, being sedated and who needed invasive mechanical ventilation in assisted-controlled mode during their hospital stay.

The data corresponding to patients hospitalized outside the stipulated period was not considered. Patients who had difficulty in sedation, psychomotor agitation, asynchrony with the mechanical ventilator; in the spontaneous mode of mechanical ventilation; performing spontaneous breathing test (ERT) for ventilatory weaning; requiring tracheostomy; or with brain death diagnosis were excluded from this study.

The criteria described above were adopted because they interfere with the reading by the electrical impedance tomography, causing low reliability of the recorded data. Also excluded from this study were data from medical records and the integrated project database that were in short supply or lack of information. Thus, a partial sample was obtained from thirteen mothers.

As this is a prospective and retrospective study, after sample eligibility, a separate form was used to collect data on the epidemiological and ventilatory profile of patients discharged from September 2017 until the beginning of data collection in March 2018. From this, files of medical records were analyzed in the sector of Patient Information Management of the FSCMP. Data on patients hospitalized from March to September 2018 were collected from medical records present in the adult ICU of the FSCMP.

For the composition and analysis of the epidemiological profile of the mothers, the following data were extracted from the medical records: age, municipality of origin, occupation, marital status, life habits, morbid history, obstetric data (number of pregnancies, number of abortions, gestational age, type of delivery) outcome of ICU admission, length of stay in the ICU and length of stay on invasive mechanical ventilation.

The analysis of ventilatory data in this study was based on information stored in the integrated project database through the EIT data collection form, which obtained data on the regional distribution of pulmonary aeration, driving pressure, Tidal Volume (TV), static compliance (Cst) of the respiratory system and PEEP of patients discharged from hospital as well as patients hospitalized during the data collection period.

After a retrospective survey of the sample, data from patients who were in the ICU were searched while they were under invasive mechanical ventilation and monitored by EIT. When presenting satisfactory conditions for the weaning process of mechanical ventilation, the data were no longer tabulated, since, by reducing the levels of sedation, the respiratory incursions and the patient's movement generated interference in the reading of the EIT, making them unreliable.

At the end of the data survey and card storage, descriptive analysis was used to describe the clinical and epidemiological characteristics of the patients who used the EIT in MV during the ICU stay. These data were tabulated in Microsoft Office Excel 2010®.

RESULTS

The initial sample was composed of 14 mothers. After entering the integrated project, 1 patient had difficulty with sedation and psychomotor agitation, due to the low reliability of the data presented, this was removed from the study. Thus, the total sample consisted of 13 postpartum women.

In Table 1, the epidemiological profile of postpartum women submitted to invasive mechanical ventilation and monitored using EIT was analyzed, considering sociodemographic and obstetric data.

Table 2 shows the incidence of HELLP syndrome, sepsis and ARDS, as well as the number of mothers who had more than one diagnosis and the outcome of their hospitalizations in the ICU.

Table 3 shows the mean of the ventilatory parameters assessed through the EIT, in the 13 patients of the three predicted groups, followed by the reference values recommended by the literature for driving pressure, pulmonary static compliance (Cst), Anterior, Posterior Regional Ventilation, Right and left.

DISCUSSION

Within the pregnant puerperal cycle, HELLP syndrome is a pathology with high morbidity and mortality, a relatively rare condition, which carries a risk of death and occurs between 0.2% to 0.6% of pregnancies[15]. This syndrome is characterized by hemolysis, elevated liver enzymes and thrombocytopenia; the term 'HELLP' is an acronym formed from these characteristics. It is estimated that for every 1,000 pregnancies, 1 to 2 women develop HELLP syndrome[16].

In the analysis of the epidemiological profile of postpartum women, on the obstetric data found, 4 (30.8%) were primiparous and 9 (62.9%) multiparous. The mean gestational age of the mothers in weeks was 32.4±5.0, the number of pregnancies was 2.2±1.4 with 1.1±0.9 deliveries by cesarean section, 0.1±0.3 normal births, 0.8±1.3 obtained some type of abortion, which were spontaneous, provoked or therapeutic.

Saintrain et al.[17] developed research to identify the factors associated with maternal death in an intensive care unit (ICU). In this study, among the most significant diagnoses of ICU admission, hypertensive diseases can be cited, associated with pregnancy, which are eclampsia, severe pre-eclampsia and HELLP syndrome, with respiratory failure being one of the main causes maternal

Table 1: Epidemiological profile of postpartum women on mechanical ventilation monitored using electrical impedance tomography.

	Media ± Standard deviation	
Age	24,6 ± 6,2	
	Frequency (n = 13)	**%**
Precedence		
Capital	3	23,1
Interior	10	76,9
Education		
Elementary	9	69,2
High school	3	23,1
Not declared	1	7,7
Marital status		
Married	2	15,4
Single	4	30,8
Stable union	7	53,8
Alcoholism		
Yes	3	23,1
No	10	76,9
Smoking		
Yes	2	15,4
No	11	84,6
Pre-existing diseases		
Yes	7	53,8
No	6	46,2
What diseases		
Systemic Arterial Hypertension	4	57,1
Diabetes	1	14,3
Heart diseases	1	14,3
Asthma	2	28,6
Gestational hypertension	1	14,3
Number of pregnancies		
Primiparous	4	30,8
Multiparous	9	69,2
	Media ± Standard deviation	
Pregnancies	**2,2 ± 1,4**	
Abortion	0,8 ± 1,3	
Normal birth	0,1 ± 0,3	
C-section	1,1 ± 0,9	
Gestational age (weeks)	**32,4 ± 5,0**	

death and mechanical ventilation was used in 100% of the cases that died.

In the analysis of the outcome of the ICU puerperal hospitalizations, two (15.4%) patients died, while 11 (84.6%) were discharged to the FSCMP wards.

Acute respiratory distress syndrome (ARDS) consists of respiratory failure associated with inflammatory edema in the lungs; consequently, a physiological condition is obtained in which the alveoli are perfused, however, proper ventilation does not occur, thus failing in the air supplies in certain regions of the lung. Thus, the occurrence of ARDS and sepsis in puerperal women with HELLP syndrome can be associated, which can lead to the worsening of this pathology, making intensive care necessary[4,13].

Table 2: Clinical profile of patients on mechanical ventilation monitored by electrical impedance tomography.

	Frequency (n=13)	%
Group HELLP*		
Yes	7	53,8
No	6	46,2
Group Sepsis		
Yes	8	61,5
No	5	38,5
Group ARDS**		
Yes	4	30,8
No	9	69,2
Diagnoses		
Only one group	8	61,5
More than one group	5	38,5
Diagnostic Association		
HELLP and SDRA	1	7,7
HELLP and SEPSE	2	15,4
SEPSE and SDRA	2	15,4
Outcome		
Death	2	15,4
Hospital discharge	11	84,6

*HELLP: *Hemolysis, Elevated Liver enzymes, Low Platelet count.*
**ARDS: Acute Respiratory Discomfort Syndrome

Table 3: Ventilatory parameters of patients on mechanical ventilation assessed by electrical impedance tomography.

Ventilatory parameters of EIT	Media	Standard deviation	Reference values*
Tidal Volume (TV) (ml)	378,9	103,9	-
Positive end expiratory pressure (PEEP) (cmH_2O)	9,8	1,9	-
Driving pressure (cmH_2O)	11,1	1,4	≤15
Static pulmonary compliance (Cst) (mL/cmH_2O)	40,4	14,9	60
Previous regional ventilation (%)	52,7	6,8	40
Posterior regional ventilation (%)	47,3	6,8	60
Right regional ventilation (%)	52,5	4,1	55
Left regional ventilation (%)	47,3	4,0	45

* Reference values predicted in literature [9,14]

In this context, sepsis can manifest itself with signs such as acute pulmonary edema of non-cardiac origin, after hypoxemia; not infrequently, acute lung injury or ARDS is diagnosed. In most of these cases, there is a need for invasive mechanical ventilation (IMV), a protective strategy for the lung, using ventilatory parameters such as driving pressure, which directly interferes with Cst and regional pulmonary ventilation[8,18].

As for the analysis of the profile of the clinical profile of patients on mechanical ventilation monitored using electrical impedance tomography, 7 (53.8%) mothers had a diagnosis of HELLP syndrome during pregnancy and 6 (46.2%) did not. In the sepsis group, 8 (61.5%) were diagnosed and 5 (38.8%) did not develop this condition. About ARDS, 4 (30.8%) obtained this diagnosis and 9 (69.2%) did not present it. Therefore, sepsis with pulmonary focus was the most common pathology among the patients in the study, followed by HELLP syndrome and ARDS.

It was also observed that, of the 13 patients, eight (61.5%) obtained only one diagnosis during the ICU stay, while 5 (31.5%) evolved with more than one pathology in that period.

For Santos *et al.*[19], sepsis has become a problematic factor that directly interferes in world health, when it reaches a large number of people, with high rates linked to mortality and morbidity. Such a condition is the trigger of 25% of the ICU beds occupied in Brazil, being considered as the main cause of mortality in the intensive care environment. In the study on sepsis in adults in the ICU, the same authors identified that lung infections made up the most significant number.

Therefore, the pulmonary site is considered to be the generator of the infection process, showing compatibility with the increasing number of patients undergoing mechanical ventilation and with long hospital stay in intensive care units[19].

In the context described and emphasizing the need for MV as a therapy in the ICU, important ventilatory variables can be assessed and monitored by Electrical Impedance Tomography (EIT) in real-time, a method that has proven to be reliable for directing the specific conduct for each patient, in order to reduce, mainly, the risk of lung injuries associated with IMV[12,13]. The use of tidal volume (VT) close to the predicted and appropriate levels of PEEP are beneficial to the patient on IMV[20,21].

However, in patients who evolve with reduced Cst of the respiratory system as in ARDS, the use of VT calculated from the patient's predicted weight may not be enough to protect the lung from the harmful effects of VM[20]. According to Annoni et al.[14], the reference value for Cst is 60-100 ml/cmH_2O for efficient pulmonary mechanics. Therefore, the present analysis of the static compliance variable 40.4±14.9 stands out, significantly below the value predicted by the literature.

Amato et al.[9] raised the hypothesis that normalizing the VT according to compliance and using this proportion as an

indicator of the "functional" size of the lung would provide better results in patients with ARDS than the tidal volume alone (driving pressure indicator). Thus, they developed a study to evaluate the monitoring of driving pressure compared to other ventilatory variables (VC, P. Plateau and PEEP), with the assumption that this index could be a better predictor of survival in patients with ARDS.

The results obtained in this research identified that, of all the variables analyzed, driving pressure was the most associated with patient survival, and should be maintained at values ≤15cmH_2O. They also concluded that the driving pressure predicts the adjustments of P. Plateau, PEEP and VT, avoiding ventilator-induced lung injury (LPIV) through cyclical stresses in the lung parenchyma.

The analysis of the monitoring time of the mothers in the ICU under IMV through the EIT, which corresponded to 3.8% days, is highlighted. Based on the monitoring performed, the analysis of the ventilatory parameters, with the VT value of 378.9±103.9, and the mean values found for PEEP 9.8±1.9, driving pressure 11.1±1.4, are below those recommended by the literature, predicting a good mortality and morbidity index[21].

On the other hand, Chiumello *et al.*[22] carried out a study to predict pulmonary stress through driving pressure, calculate adequate levels of PEEP and reduce VT, based on this calculation. The results showed that higher values of driving pressure are related to increased pulmonary stress regardless of PEEP values. The authors concluded that driving pressure was an effective and non-invasive method capable of detecting the presence of pulmonary overstress.

Guérin *et al.*[10] identified a significant association between driving pressure and increased patient survival. Each 1cmH_2O increase in driving pressure increased the risk of mortality by 5%. However, the authors observed that, by keeping the patient on protective ventilation (CV: 6ml/kg and P. Plateau: 28–30cmH_2O), P. Platô would have the same significance as driving pressure to predict mortality.

The same authors used EIT to assess changes in regional ventilation, in order to clarify whether an intraoperative PEEP level of 10 cmH_2O would influence early postoperative ventilation. It was found that the distribution of regional tidal volume derived from EIT is effective to assess regional recruitment induced by PEEP[23], a relevant fact for the patient with ARDS, since alveolar recruitment maneuvers have been widely discussed as a strategy to improve this patient's condition[24].

Nebuya *et al.*[25] applied a different look aimed at regional pulmonary quantification when assessing the clinical use of pulmonary density estimation using EIT data. The study had 11 patients on mechanical ventilation, with significant differences in regional pulmonary densities recorded in the supine position, between normal lungs and patients associated with pneumonia, atelectasis and pleural effusion. The results indicated the possibility of obtaining reliable quantitative values for regional lung density using EIT.

Given the analysis of the variation of regional ventilations, the average value found for the right regional ventilation was 52.5±4.1 and left regional ventilation 47.3±4.0. Regarding the variation of values of regional ventilation anterior 52.7±6.8 and posterior 47.3±6.8, this difference can be explained by the position in the patient's supine position, in which posterior ventilation is restricted, mainly by present a smaller opening of the alveolus as a starting point in this region, facilitating by redirecting to the previous ventilation.

In a study on the assessment of regional ventilation by EIT in patients with unilateral bronchial stenosis, Marinho et al.[26] found that the relative distribution of this variable, during spontaneous ventilation, was always greater in the right lung, with values of 91%, 82% and 58% in the supine position, right lateral decubitus and left lateral decubitus, respectively, showing the effect of bronchial stenosis on the distribution of regional pulmonary ventilation and the influence of postural changes. This finding demonstrates that monitoring by means of EIT becomes properly consistent and effective in several clinical conditions, contributing to conducts directed to the patient's need.

Confirming the studies as well as the data presented, according to Frerichs et al.[27], experimental studies showed that regional responses of the lung to a recruitment maneuver, PEEP, oxygen fraction or VT adjustment can be continuously obtained by EIT, even with the behavior heterogeneous pulmonary tissue under dynamic conditions. The most recent clinical data suggest the promising use of parameters assessed by EIT to the rapid response to titrate protective PEEP/VT combinations or to assess the potential for pulmonary recruitment in patients with ARDS. These measures are most often derived from the decremental PEEP titration maneuver.

Conclusion

The design of the epidemiological profile of the puerperal women admitted to the adult ICU of the FSCMP was an extremely relevant finding, which showed the incidence of sepsis with pulmonary focus, followed by HELLP syndrome and, finally, ARDS. Usually, patients were restricted to only one clinical diagnosis, and cases with associated disease evolution were identified. In addition, the use of EIT represented an important advance in the biosafety of critically ill mothers, being fundamental in the adequacy of ventilatory parameters, contributing to reduce the incidence of ventilator-induced lung injury and, consequently, in the mortality of this population. Future studies with EIT are essential to assist and identify situations in which mechanical ventilation can be better evaluated and applied.

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