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Peripheral Venous Pressure as an Indicator of Central Venous Pressure in Post-Operative Surgical Patients: a Randomized Control Trial

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ABSTRACT

Objective: To determine correlation between the values of Peripheral Venous Pressure and Central Venous Pressure in post-operative surgical patients.

Study Design: Clinical Trial (ClinicalTrials.gov vide identifier no. NCT05476666).

Place and Duration of Study: Surgical Intensive Care Unit of Pakistan Naval Services Shifa Hospital, Karachi Pakistan, from Jan to Jun 2022.

Methodology: Human clinical trials were undertaken on 40 patients between the ages of 18 and 65 years who were shifted to Surgical Intensive Care Unit for post-operative care and had consented to participate in this clinical trial, in addition to fulfilling preset inclusion and exclusion criteria. Central Venous Pressure (CVP) and Peripheral Venous Pressure (PVP) was measured simultaneously through a water manometer. Mean readings were compared.

Results: The mean difference between PVP and CVP readings in our study was 3.65±2.21 cmH2O with $p<0.001$ which was statistically significant. The mean age of the patients was 42.1±12.1 years and included 31(77.5%) males and 09(22.5%) females.

Conclusion: Our study showed that there is significant correlation between PVP and CVP in post-operative surgical patients suggesting that PVP monitoring can be used as an easy, economical and less complicated alternative to CVP monitoring.

Keywords: Central Venous Catheter, Central Venous Pressure, Peripheral Venous Pressure, Post-Operative Period.

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INTRODUCTION

Central Venous Pressure (CVP) is extensively used as an indicator of volume status of a patient in association with other clinical signs. Despite being extensively used world over, CVP is still not unanimously considered as a gold standard.[1] Additionally, the insertion of a venous catheter into a central vein is frequently associated with significant complications, morbidity and even mortality. Furthermore, the pre-requisites, procedural time, patient comfort and cost have all shifted the attention away from such an invasive procedure.[2]

In recent years a number of clinical studies have focused on Peripheral Venous Pressure (PVP) as an alternative to CVP in assessing the volume status of a patient.[1-3] These studies have also demonstrated a persistent relationship between CVP and PVP. However, the extent to which PVP relates to the actual volume status of the patients still remains controversial especially in scenarios of heart and lung disease, blood loss or other pathological processes.[4] A number of therapeutic interventions can also lead to effects on intravascular and extravascular fluid volumes of the patients.[5]

In situations where central venous catheterization may not be possible or convenient due to patient conditions or procedure related factors, the estimation of CVP may be possible by measuring PVP or interpreting its waveform in association with clinical variables obtained from hemodynamic monitoring.[6] Other studies comparing PVP as an indicator for CVP have also been done in operation theaters and intensive care units for adult as well as pediatric patients.[7-10] However, these studies have failed to establish consensus as to whether PVP can be used alone to reliably assess the volume status of the patients.

The aim of this trial was to determine correlation if any in the values of PVP in comparison to CVP by taking CVP as standard for volume status of post-operative surgical patients.

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METHODOLOGY

This clinical trial was conducted at the Surgical Intensive Care Unit of Pakistan Naval Services Shifa Hospital Karachi, Pakistan after acquiring Hospital Ethical Review Committee approval (vide letter no. ERC/ANS/2022/1) and registering with ClinicalTrials.gov (vide identifier no. NCT05476666) from January 2022 to June 2022.

Inclusion Criteria: Surgical patients of either gender aged 18 years, who required post-operative management in the Surgical Intensive Care Unit, and had electively placed 7 French Central Venous Catheter (Arrow International) in either of their Internal Jugular or Subclavian veins, in addition to an intravenous cannula of 18 gauge or wider lumen in either of the forearms or hands as part of peri-operative management plan were included.

Exclusion Criteria: Patients who did required support for more than one organ were excluded.

The sample size for our study was calculated using Clinical and Transitional Science Institute Calculator with the reference value of r=0.893, which came to 40.8 Consent was obtained from the patient or the next of kin in case of mechanically ventilated patients. No central venous catheter or intravenous cannula was placed simply for the sake of this clinical trial in any patient.

Correct placement of the central venous catheter was confirmed by mandatory chest X-ray, performed as part of routine Surgical Intensive Care Unit investigations profile upon receiving the patient from the Operation Theater. This was identified as the junction of Superior Vena Cava and Right Atrium. The CVP and PVP measurements were done after flushing the central venous catheter and intravenous cannula with 10-15 ml of normal saline and attaching to a water manometer zeroed at the mid-axillary line in the fourth intercostal space, also known as the phlebostatic axis. The patient was kept in supine position while the measurements were taken. One-third of Positive End Expiratory Pressure (PEEP) was subtracted from the measured CVP and PVP readings for any mechanically ventilated patients.

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 22. Quantitative data was represented using Mean±SD and qualitative data was represented using percentage and frequency. Pearson correlation was used to find the relationship between CVP and PVP and independent sample t test was applied, *p*-value of ≤0.05 was considered as statistically significant.

RESULTS

The trial was done on 40 patients which included 31(77.5%) males and 09(22.5%) females with an average age of 42.1±12.1 years.

The lowest CVP reading was -01 cmH2O and the highest CVP reading was +20 cmH2O. The lowest PVP reading was +06 cmH2O and the highest PVP reading was +24 cmH2O. The most difference in CVP and PVP readings for the same patient was +05 cmH2O and +16 cmH2O respectively. The same CVP and PVP readings was measured in one patient which was +16 cmH2O each. Ten (25.0%) patients out of 40 were mechanically ventilated and one third of PEEP was subtracted from their CVP and PVP readings. The CVP measured in all patients was lower than the PVP measured in the same patient.

The mean difference between PVP and CVP readings in our study was 3.65±2.21 cmH2O with *p*<0.001. The r-value 0.872 which was calculated by taking PVP as the dependent and CVP as the independent variable (Table).

Table: Relationship between Central Venous Pressure and Peripheral Venous Pressure (n=40)

	Mean±SD (mmHg)	r-value	*p*-value
Central Venous Pressure	9.25±4.51	0.872	<0.001
Peripheral Venous Pressure	12.90±3.97		

DISCUSSION

We studied the relationship between Peripheral Venous Pressure (PVP) and Central Venous Pressure (CVP) in 40 adult post-operative surgical patients.

Our study showed that there is significant correlation between Peripheral Venous Pressure and Central Venous Pressure in post-operative surgical patients, suggesting that PVP monitoring may be used as an easy, economical and less complicated alternative to CVP monitoring. A persistent correlation between CVP and PVP has been demonstrated by multiple studies previously.[11-15] These findings are consistent with numerous other studies done on intensive care unit patients.[8-10,16,17]

As the difference between PVP and CVP remained relatively in a constant range therefore changes in volume status of the patient associated with fluid loss or overload could be assessed reasonably by measuring PVP. In medical practice

however it will always be prudent to rely on additional hemodynamic parameters, clinical signs and serial readings to safely come to a conclusion regarding fluid status of any patient before a therapeutic intervention rather than relying on a single PVP reading.

In a study by Amoozgar *et al.,* it was demonstrated that in children and infants with congenital heart diseases, PVP measured by inserting an intravenous catheter peripherally was in good correlation with CVP and changes in its value.[18] Tugrul *et al.,* also concluded that PVP measurement showed a clinically relevant correlation with CVP.[6] However in the study by Charalambous *et al.,* in critically ill intensive care unit patients, measurement of PVP did not give a reliable estimation of CVP.[15]

The mean difference between PVP and CVP readings in our study was 3.65±2.21 cmH2O (2.68 mmHg±1.62 mmHg). The upper limit of these readings was comparable to data obtained from previous studies and fell well within clinically acceptable range. Amar *et al.,* concluded in their study that the mean difference between PVP and CVP was 1.6 mmHg intra-operatively and 2.2 mmHg in postoperative patients.16. Munis *et al.,* also reported a difference of 3 mmHg between PVP and CVP.[17] Hoftman *et al.,* concluded that PVP correlated well with CVP in patients undergoing liver transplant surgeries even during adverse hemodynamic conditions.[8]

Studies have demonstrated that neither the site of intravenous cannula placement nor its lumen size had any significant effect on the correlation between CVP and PVP.[6,16] Many studies have also shown that the difference in the correlation between the values of CVP and PVP changes with a change in CVP value. Hoftman *et al.,* demonstrated a poor correlation between the values of CVP and PVP at lower values of CVP.[8] It is also postulated that PVP readings may be raised or erroneous when the CVP is low due to collapse of vascular beds.[19] Likewise, in our study, one such patient was observed whose CVP measured was +01 cmH2O whereas the PVP measured was +10 cmH2O whereas another patient had a CVP reading of +05 cmH2O and PVP reading of +16 cmH2O. However, Cave *et al.,* demonstrated that when the value of CVP increases, the difference between CVP and PVP becomes less significant which was also appreciable in our study.[13]

LIMITATIONS OF STUDY

There are certain limitations to our current study. The number of patients was too small for analyzing the variance in the correlation between CVP and PVP in terms of different pre-existing pathological conditions or types of surgical interventions that were made. We additionally did not cater for any ongoing medication that could affect peripheral vascular lumen size such as inotropic or vasoactive support or purposefully keeping the patient's fluid balance in the negative or positive due to any clinical indication. Furthermore, temperature which is known to effect peripheral venous tone and therefore effect the correlation between CVP and PVP was not accounted for in our study. Additionally, the observers were not blindfolded to the measurement of either CVP or PVP which could lead to observer bias however multiple observers were utilized in our study minimizing this bias.

CONCLUSION

Our study showed that there is significant correlation between PVP and CVP in post-operative surgical patients suggesting that PVP monitoring can be used as an easy, economical and less complicated alternative to CVP monitoring.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

KAK & MAKB: Data acquisition, data analysis, critical review, approval of the final version to be published.

AHB & BY: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

ZAM & AA: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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