Peripheral Venous Pressure: An Alternative to Central Venous Pressure?

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Abstract

Background - *Central Venous Pressure (CVP) monitoring is useful in the assessment of the right ventricular preload and also to guide fluid therapy. Neurosurgical procedures like craniotomies for brain tumours, aneurysms and operative procedures for spinal meningiomas are associated with excessive blood loss and hemodynamic fluctuations. Thus CVP monitoring plays an important role in these patients. However central venous catheterization is an invasive procedure and is associated with complications like arrhythmias, pneumothorax, vascular injury and cardiac tamponade. Peripheral venous pressure (PVP) monitoring can be used as a substitute for central venous pressure monitoring and thus technical difficulty and complications of the same can be avoided.*

Material and Methods- *We investigated 25 patients posted for neurosurgical procedures. Central venous catheter and peripheral venous catheter were connected to a pressure transducer and linked to a multichannel monitor, and both the readings were noted at 15-minute interval simultaneously. In this prospective observational study, we investigated whether CVP can be predicted from PVP and also whether PVP can be substituted for CVP.*

Results- *Peripheral venous pressure was consistently higher than central venous pressure, and both were positively correlated. There was a time-dependent increase in the correlation coefficient between CVP and PVP. Multiple linear regressions demonstrated statistically significant association between CVP and PVP (P value <0.001). Agreement between CVP and PVP was calculated using intra class correlation coefficient and Bland Altman plot. There was statistically significant agreement between CVP and PVP.*

Conclusion- *Peripheral venous pressure can be used to predict central venous pressure as an easier surrogate measurement for the assessment of right heart filling pressure and also for guidance of fluid therapy, in neurosurgical patients. We found that there was a correlation between CVP and PVP in these patients. CVP can be predicted from PVP with proper adjustment for age sex and BMI. Changes in CVP mirrored changes in PVP.*

Key Words—*Central venous pressure, Peripheral venous pressure, neurosurgical patients.*

INTRODUCTION

Central venous pressure is described as the hydrostatic pressure measured in the thoracic vena cava near the right atrium. Measurement of central venous pressure is useful for the assessment of right ventricular preload and also to guide fluid therapy. In critically ill patients, CVP monitoring is useful to guide fluid administration as well as to know the right ventricular filling pressure[1]. Measurement of CVP requires cannulation of the

central vein, which is connected to an electronic pressure transducer or a water column manometer and is linked to a monitor which continuously displays a pressure wave.

Central venous pressure is determined by the interaction between the cardiac function and venous return, which in turn are influenced by total blood volume, vascular tone, cardiac output, right ventricular compliance, and intra thoracic pressure. Thus trends of central venous pressure value is more important than the absolute values of central venous pressure[2].

Neurosurgical procedures like craniotomies for brain tumours, aneurysms and operative procedures for spinal meningioma are associated with excessive blood loss and hemodynamic fluctuations. Factors which are linked to hemodynamic instability are due to the surgical procedure per se, and apart from that effect of anaesthetics, positive-pressure ventilation, position of the patient, relative blood volume and vascular tone also come into play. Central Venous Pressure monitoring thus plays an important role, especially in patients with associated cardiovascular diseases, and with a likelihood of significant blood loss.

Central venous pressure monitoring is unreliable for estimating left ventricular filling pressures in patients with cardiopulmonary diseases. Moreover, catheterization of a central vein is an invasive procedure and thus associated with various complications like arrhythmias, pneumothorax, vascular injury, cardiac tamponade, tracheal and laryngeal injuries, and so on.[3,4].The tip of the catheter should be kept above the pericardial reflection on superior vena cava and should always be detected by a radiological examination.

Peripheral venous pressure monitoring is an important alternative to central venous pressure monitoring and is measured by connecting the pressure tubing of the transducer to a peripheral venous catheter. Trends of peripheral venous pressure parallels to that of central venous pressure[5-7]. Complications and technical difficulties associated with central venous pressure monitoring can thus be avoided. Measurement of peripheral venous pressure is less invasive,

cost-effective and can predict the central venous pressure[8]. Neurosurgical patients are post operatively followed up in Intensive Care Units. In critically ill patients, the PVP monitoring can be done as a substitute to CVP[9-11]. PVP lines can be inserted by the nursing staff, thereby avoiding the insertion of invasive CVP by the Anesthesiologists or intensive care units physicians. However, most of the studies conducted are aimed at finding out only the correlation between CVP and PVP.

We conducted this study to predict the CVP from PVP during neurosurgical procedures lasting for more than five hours, and we aimed to assess whether PVP could be potentially used as an alternative to measuring central venous pressure.

MATERIAL AND METHODS

We conducted this prospective observational study in the super specialty block operation theater of Government Medical College, Trivandrum during the period July 2013 to November 2014. A formal sample size calculation was done prior to conducting the study and sample size fixed at 25 considering the possibility of missing values and case load. Institutional ethics committee approval was obtained and informed consents were taken from all eligible patients. We followed the declaration of Helsinki in all phases of the study. Proper precautions were taken to maintain the confidentiality of the participants in the study.

This study included 25 adult patients undergoing major neurosurgical procedures lasting for more than five hours. We selected all consecutive patients aged between 20 to 60 years satisfying the inclusion criteria. Only those patients in whom surgery was done in supine position without extreme positioning were included in the study. In addition, only patients with ASA PS grade I (American society of anesthesiologists physical status)and ASA PS grade II without cardiac disease were considered for the study. Frail patients and patients with septicemia were excluded from the study. Moreover, patients with fever, AV fistula and with peripheral vascular disease were not included in the study. In addition, history of bleeding disorders and coagulation disorders were

other contraindications. We excluded patients with difficult peripheral venous access. Those cases with pulmonary diseases were also excluded from the study.

After a thorough pre anaesthetic check up involving history, physical examination including systemic examination, airway examination and laboratory investigations, patients were accepted for anesthesia. Patients were reviewed on the preoperative day, all the procedures, risks, benefits were explained and the patients were relieved of anxiety. Instructions regarding nil per orally 8 hours prior to surgery, informed consent, arrangement of blood, oral premedication Tab Pantoprazole40 mg and Tab Domperidone 10 mg was given. Same drugs were repeated at 6 am the next day morning.

On the day of surgery all patients received Inj Glycopyrolate 0.005mg/kgwt, Inj Morphine 0.05 – 0.1 mg/kgwt and Inj Ondansetron 4mg intravenously, after putting 18 G I/V cannula in right upper limb and left lower limb under local anesthesia. Preinduction monitors included echocardiogram, noninvasive blood pressure, pulseoximeter and endtidal carbon dioxide. Preoxygenation was done using 6 liters of oxygen per minute for 3-5 minutes. Anesthesia was induced with inj Thiopentone Sodium 3-5 mg/kg body weight I/V or inj Propofol 2-3 mg/kg body weight I/V. Inj Lignocaine (preservative free) 1.5 mg/kg body weight was given intravenously to attenuate the stress response of laryngoscopy and intubation.Inj Succinyl choline 1- 1. 5mg /kg was given and the patient ventilated. After one minute direct larynogoscopy and endotracheal, intubation was done with endotracheal tube size 7.0 - 7.5 mm ID in females and 8.0 - 8.5 mm ID in males and was connected to the breathing circuit with oxygen inflow using the circle system. Endotracheal tube was properly secured using adhesive tape after confirming the correct position. Anaesthesia was maintained with nitrous oxide, oxygen, and isoflurane along with Vecuronium and Propofol infusion. Under sterile precautions, the right subclavian venous cannulation was planned. The area above clavicle and below clavicle upto

mammary region was draped. Patient was positioned supine with trendelengburg tilt and head turned to the left. The right subclavian vein was cannulated using 18G central venous catheter (Cavafix). The three way with venous extension line was placed in line with the central venous catheter, and thereby connected to the pressure transducer which was zeroed at the level of right atrium. CVP waveform and the reading was noted in the multichannel monitor.

Peripheral venous catheter attached to upper limb was connected to the pressure transducer and to the multichannel monitor. Intermittent flushing with heparin/saline was done, in both peripheral and central venous catheters. Zeroing of the peripheral venous catheter was also done. The intra-arterial cannulation was done under sterile precaution. The CVP and PVP were recorded immediately after their placement and recorded as at zero minute. CVP and PVP were simultaneously measured at 15 minutes interval and a total of 15 recordings of each were noted. Post induction monitors used were CVP, PVP, urine output, intra-arterial blood pressure and temperature.

At the end of the surgery, patient was reversed with inj Neostigmine 2.5 mg and inj Glycopyrolate 0.4 mg I/V and extubated awake after return of muscle power, respiration or postoperatively ventilated depending on hemodynamic stability and duration of surgery.

All variables were recorded in a pretested case report form which was later entered into an excel database for analysis.

All statistical analyses were done in stats direct 3 and R statistical software. Baseline demographics were described as frequencies and percentages for categorical data and summarized with mean and standard deviation or median and interquartile range depending on the distribution of the variables. Paired t-test was used to compare the CVP and PVP. We used linear regression to predict CVP from PVP. Correlations between the CVP and PVP were calculated for each time interval and their statistical significances were tested. A p value less than 0.05 was considered as statistically significant. Intra class correlation coefficients

(ICC) were calculated to estimate the agreement between CVP and PVP. Bland-Altman diagram with the difference of the measurements in CVP between PVP was plotted against the mean of the two measurements at different time points. Plot with the 95% confidence interval showed the acceptable limit of agreement. The differences between the measurements were compared with paired t test.

RESULTS

In this study, out of the 25 patients, 9(36%) were males and 16 (64%) females. The mean age of these patients were 42.4 ± 10.3 years. Most of the patients belonged to ASA class I. The most common operative procedure done in the study population was aneurysm clipping. Baseline and operative details are presented in table 1.

TABLE – 1 Patients characteristics and operative data. Data are presented as mean and sd) or n

VARIABLES	[ALL] N=25
AGE-	42.4 (10.3)
SEX-	
Male	9 (36.0%)
Female	16 (64.0%)
ASA-PS Grade	
I	14 (56.0%)
II	11 (44.0%)
SURGERY:	
ACOM Aneurysm Clipping	2 (8.00%)
Arachnoid Cyst Fenestration	1 (4.00%)
C6-7 Foraminotomy	1 (4.00%)
Cerebellar Abcess Drainage	1 (4.00%)
CP Angle Tumor Excision	2 (8.00%)
Craniotomy &Excison Cerebellar Tumour	2 (8.00%)
Excision Glioblastoma	1 (4.00%)
Excision ICSOL*	4 (16.0%)
Excision Parasagittal Meningioma	1 (4.00%)
Excision Pituitary Adenoma	1 (4.00%)
Frontal Meningioma Excision	2 (8.00%)
Glioblastoma Excision	1 (4.00%)
III Ventricle Colloid Cyst Excision	1 (4.00%)
Intraventricular Tumor Excision	1 (4.00%)
MCA Aneurysm Clipping	1 (4.00%)
Meningioma Excision	1 (4.00%)
Optic Nerve Decompression	1 (4.00%)
Right Parietal Meningioma Excision	1 (4.00%)
HEIGHT-	164 [158;170]
WEIGHT-	63.2 (7.09)

*intracranial space occupying lesions

Table 2 shows the summary statistics of CVP at different time intervals. The details about the peripheral venous pressure measured at different time interval is displayed in table 3. Compared to the CVP, PVP consistently had a higher value and both values were positively correlated. Moreover there was a time dependent increase in the correlation coefficient between CVP and PVP.

Relation between CVP and PVP was implemented with multiple regression modeling with age, sex, height and weight as potential confounders. Multiple linear regression demonstrated a statistically significant association between CVP and PVP (p<0.001) as shown in table 4 and figure 1. In addition, agreement between CVP and PVP was calculated using intra class correlation coefficient and Bland Altman plot was drawn for all time points (figure 2). The ICC for these points are shown in table 5. This showed a statistically significant agreement between CVP and PVP. The mean difference between the measurements varied from 2.72 (CI 2.1 to 3.3) to 2.92(CI 2.3 to 3.45) which were statistically significant.

TABLE 2: summary statistics of central venous pressure at different time points.

	N	Mean	SD	Maximum
CVP_0M	25	10.640	2.7368	16.000
CVP_15M	25	10.680	2.0960	15.000
CVP_30M	25	10.680	2.1741	16.000
CVP_45M	25	11.240	2.6658	16.000
CVP_60M	25	10.720	2.5087	16.000
CVP_75M	25	10.880	2.1856	15.000
CVP_90M	25	10.960	2.2264	15.000
CVP_105M	25	11.200	2.3805	16.000
CVP_120M	25	10.880	2.2420	16.000
CVP_135M	25	11.000	2.0207	15.000
CVP_150M	25	11.240	2.6026	17.000
CVP_165M	25	11.760	2.5212	19.000
CVP_180M	25	11.880	2.6665	19.000
CVP_195M	25	11.280	2.2457	15.000
CVP_210M	25	10.960	2.1502	15.000

TABLE 3: summary statistics of peripheral venous pressure at different time points.

	N	Mean	SD
PVP_0M	25	13.360	2.7062
PVP_15M	25	12.800	2.2730
PVP_30M	25	12.920	2.1393
PVP_45M	25	13.200	2.3629
PVP_60M	25	13.040	2.3889
PVP_75M	25	13.000	2.1213
PVP_90M	25	13.200	2.2546
PVP_105M	25	13.280	2.4752
PVP_120M	25	13.000	2.1794
PVP_135M	25	13.320	1.7963
PVP_150M	25	13.360	2.6439
PVP_165M	25	13.956*	
PVP_180M	25	13.696*	
PVP_195M	25	13.360	2.1772
PVP_210M	25	13.880	2.1471

*Back transformed after logarithmic transformation

Table 4 : Results of multiple linear regression between CVP and CVP over time

Time	Unadjusted coefficient	Adjusted coefficient	P value
0 minute	0.84	0.82	<0.001
15 minutes	0.62	0.62	<0.001
30 minutes	0.84	0.80	<0.0001
45minutes	0.80	0.97	< 0.0001
60 minuts	0.80	0.94	< 0.0001
75 minutes	0.59	0.63	0.0036
90 minutes	0.80	0.77	< 0.0001
105 minutes	0.82	0.80	< 0.0001
120 minutes	0.75	0.78	< 0.0001
135 minutes	0.76	1.01	< 0.0001
150 minutes	0.88	0.88	< 0.0001
165 minutes	0.83	0.88	< 0.0001
180 minutes	0.66	0.88	0.0011
195 minutes	0.77	0.75	< 0.0001
210 minutes	0.84	0.90	< 0.0001

FIGURE 1 : Association between CVP and PVP at different time periods

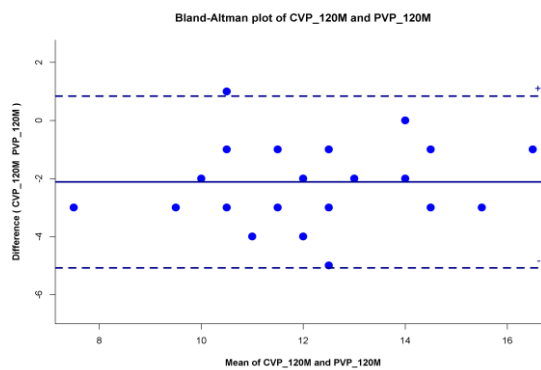**FIGURE 2:** Bland-Altman plot at different time intervals
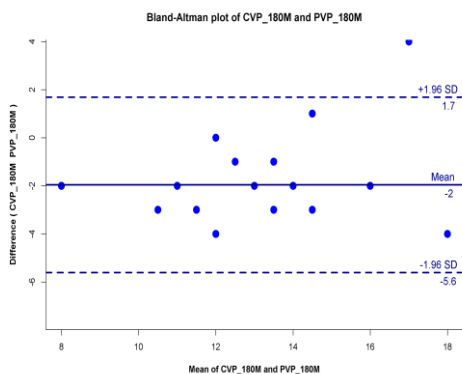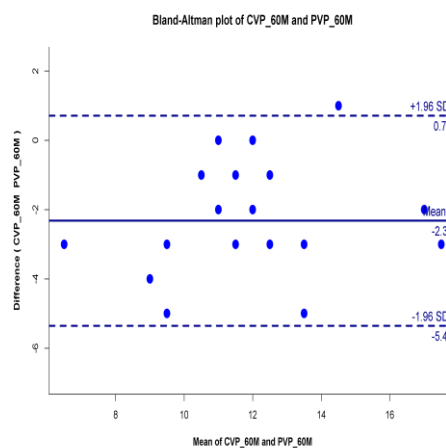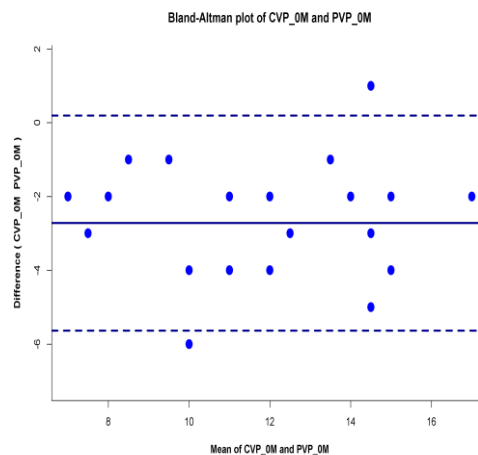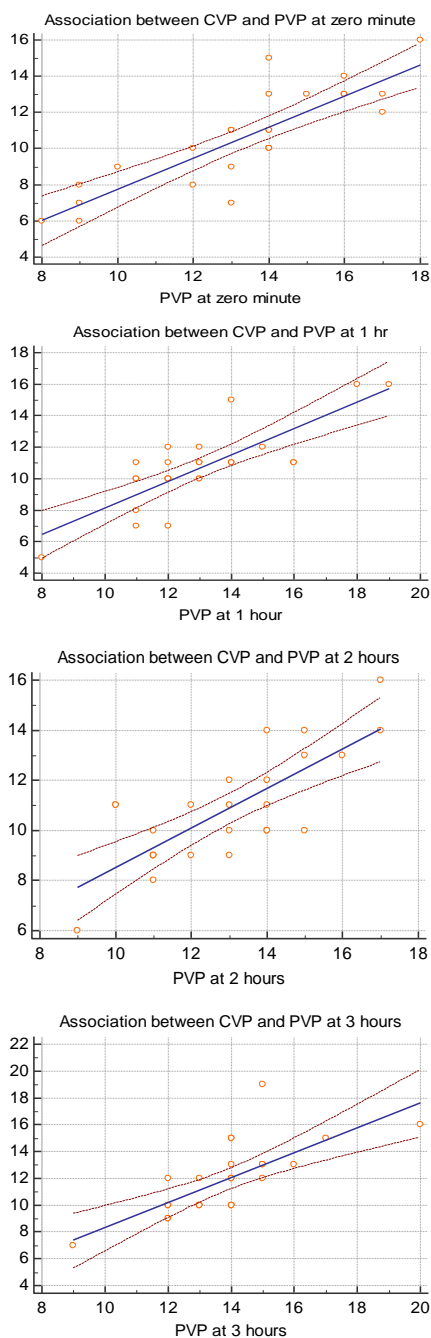
TABLE 5: Intraclass correlation coefficients at different time periods

Time interval	ICC (95% CI)
0 minutes	0.653 (0.221, 0.846)
15 minutes	0.61 (0.126, 0.827)
30 minutes	0.627 (0.164, 0.835)
45 minutes	0.76 (0.462, 0.894)
60 minutes	0.645 (0.203, 0.843)
75 minutes	0.467 (-0.194, 0.764)
90 minutes	0.615 (0.136, 0.829)
105 minutes	0.706 (0.341, 0.87)
120 minutes	0.613 (0.133, 0.829)
135 minutes	0.473 (-0.181, 0.767)
150 minutes	0.778 (0.503, 0.902)
165 minutes	0.646 (0.206, 0.843)
180 minutes	0.645 (0.204, 0.843)
195 minutes	0.645 (0.204, 0.843)
210 minutes	0.398 (-0.35, 0.733)

DISCUSSION

This study aimed at predicting the CVP among neurosurgical patients and feasibility of using PVP as an easier surrogate measurement for assessing the right heart filling pressure. Our study has shown that there is a correlation between CVP and PVP among these patients and CVP can be predicted from PVP with proper adjustment for age, sex and BMI. We found that changes in PVP mirrored the changes in CVP.

The correlation coefficient varied from 0.71 to 0.90 indicating high correlation between these values. As PVP is linked to CVP by a continuous fluid column, it is expected that CVP and PVP will show a consistent correlation. Our study has shown a statistically significant and clinically important correlation between these measurement over different time periods, thereby establishing the consistency of the correlation. Previous studies reported in the literature agree with our findings. Studies by Sheriff et all, Rajan et all , Kumar et all showed similar results[12-14].

From the mean difference between the measurements at different time period, we can conclude that the PVP has a higher value compared to the CVP. This could be easily explained the normal physiological phenomenon. The change in the difference between the measurement over a period of time was not statistically significant . In view of this, we can potentially estimate the CVP through the measurement of PVP. In this regards as well, our results are in consistent with the results obtained by Charolabmbous et all and Amoozgar et all [11,15]. However the difference obtained by Kim et all showed higher values[16]. This deviation from the result we obtained may be due to result of physiological effect of pneumoperitoneum on the vascular system in those laparoscopic colostomy patients.

The regression modeling with multiple linear regression fitted well in our study with potential confounders adjusted showed that CVP can be predicted from the values of PVP. Most of the studies reported in the literature take into account only the PVP. One of the advantages of our study is that this study takes into consideration the potential confounding effects of demographic feature. Kim et all , Kumar et all, Amoozgar et all and Choi et all reported similarly the predictive value of PVP in assessing the CVP [14-17]. However the adjusted values obtained in this study can potentially better predict the CVP as a a result of inclusion of confounders into the regression modeling.

The potential limitations of our study was the low sample size. In our study, catheterisaion procedures were not standardized. There was a selection bias in selecting the patients. Another issue was that the neurosurgical procedures were not standardized. A larger study is needed with adequate sample size to model multiple linear regression in predicting CVP. There was no blinding in our study. This could have introduced selection bias in our study.

In conclusion, these results suggest that CVP may be calculated from the measurement of PVP. This may potentially obviate the need for CVP in neurosurgical patients. The peripheral cannulation, a relatively easy procedure can help in planning long neurosurgical procedure in resource poor settings.

Our study concludes that peripheral venous pressure measurement may be used as an alternative to central venous pressure during prolonged neurosurgical procedures.

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