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Original Article

Investigating the effect of Positive end-expiratory pressure (PEEP) on central venous

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Abstract

Investigating the changes in CVP at different positive end-expiratory pressures (PEEP) can play an important role in more accurately assessing ICU patients in terms of their treatment strategies and fluid therapy as effectively as possible. This present study was performed to evaluate the effect of PEEP changes on CVP in patients admitted to the emergency ICU. In this quasi-experimental clinical trial study, 82 intubated patients with right subclavian central vein catheter admitted to the trauma ward were studied. Patients were treated with etomidate at a dose of 0.3 mg/Kg and fixed ventilator settings. CVP in PEEPs 3, 5 and 7 was measured every 30 minutes. 52.2% of patients were male. The mean age of the patients was 61.65 years. The most common causes of hospitalization in patients were cerebrovascular accident (CVA) (37.1%) and sepsis (23.2%). The mean CVP recorded in PEEPs 3, 5 and 7 were 10.42 ± 1.37, 11.15 ± 1.53 and 12.36 ± 1.69 (cmH2O), respectively. We found that with increasing PEEP, CVP level increases ($p < 0.05$) and also found that for every 2 cmH2O increases in PEEP, the CVP increases by 4% (cmH2O). No significant relationship was observed between age, sex and reason of hospitalization and changes in CVP with PEEP changes ($P > 0.05$). This study showed that there is a significant relationship between increased PEEP and increased CVP in hospitalized patients and it was found that for every two cmH2O increase in PEEP, the CVP increases by 4%.

Keywords: PEEP, CVP, Clinical trial

Introduction

Today, the use of central venous catheter (CVC) in the medical care of patients has become particularly important. Central venous catheters are used not only as a means of accessing central veins, but also for hemodynamic monitoring, intravenous nutrition, chemotherapy, hemodialysis, etc. [1]. The use of central venous catheters in modern medicine plays an important role and reduces the hospitalization time of patients [2]. Typically, the first step in treating critically ill patients with unstable hemodynamics without impaired cardiac contractility begins with optimizing cardiac output or, in fact, determining the need for intravenous fluids[3]. However, excessive and unnecessary administration of intravenous fluids can aggravate the disease and side effects in the patient [4, 5]. Although relying on clinical signs (cold and pale skin, tachypnea, tachycardia, decreased urination, weak pulse, etc.) has the highest diagnostic value, as in most medical fields, in a classic way since decades ago, adjusting the volume of patient's intravenous fluid is measured by measuring the pressure of the central veins also known as filling pressure of the heart [2]. Central venous pressure (CVP) monitors are commonly used in operating rooms, intensive care units, and emergency departments. The normal range of CVP is between 8 and 12 (cmH20), which increases to 12 to 16 (cmH20) in mechanically ventilated patients [2, 6, 7]. Factors such as misalignment of the zero-point ruler, poor patient conditions, improper catheter placement, and the use of vascular blood pressure boosters may prevent the correct measurement of CVP [1]. Positive end-expiratory pressure (PEEP) can affect CVP by increasing intrathoracic pressure. There are various reports of a direct relationship between these two pressures [8].

There is still no suitable solution or formula based on PEEP level to regulate CVP in mechanically ventilated patients. Yang showed that for every 1 cmH2o increase in PEEP, there is a 0.38 cmH2o increase in CVP [9]. Due to the deteriorating condition of patients admitted to ICU, appropriate and timely fluid therapy can play an important role in improving patients or preventing further problems for patients [10]. What is more, investigating confounding factors in measuring the exact number of CVP and eliminating them can be effective in improving patients' fluid therapy [6]. Finding a possible pattern between PEEP changes and CVP can lead to a suitable formula to improve CVP count measurement and will help patients in more appropriate fluid therapy. Therefore, the present study aimed to investigate the effect of PEEP changes on CVP.

Materials and Methods

This study was a quasi-experimental clinical trial and the study population comprised patients under mechanical ventilation with a CV line ventilator in the Emergency Department (ED) of Poursina Hospital in Rasht. The present study was conducted after obtaining permission from the ethics committee of Guilan University of Medical Sciences with the code IR.GUMS.REC.1398.320 and the management of Poursina Hospital in Rasht. Patients over 18 years of age with CV line who were under mechanical respiration and had stable vital signs and were admitted to the trauma ward of Poursina Hospital in Rasht were included in the study. To eliminate other CVP confounding factors, all patients were sedated with 0.3 mg / kg ethomidite, and the same settings were made for all patients:

• Tidal volume: 6 mL / Kg • Pressure support: 12-14 cm H2O • FiO2 = 40-70% • Rate = 10-12 L / min • PEEP = 3, 5, and 7cm H2O

Serum intake per hour was almost the same and normal saline (0.9% N.S) was used for patients. Inclusion criteria covered all patients over 18 years of age intubated admitted to the emergency ICU of Poursina Hospital in Rasht who had a CV line and stable vital signs. Exclusion criteria included patient instability, need for more than 200 cc of serum per hour, need for more than 7 cmH2o PEEP, need for more than 200 cc per hour, patients with automatic PEEP, need for PEEP more than of 10 cmH2o, dissatisfaction of first-degree relatives of the patient, any contraindication to increased PEEP in patients studied, any significant changes in vital signs with changes in PEEP, lung damage, COPD, asthma, valvular disorders, ARDS, and BMI> 30. Demographic characteristics of patients were recorded within pre-designed checklists. To reduce the incidence of error, patients with right subclavian vein were included in the study. Patients' CVP was measured after ten minutes in PEEP 3, 5, 7, and then the CVP number and its changes in three measured PEEPs (3, 5 and 7) were recorded in the checklists. Furthermore, the PEEP changes from all the measurements by one person (an emergency medicine resident who was aware of neither the study and nor the PEEP's status, meaning that he was only asked to read the CVP number (for blindness)) and was performed on a level surface with a sternal angle and a special CVP ruler. Then, CVP changes in different PEEPs (PEEPs 3 to 5, 5 to 7, and 3 to 7) were examined and analyzed by statistical tests. After collecting the data, the information was entered into SPSS software version 21. Chisquare test was used to compare the frequency of changes by sex, age and underlying disease [6]. Additionally, t test and linear regression were used to compare the CVP in different PEEPs [6]. Significance level of tests in this study was considered with P <0.05. The sample size of the present study was calculated according to the data of the study of Shojaei et al. [6] and the following formula.

- Zα= 0.5%
- B=0.2
- r = 0.35 (1)

The number of samples according to the coefficient correlation sample size formula was equal to 62 samples, which was increased to 82 to be sure.

$$n \geq \left(\frac{Z_{1-\alpha/2} + Z_{1-\beta}}{\frac{1}{2}\log_e \frac{1+r}{1-r}} \right)^2 + 3$$

The sampling method of this study was gradual (consecutive), so patients who met the inclusion criteria were admitted to the study on a daily basis.

Results

The results showed that 51.2% of the samples were male and 48.8% were female, the mean and standard deviation of the age of the samples was 61.65± 16.37

Table2. Analysis of CVP relationship between PEEPs 3 and 5 (cmH2o)

	Number of observations	Average	Standard Deviation
PEEP 3	82	10.426	1.370
PEEP 5	82	11.158	1.535
Difference	164	-0.731	0.227
T test	-3.219		
Significance	<0.001		

Table 3. Analysis of CVP relationship between PEEPs 5 and 7 (cmH2o)

	Number of observations	Average	Standard Deviation
PEEP 5	82	11.158	1.523
PEEP 7	82	12.365	1.696
Difference	164	-1.207	-0.252
T test	-4.778		
Significance	<0.001		

years. Also, the cause of hospitalization in 31.7% of the studied patients was ischemic CVA. Other causes of hospitalization: 23.2% had sepsis, 20.7% ICH, 19.6% trauma and 4.9% brain tumor. Mean and standard deviation of right central subclavian vein pressure in PEEP 3, 5 and 7 were 10.42 ± 1.370, 11.15 ± 1.523 and 12.36 ± 1.69 (cmH20), respectively. After reviewing the data by comparative t-test, it was found that there is a significant difference between PEEP changes and CVP ($p < 0.05$).

Table 1. Analysis of CVP relationship between PEEPs 3 and 7 (cmH2o)

	Number of observations	Average	Standard Deviation
PEEP 3	82	10.426	1.370
PEEP 7	82	12.365	1.696
Difference	164	-1.939	0.240
T test	-8.052		
Significance	<0.001		

According to the data in Tables 1, 2 and 3, with increasing the PEEP from 3 to 5 and from 5 to 7 (cmH20) and also from 3 to 7 (cmH20), the CVP increases significantly ($P < 0.05$). Due to the increase in the central vein with the increase of the PEEP, statistical analyzes were performed to find the increase in the pressure of the central vein with the increase of one PEEP unit. It was found that for every 2 (cmH20) increase in PEEP, the CVP increases by 1.04 (cmH20). Therefore, for every two (cmH20) PEEP increase, the CVP increases by 4% (cmH20). The IRR coefficient here was 1.04, indicating that if two cmH20 were added to the PEEP, about 4 percent would be added to the CVP. That is, if the CVP is equal to 10, this value will increase to 10.4 (Table 4). Also, according to our analysis, it was found that there is no significant relationship between patients' sex with changes in CVP with increasing PEEP ($p > 0.05$). This means that it is possible to calculate changes in CVP with PEEP changes, regardless of gender. According to the analyzes performed in this study, there was no significant difference between changes in CVP and increase in PEEP by age and cause of hospitalization. This means that it is possible to calculate changes in CVP with PEEP changes, regardless of the age and cause of hospitalization.

Discussion

The purpose of fluid administration and volume therapy in patients is to improve tissue oxygenation and avoid hypoperfusion and organ damage [2]. Fluid administration increases the volume of vascular interventions, and intravascular volume regulates moderate circulatory pressures and venous return to the heart. However, during fluid therapy, we must be aware that infusion of large volumes of fluid can have adverse effects on the patient [2]. The effects of positive fluid balance can be systematically manifested by electrolyte disturbances, acid and base disorders, hypertension, increased myocardial need, pulmonary edema, respiratory failure, peripheral edema, and many other problems [7]. Therefore, it is necessary to pay attention to the patient's intravascular volume and estimate his cardiovascular condition in replacing the patient's volume [10]. In terms of demographic indicators of the current study, the sample size with 82 patients was the largest compared to similar studies including Shojaei [6] et al. with 60 patients, Yung [9] with 30 patients, Cao [11] et al. with 30 patients and Saner [12] et al. with 72 patients. The mean age of patients in our study was 61.65 years. Among similar studies, the highest mean age was in Shojaei's [6] et al. study with 73.95 years and the lowest mean age was in the study of Saner [12] et al. with a mean age of 51

Table 4: Data analysis to find the rate of increase in CVP in exchange for an increase in two PEEP units*:*

PEEP	IRR	Standard Deviation	Significance	Low limit	High limit
Variable	1.0438	0.0121	>0.001	1.0203	1.0678
Constant coefficient	9.1105	0.5686	<0.001	8.0615	10.296

years. In this study, PEEPs in the physiological range (3, 5 and 7 cmH20) were used according to the opinion of the research committee to avoid harming patients. In the study of Shojaei [6] et al. And saner [12] et al. And Cao [11] et al. In the study, Yung [9] et al. Evaluated PEEPs zero, 3, 6, 9, 12 and 15 (cmH20). According to our study, the mean CVP in PEEPs 3, 5 and 7 (cmH20) was significantly different from each other and with increasing the PEEP, the CVP also increased significantly. In the study of Shojaei et al. [6], which was conducted in 2017 under the title of "PEEP effect on CVP in patients under mechanical ventilation", the CVP also increased significantly with increasing PEEP. In studies by Cao et al., Yung et al., Et al., And Saner et al., Published in 2009, 2012, and 2006, respectively, CVP increased significantly with increasing PEEP. According to our study, for every 2 (cmH20) PEEP increase, the CVP increases by 4%. In the study of Shojaei et al., For every 5 (cmH20) increase in CVP, the tube increased by 2.47 (cmH20). Also in the study of Yung [9] et al., It was found that for every 1 cmH20 increased by PEEP, CVP increases by 0.368 cmH20. In the study of Saner [12] et al., It was found that in PEEP 5, 23.8% and in PEEP 10, 31.8% CVP increases. Also, a study [13] on 70 heart surgery patients in 2007 showed that the average CVP of patients at zero, 5 and 10 cm water pressures in 11, 12 and 14 (water), respectively. In this study, we did not find any significant relationship between gender, age and cause of hospitalization of patients with CVP changes with increasing PEEP. This means that in calculating the change in CVP with PEEP changes, there is no need to take into account the sex, age and cause of hospitalization. Our study in this respect was similar to the study of Cao [11] et al., Shojaei [6] et al. and Saner [12] et al. In the studies of Saner [12] et al. and Yung [9] et al., The relationship between increased PEEP and heart rate and patient blood pressure was investigated, but there was no significant relationship between them. Also in the study of Cao et al. [14] it was found that with increasing the PEEP pressure, the pressure of the common iliac vein also increases. In that study, there was no significant relationship between age, sex and cause of hospitalization with changes in CVP with changes in the PEEP, which is consistent with the study.

Due to the concern of patients' injuries in very high or low PEEPs, the PEEP was examined only in the physiological range (3 to 7 units). There was also a restriction on increasing or decreasing the PEEP in patients with contraindications for PEEP changes who were excluded from the study. CVP measurement method was used to evaluate the CVP due to the limitations. To reduce the error in each PEEP, the CVP was measured twice and the mean was recorded. Also, all measurements were performed by a person (emergency medicine resident) who did not know the subject of the study. Due to the importance of very accurate ventilation in patients with Covid-19, these patients were not included in the study.

Our study showed that there is a significant relationship between PEEP increase and CVP increase and it was found that for every two cmH20 of increase in PEEP, CVP increases by 4%. Studies with higher sample sizes and higher PEEPs can play an important role in further confirming this relationship and more accurately, determine a fixed formula for determining the relationship between CVP and PEEP changes.

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Author contribution

Study concept and design: S.M.Z.Z, S.M.Z.Z, A.A, and R.S.L; analysis and interpretation of data: S.M.Z.Z, R.S.L and S.R; drafting of the manuscript: R.S.L; critical revision of the manuscript for important intellectual content: SMZZ, and R.S.L; statistical analysis: E.H.R.

Conflict of Interest

The Authors declares that there is no conflict of interest

Ethical declaration

Ethics approval and consent to participate

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors. The present study is part of a Ph.D. dissertation (ethics code: IR.GUMS.REC.1398.320) in social work approved by the Guilan University of Medical Sciences

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