

# Correlation between Peripheral Venous Pressure and Central Venous Pressure Monitored by CVP Manometer: an Observational Study

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**Abstract- Background:** Central Venous Pressure (CVP) measurement is used to assess intravascular status. But today complicated procedures are replaced by minimally invasive and simple procedures. The objective of this study was to determine the correlation between peripheral venous pressure and central venous pressure in critically ill patients.

**Methods:** 60 critically ill patients above 18 years of age were taken for the study. Central venous pressure and peripheral venous pressure were measured by CVP manometer and the measurements were recorded along with their physiological parameters. 03 paired measurements of CVP and PVP per patient were recorded in the data sheet. The date, time and the day of insertion of both central venous catheter and peripheral venous catheter was also recorded.

**Results:** The data was analyzed using descriptive and inferential statistics. The study showed a strong correlation between central venous pressure and peripheral venous pressure with correlation coefficient of 0.840( $p < 0.0001$ ). The envisaged correlation regression equation formulated as  $PVP = 0.868(CVP) + 2.63$  and  $CVP = 0.812(PVP) + 1.05$ . The degree of freedom for regression was 1 and residual error was 58. Bland Altman analysis demonstrated the lower limit of agreement as -3.84, mean (difference) as 2.52, and upper limit of agreement as 6.24.

**Conclusion:** The study revealed that PVP and CVP strongly correlate ( $r = 0.84$ ,  $p < 0.0001$ ) and has a clinically acceptable agreement. Peripheral venous pressure monitoring is a simple nursing procedure and can be alternated to central venous pressure in determining fluid volume status among critically ill patients.

**Index Terms-** Central Venous Pressure, Peripheral Venous Pressure, Correlation

## I. INTRODUCTION

Hemodynamic monitoring plays an important role in the management of acutely ill patient. After recognition of critical condition, monitoring and evaluation is done to identify the underlying patho-physiological processes and initiate appropriate therapy. A key component in the management of the critically ill patients are the optimization of cardiovascular functions, including the provision of an adequate circulating volume and the titration of cardiac preload to improve cardiac output. Accurate body fluid assessment is always challenging,

and estimation of fluid status is needed for guiding fluid therapy for such patients<sup>1</sup>. In spite of the availability of several newer monitoring techniques, central venous pressure (CVP) monitoring remains in common use as an index of circulatory filling and cardiac preload since central venous pressure is the intravascular pressure in the thoracic veins, measured relative to the atmospheric pressure. Being able to determine and interpret the CVP for assessing the fluid status, is one of the most commonly followed techniques at most hospitals even today.

But central venous pressure line insertion and monitoring is associated with numerous complications which include pneumothorax, arrhythmias, carotid artery puncture and catheter related infections.<sup>1</sup> It is not easily done in an emergency setup. Moreover it is time consuming and it is difficult to maintain asepsis of the site as it is repeatedly used for administration of parenteral nutrition, intravenous fluids and antibiotics. It is also documented that placement of central venous catheter leads to mechanical complications like cardiac tamponade, haemothorax, pneumothorax, carotid artery injury, subclavian artery injury, venous rupture, air embolism, catheter malpositioning, catheter transaction and wire or catheter embolism<sup>4</sup>. Besides mechanical complications, catheter related bloodstream infections are also a serious complication. Literature reflects that catheter related blood stream infections are associated with increased morbidity and health care utilization<sup>5,6,7</sup>. In Australia, the reported incidences of catheter related bloodstream infection is over 3500 annually, with an associated mortality of 12%<sup>8</sup>.

Although not practiced, the measurement of peripheral venous pressure has long been considered as an optimal form of hemodynamic monitoring allowing for continuous, simultaneous recording of venous pressures to evaluate the preload and estimated cardiac output. Studies also reveal that the incidences of peripheral catheter related blood stream infections ranges from 02 to 14 episodes per 1000 catheter days only.<sup>9</sup>

Therefore there is a need to address the assessment of fluid volume status of critically ill patients in a less complicated way. Practising a new technique of hemodynamic monitoring on the platform of evidences and scientific reasoning will open a new gateway to less complicated yet effective critical care to patients. Certain interesting and noninvasive techniques had emerged to reduce CVC related complications. Thalhammer et al, (2007) conducted a study of assessing CVP by a new noninvasive technique i.e high-resolution compression sonography combined with translucent pressure manometer, in Switzerland. The compression sonography was used at the forearm. A strong correlation ( $r = 0.95$ ;  $p < 0.001$ ) was found between noninvasive

and invasive peripheral venous pressure. The mean difference between invasive and non-invasive measurements was negligible (-0.1 +/- 3.5 cm H<sub>2</sub>O and -0.7 +/- 3.4 cm H<sub>2</sub>O, respectively)<sup>10</sup> From the background it is proved that PVP significantly correlates and have been used as an alternative to predict CVP. Hence the researcher felt the need to find the correlation of CVP and PVP in an effort to establish PVP monitoring as a standard procedure for evaluating fluid volume status in critically ill patients through evidences.

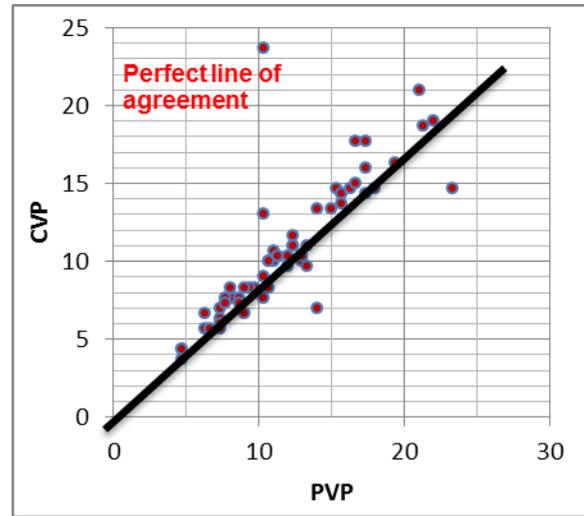
## II. MATERIALS & METHODS

This study is a correlational observational study conducted on 60 critically ill patients admitted to Intensive Care Units of Tertiary Care Hospitals. Patients with both central venous catheter and peripheral venous catheter (18G) in the Intensive Care Unit admitted during the month of Aug- Sep 2013 were taken for the study. The procedure involved recording of CVP and PVP of 60 critically ill patients in ICU by concurrently connecting the CVP manometer to the central venous catheter and peripheral venous catheter of patient and recording both the pressures at the same time, three times a day, at four hours interval. The sample size calculated was 60. Ethical clearance was obtained from the Institutional Ethical committee.

In this study the researcher used a standardized tool (CVP manometer of Polymed Company) for measuring the CVP and PVP. The willingness for participation in the study was sought from the patient/next of kin/treating physician and written informed consent was obtained in the language they understood. The investigator had followed absolute asepsis during the procedure. After positioning the patient, the manometer was connected to the central line and recorded the CVP. Thereafter the manometer was connected to the 18G peripheral catheter (radial/basilic vein) and PVP was also recorded. The procedure was repeated every 04 hourly on the same patient to obtain 03 paired readings (concurrent CVP/PVP). Recordings of the readings that coincides with the lower meniscus of the normal saline was taken as reading for CVP and PVP. Data was entered in the data sheet. Experts from the field of biostatistics and anesthesiology directed the development of data analysis plan. The hypothesis testing was done using ANOVA, Bland Altman plot diagram and regression analysis and descriptive statistics was used to describe the subjects.

## III. RESULTS

In this study among 60 critically ill patients, majority were males 40(67%) and only 20(33%) were females. With regard to age, 12(20%) of the critically ill patients were less than 40 years of age, 24(40%) of the critically ill patients were between the age of 41-60 years and remaining 24(40%) were above 60 years of age. Out of the 60 critically ill patients, 24 (40%) had cardiac diseases, 4(6.67%) of the critically ill patients had respiratory diseases, 4(6.66%) of the patients had hepatic diseases, 3(5%) had renal disease and 25(41.67%) suffered from other diseases (Table 1)



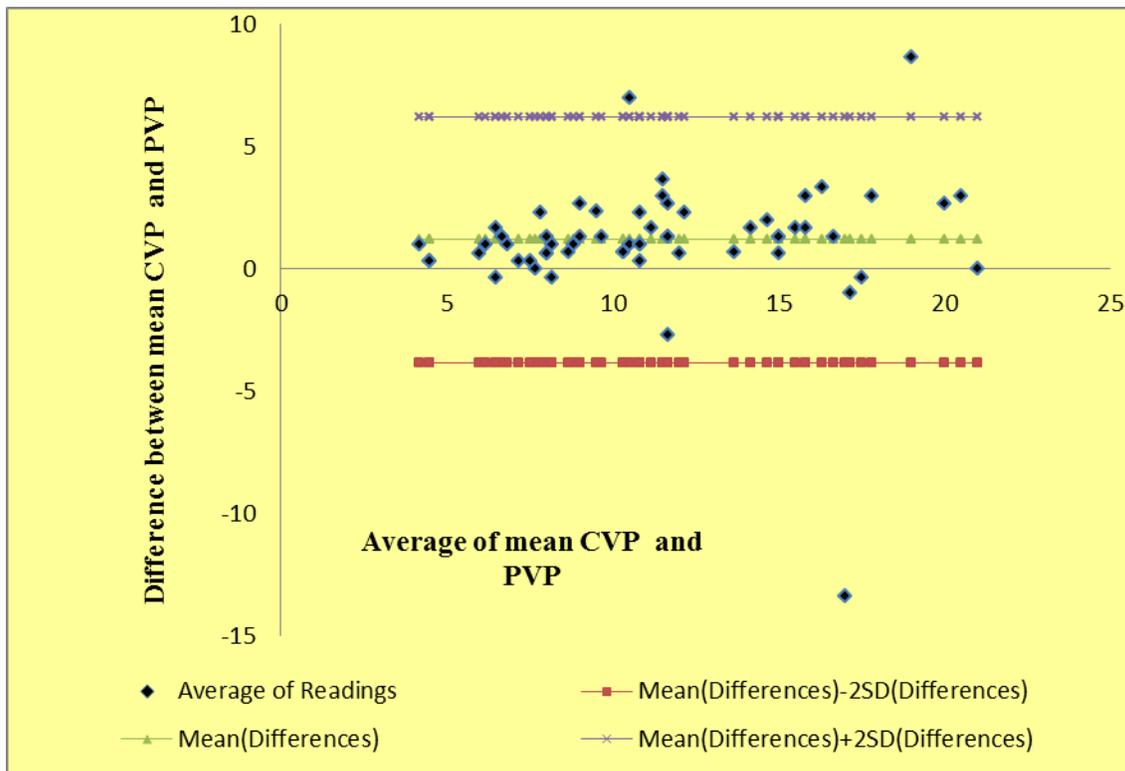
**Figure 1.0 Scatter Diagram showing the correlation between CVP and PVP measurements in critically ill patients**

**Table 1. Distribution of sample characteristics**

Parameters	Criteria	No of cases	Percentage (n=60)
Age (Yrs)*	• <40	12	20.0
	• 41 – 60	24	40.0
	• >60	24	40.0
Sex*	• Male	40	66.67
	• Female	20	33.33
Diagnosis*	• Cardiac diseases	24	40.0
	• Respiratory diseases	04	6.67
	• Hepatic diseases	04	6.66
	• Renal diseases	03	5.0
	• Others	25	41.67
Day of insertion of IV Cannula	• Do	51	85.0
	• D1	09	15.0
Site *	• Radial Vein	36	60.0
	• Cephalic Vein	11	18.33
	• Dorsal vein	07	11.67
	• Brachial Vein	06	10.0
Day of central line*	• Do	43	71.67
	• D1	16	26.66
	• D3	01	1.67

The overall mean CVP was 10.81(SD 4.37) which was significantly lower than that of the PVP which was 12.01(SD 4.5) cm of H<sub>2</sub>O (p<0.0005).The study showed a strong correlation between CVP and PVP at r= 0.84, p<0.0001. There was no significant association of mean CVP and mean PVP with the demographic variables like age, sex and diagnosis of critically ill patients (p> 0.05). The study also revealed that there

was no association of PVP with the day and site of insertion of intravenous cannula in the critically ill patients(p > 0.05). Similarly it was also seen that there is no association of central venous pressures with the day of insertion of peripheral catheter (p>0.05). The regression equation formulated from the study was PVP= 0.868 X CVP +2.63 and CVP= 0.812 X PVP + 1.05 (p<0.05).



**Figure 2.0 Bland Altman plot to compare CVP and PVP measurements of the mean readings**

Bland and Altman plots were created to evaluate the degree of agreement between the two modes of venous pressure monitoring. The mean(difference) was 1.2 with SD(difference) as 2.52,(-3.84 to 6.24) with 95% confidence interval(CI) with upper limit of agreement 7.36 to 5.11 and at 95% CI with lower limit of agreement between -2.71 to-4.96 cm of H<sub>2</sub>O. Pearson correlation between CVP and PVP was also 0.84 with p=0.0005.

95% CI for mean(diff)-2SD(diff)	-4.96	-2.7104
95% CI for mean(diff)	0.55	1.84966
Pearson Correlation Coefficient between PVP and CVP	0.84	
95% CI for Pearson Correlation Coefficient	0.74	0.90

**Table 2.0 Bland Altman analysis**

N	60.00	
mean(diff)	1.20	
SD(diff)	2.52	
mean(diff)-2SD(diff)	-3.84	
mean(diff)+2SD(diff)	6.24	
Tstatistic	3.69	
t value	2.00	
Pvalue	0.0005	
95% CI for mean(diff)+2SD(diff)	5.11	7.36207

**IV. DISCUSSION**

Central venous pressure monitoring through central venous catheter has been an established gold standard method of measurement to assess preload for many decades .But this method involves numerous complications starting from the procedure of insertion, establishment of line till monitoring of the pressures. Therefore several efforts have been made to devise a simple, easier and minimally invasive procedure to assess the fluid volume status in critically ill patients. One of such effort is the recent study done by the researcher. The current study demonstrated high degree of agreement between CVP and PVP, suggesting that PVP monitoring can replace CVP monitoring in

critically ill patients. This research revealed a high correlation of 0.84 ( $p < 0.0005$ ). To envisage the correlation the regression equation formula is  $PVP = 2.63 + 0.868 \times CVP$  and  $CVP = 1.05 + 0.812 \times PVP$ . Kim and his friends<sup>2</sup>, Choi et al<sup>4</sup>, Hoftman and his co-researchers<sup>3</sup>, Desjardins et al<sup>5</sup>, Munis et al<sup>6</sup> and various other researchers also concluded the same in their studies,

In this study, 24 critically ill patients had cardiac diseases with PVP values of 12.78 $\pm$  5.04 cm H<sub>2</sub>O and CVP value of 11.28 $\pm$  4.42 cm H<sub>2</sub>O, 04 patients had respiratory diseases with PVP values of 13.84 $\pm$  5.87 cm H<sub>2</sub>O and CVP value 11.99 $\pm$  5.36 cm H<sub>2</sub>O, 04 patients had hepatic diseases with PVP values of 14.58 $\pm$  2.33 cm H<sub>2</sub>O and CVP value of 13.50 $\pm$  3.24 cm H<sub>2</sub>O, 03 patients had renal diseases with PVP values of 12.22 $\pm$  4.62 cm H<sub>2</sub>O and CVP value of 11.45 $\pm$  4.42 cm H<sub>2</sub>O and 25 other patients had PVP values of 10.55 $\pm$  3.81 cm H<sub>2</sub>O and CVP value of 9.67 $\pm$  4.33 cm H<sub>2</sub>O. These values proved that there is no association of CVP and PVP with the diagnosis of the critically ill patients. ( $P > 0.05$ ). A study was conducted by Kim et al. in the Republic of Korea on 42 patients undergoing elective laparoscopic colorectal surgery and found that both the pressures significantly correlated (correlation coefficient=0.96,  $p < 0.0001$ ). In another prospective clinical study performed by Hoftman et al. on 09 liver transplant surgery patients, a high correlation was found at  $r = 0.95$  ( $P < 0.0001$ ).<sup>3</sup> Choi et al. of Korea also confirmed the same findings on 50 patients undergoing right hepatectomy in living liver donors<sup>4</sup>. Desjardins et al. had done the same research on patients undergoing elective cardiac surgical procedure under cardiopulmonary bypass. The highest mean difference was -0.72  $\pm$  0.78 mmHg (95% CI of -1.25 to -0.19 mm Hg)<sup>5</sup>. Munis et al. conducted an observational research study in neurosurgical patients in Ohio. Repeated measures of analysis of variance revealed a significant relationship between PVP and CVP ( $p < 0.001$ )<sup>6</sup>. Amar et al, from the Department of Anesthesiology, Critical Care Medicine and Biostatistics, New York, studied the correlation between peripheral venous pressure and central venous pressure in 150 surgical patients. They also found that, during the surgery, PVP correlated highly to CVP ( $r=0.86$ )<sup>18</sup>. Hence we can conclude that irrespective of the disease condition (surgical or medical) there is a strong correlation between CVP and PVP.

The study further revealed that there was no significant association of mean CVP and mean PVP with age. ( $p > 0.05$ ). Amoozgar<sup>17</sup> and his fellow researchers have established the same finding among children. Tobias et al also conducted a study on infants and children and revealed similar finding.

In this current research study, 40 critically ill patients were male and had PVP of 11.81 $\pm$  4.37 cm H<sub>2</sub>O and CVP value of 10.42 $\pm$  3.95 cm H<sub>2</sub>O<sup>1</sup>. Whereas, 20 critically ill patients were female and had PVP value of 12.42  $\pm$  4.88 cm H<sub>2</sub>O and CVP value of 11.60 $\pm$  5.12 cm of H<sub>2</sub>O. There was no association of CVP and PVP with the sex of the critically ill patients. ( $p > 0.05$ ). Thus we can affirm that sex do not have any association with the CVP and PVP measurements

Further in this study, it was also observed that there was no association of PVP measurements with the site of intravenous cannula insertion. Out of the 60 critically ill patients, 36 critically ill patient's peripheral line was inserted in the radial vein with PVP of 12.04  $\pm$  4.36 cm H<sub>2</sub>O, 11 patients had peripheral line in cephalic vein with PVP of 12.57  $\pm$  4.39 cm H<sub>2</sub>O, 07 patients

had their intravenous cannula in dorsal vein with PVP of 11.47  $\pm$  4.66 cm H<sub>2</sub>O and 06 critically ill patients had PVP of 11.45 $\pm$  6.40 cm H<sub>2</sub>O ( $p > 0.05$ ). Similar results were also found by various other researchers. Desjardins and his co-researchers had done this study by using several different peripheral sites and did not observe any significant differences<sup>5</sup>. From all the above evidences it can be inferred that irrespective of the diagnosis, age, sex and site of insertion of the peripheral cannula, CVP and PVP correlate with each other.

## V. CONCLUSION AND RECOMMENDATION

The measurement of PVP is a non-invasive and cost-effective procedure for assessing preload among critically ill patients and can be used as an alternative to CVP when instruments and conditions are impractical for direct measurement of CVP. Hence PVP recording can be established as a standard procedure in determining the patient's fluid condition in centre's/hospitals where facilities for advance monitoring are not available. It is hoped that this research study has opened doors for readers to appreciate the possibility of monitoring a sensitive parameter through a simple procedure which can be implemented in the clinical settings. However, studies can be conducted on larger samples to explore further.

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