

Comparative Study of Venous Pressure Obtained From Central and Peripheral Venous Catheter

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Abstract

Background: Venous pressure can be measured by placing Central venous catheter (CVC) and Peripheral venous catheter (PVC). Venous pressure recording obtained from CVC is called central venous pressure (CVP) and that obtained from PVC is called peripheral venous pressure (PVP). PVC is easy to place and free of complication and sometimes preferable in some cases. CVC though used commonly is not free from complications. We investigate the feasibility and accuracy of measuring PVP and precise correlation between PVP and CVP.

Methods: In this prospective, observational study, a total of 2522 readings of CVP and PVP were obtained from 60 patients in varying positions before and after 500 ml of fluid challenge intraoperatively.

Results: Throughout the study period, PVP persistently showed a positive trend with a significantly higher value than CVP ($P < 0.001$). Correlation for the entire data showed a significant consistency of CVP-PVP difference [$r = 0.89$ (95% CI: 0.87 to 0.90); $p < 0.0001$]. Tests of correlation revealed that whenever CVP trends changed rapidly so did PVP trends, and in synchrony with each other. The results revealed strong correlation between CVP and PVP ($r^2 = 0.79$).

Conclusion: Our study suggests that CVP and PVP change similarly due to changes in intravascular volume in a given patient. The CVP-PVP gradient is not similar between patients; therefore it is not possible to predict CVP from PVP unless the gradient in the individual patient is known beforehand.

Keywords: Peripheral venous pressure, Central venous catheter, Central venous pressure.

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1. Introduction

Since the introduction of percutaneous jugular vein cannulation in 1969, direct central venous pressure (CVP) measurement has become a standard practice in any major surgical procedure associated with massive blood loss and large volume of fluid shifts for assessing right ventricular function and systemic fluid status and is a true reflection of cardiac function [1].

Measurement of CVP is possible by cannulating CVC through internal jugular and subclavian vein or by inserting peripheral inserted central catheters (PICC) from femoral veins or antecubital vein. Measurements obtained

from PICC are unreliable due to small lumen and long length of the catheter. Peripheral venous catheter (PVC) which is easy to place and free of complications is indicated wherever Internal Jugular vein (IJV) cannulation is not possible due to inaccessible neck. Literature revealed that venous pressure measured from PVCs closely related to pressure measured by central venous catheter (CVC) both intraoperatively and patients on ventilator in ICU [2-5].

In the present study, we investigate the feasibility of measuring venous pressure from PVC and to establish the precise and accurate correlation between venous pressure obtained from CVC and PVC.

2. Material and Methods

After obtaining institutional review board approval and informed consent, this prospective trial was carried out in a tertiary care hospital. Out of a total of 1043 patients listed for surgery during the study period (Jan 2015 to Feb 2016), 858 patients did not meet inclusion criteria and 95 patients were not included due to refusal and 90 cases were cancelled. A total of 60 patients in ASA physical status grade I to III, between 20 years and 80 years of age, undergoing surgery deemed to require placement of central venous catheter were included in the study. Patients with known coagulation disorder, altered anatomy precluding insertion of central venous catheter, poor peripheral venous access and patient refusal were excluded from the study.

Standard anesthetic induction using Inj propofol 2mg/kg i.v, Inj. Fentanyl 2 mcg/kg i.v. and Inj. Atracurium 0.5mg/kg i.v. followed by tracheal intubation was done. Maintenance was done with 2% Sevoflurane in 50% nitrous oxide and 50% oxygen. In all patients both CVC and PVC was cannulated. After Endotracheal intubation, central venous access was obtained by using a 7F or 7.5F double or triple-lumen catheter with placement through the internal jugular or subclavian vein. Standard depth guidelines were used to ascertain placement of the tip of central venous catheter in the cavo-atrial junction. The distal end of the triple or double lumen catheter was used for CVP measurements in all patients. Peripheral venous access was obtained by placing standard intravenous catheter (16 or 18 gauge) in the ante cubital vein in cubital fossa. The pressure transducers (pressure transducer DTX plus: Becton Dickinson, USA) were all calibrated at the mid thoracic level at the point of intersection between the midaxillary line and the fourth intercostal space and connected to Penlon anaesthesia work station with PM 9000 monitor. Both transducers were brought to this same level and zeroed separately. The pressure line was flushed with saline. After flushing and room-air zero calibration the transducer sets were re-flushed with saline and maintained at mid-thorax level throughout surgery. Occlusion errors of measurement were avoided with frequent flushing of the catheters. Drugs and fluids were not administered from the arm in which the measurements were performed. Venous pressure was measured from both the CVC and the PVC.

All patients were given 500ml of crystalloid at the start of surgery as preload through another peripheral IV catheter. Simultaneous measurements of the venous pressure from the central and peripheral catheters were performed before and after 5 minutes of completion of preload and every 15 minutes thereafter during the entire surgical procedure till completion. Measurements were not taken during the rapid administration of fluids or medications. All measurements were recorded at end expiration. The hemodynamic data are reported as single values (in mm Hg, referenced to midthorax level), rounded

to the nearest 1 mm Hg. At the end of surgery, residual neuromuscular blockade was antagonized with glycopyrrolate 0.02mg/kg and Neostigmine 0.05 mg/kg, and the trachea was extubated.

Consistency of PVP-CVP difference was analyzed by testing correlation coefficient. To test for a significant relationship, PVP and CVP were compared by one way analysis of variance ANNOVA. PVP and CVP were also compared by simple regression analysis to obtain correlation coefficients. Scatter plots of CVP versus PVP were made using all 1261 respective paired measurements. Bland-Altman analysis of agreement between methods of clinical measurements was used to test for agreement between PVP and CVP and to determine bias. A "p" value less than 0.05 was considered significant.

3. Observation and Results

The precise and accurate correlation measured between venous pressure from PVC and CVC was studied during GA in 60 patients for elective surgery. Mean age of the patients was 48.2 yrs (range 24 to 78 years) and mean weight of the patients was 59.6 kg (range 38 to 87 kg). Diagnosis and type of surgery are listed in Table 1. Forty-nine patients were in supine position, seven in lateral position and four in prone position at the time of study (Table 2). CVP was measured from subclavian vein in 35 patients and internal jugular vein in 25 patients. PVP was measured 30 each in right and left antecubital area in all patients. A total of 1261 simultaneous (peripheral and central) venous pressure readings were obtained from the 60 patients resulting in a total of 2522 readings.

PVP was easily obtained in all 60 patients in supine, lateral, and prone positions. The mean CVP was 8.5 mmHg (95 % CI 8.4 - 8.7), mean PVP was 12.0 mmHg (95 % CI 11.8–12.2), and mean PVP-CVP gradient was 3.5 mmHg (95 % CI 3.4 – 3.6) [Table 2]. Average CVP of all cases before preload was 8.2 mmHg and average CVP after preload was 9.5 mm Hg [Table 3]. Average PVP before preload was 11.9 mmHg and average PVP after preload was 13.2 mmHg. After 500ml of crystalloid preload, average increase in CVP was 1.33 mm Hg (range 0-3 mmHg) and average increase in PVP was 1.33 mm Hg (range 0-3 mmHg). Average PVP-CVP gradient remained constant at 3.7 mmHg. CVP and PVP increased similarly from 8.2 to 9.5 mmHg and 11.9 to 13.2 mmHg respectively. Analysis of agreement between CVP and PVP showed bias of 3.5 mmHg (95% CI 3.4 - 3.6mmHg) with limits of agreement 0.6 to 6.3.

Correlation for the entire data showed a significant consistency even when data was classified on basis of CVP-PVP difference [$r = 0.89$ (95% CI: 0.87 to 0.90); $p < 0.0001$] (Table 4). In most cases, there is an offset between CVP and PVP (PVP > CVP), but the degree of offset remained relatively constant throughout each case.

Tests of correlation for individual cases revealed that as and when the CVP trends changed, the PVP trends also changed, and in synchrony with each other. The results revealed strong correlation between CVP and PVP ($r^2=0.79$) (Figure 2). These results interpreted in conjunction with the results of correlation suggest that while there is a consistent CVP-

PVP difference within an individual, the difference is not similar between the patients. The implication of this finding is that it is not possible to use a single value of CVP-PVP difference for all subjects to predict the value of one parameter from the other.

Table 1: Diagnosis and type of surgery

Diagnosis	No of patients	Type of surgery
Intracranial space occupying lesions	28	Craniotomy & Excision
Intracranial Aneurysm	1	Craniotomy & Clipping
Gastro-intestinal malignancies	23	Laparotomy & Excision
Gynaecologic malignancies	4	Laparotomy & Excision
Renal transplant recipient	2	Renal transplantation
Hydatid cyst liver	1	Laparotomy & Excision
Blunt Trauma Abdomen	1	Laprotomy & Proceed

Table 2: CVP and PVP reading in different Position

Position	No of patients	No of readings	Mean CVP	SD CVP	Mean PVP	SD PVP
Supine	49	1043	8.6 (95 % CI 8.5 - 8.8)	2.9	12.1 (95% CI 11.9-12.3)	3.2
Lateral	4	143	8.1 (95 % CI 7.7 - 8.5)	2.4	11.8 (95% CI 11.3-12.2)	2.8
Prone	7	75	7.5 (95 % CI 7.0 - 8.1)	2.5	11.5 (95% CI 10.9-12.1)	2.7
Overall	60	1261	8.5 (95 % CI 8.4 -8.7)	2.8	12.0 (95% CI 11.8-12.2)	3.1

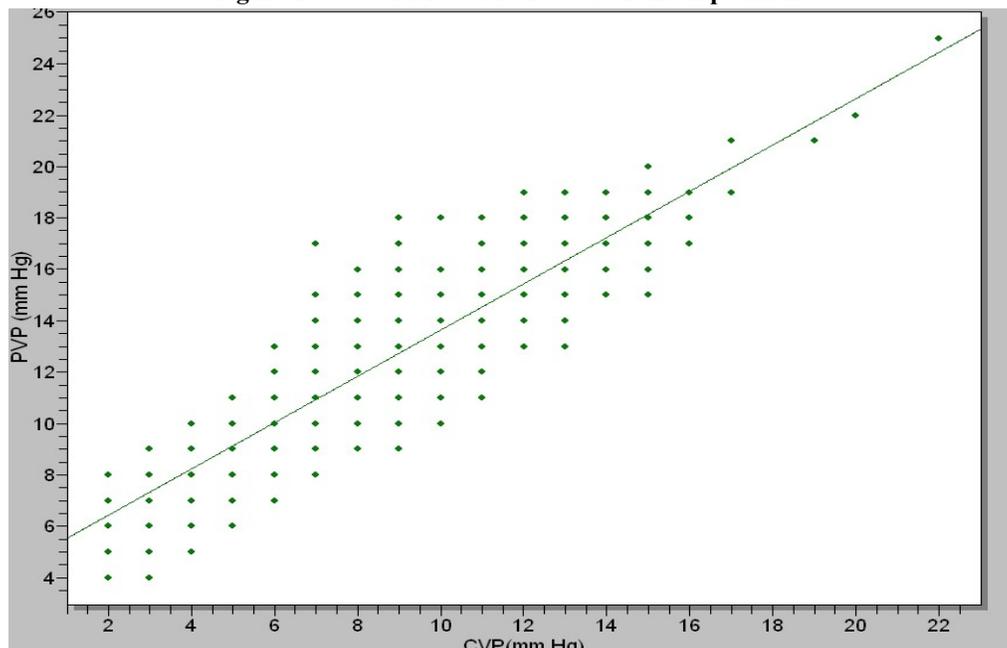
Table 3: Changes in CVP and PVP before and after preload

Preload	Mean CVP (mmHg)	SD CVP	Mean PVP (mmHg)	SD PVP	Mean (PVP-CVP) mmHg
Before	8.2	2.1	11.9	2.5	3.7
After	9.5	2.2	13.2	2.6	3.7

Table 4: Correlations of CVP and PVP

Position	Correlation coefficient	95 % CI	P value	No. of Observations	Bias (mmHg)	Limits of agreement (Mean Difference ± 1.96 SD)
Supine	0.89	0.88 – 0.90	<0.0001	1043	3.4	0.6 to 6.3
Prone	0.87	0.83 – 0.91	<0.0001	75	3.9	1.2 to 6.7
Lateral	0.89	0.79 – 0.91	<0.0001	143	3.6	1.0 to 6.3
Overall	0.89	0.87 – 0.90	<0.0001	1261	3.5	0.6 to 6.3

Figure 1: Scatter Plot of PVP Vs CVP in all positions



$y=3.6485+0.981x$
 $r^2=0.79$

4. Discussion

Similar results were reported perioperatively by Amar *et al* and Munis *et al* [2, 6]. The increase in gradient of CVP and PVP was reported by Amar *et al* was much higher, however in that study a fluid challenge of 2 liters was given which explains greater increase in absolute values of CVP and PVP than our study.[6]

In our study, patients have undergone surgery in different position of hands and body axis. The different positions of patient may lead to flexion of elbow and might result in an erroneous value in PVP. We did take care to minimize any flexion of elbow. There was clear correlation between CVP and PVP values in different positions. Analysis of agreement between CVP and PVP in our study showed bias of 3.5 mmHg with limits of agreement 0.6 to 6.3. The limits of agreement between CVP and PVP (mean difference \pm 1.96 SD) were comparable to earlier published studies.

The results of the present study imply that in a given patient, if the CVP-PVP difference is known, PVP monitoring can be used to assess haemodynamic changes caused by changes in intravascular volume or cardiac function. If the information on the CVP-PVP difference is not available, a value of PVP measured under stable haemodynamic conditions may be used as a reference value for the given patient and further PVP changes may be interpreted as being reflective of changes occurring in CVP. Some studies have shown that PVP represents mean systemic pressure in case of circulatory arrest and therefore the intravascular volume status. But since PVP varies widely between patients, it is difficult to use PVP monitoring in isolation to interpret intravascular status, limiting its usefulness. We found the correlation of PVP with CVP to be accurate regardless of the patient positioning (supine, prone, lateral). This technique may be used to estimate CVP in situations such as patient inaccessibility during a surgical procedure, technical problems, or patient-related factors that preclude placement of a CVC.

There are many limitations of this study. First is that patient position was not restricted to single position and secondly position of hands was not similar in all cases. The patient volume status was unknown before including in study. We also did not compare the effect of catheter size on pressure measurements.

5. Conclusion

In summary, our study suggests that CVP and PVP change similarly due to changes in intravascular volume in a given patient. The CVP-PVP gradient is not similar between patients; therefore it is not possible to predict CVP from PVP unless the gradient in the individual patient is known beforehand.

Financial Disclosure

The authors declared that this study has received no financial support.

Ethics Committee Approval

Ethics committee approval was received for this study from the ethics committee of Armed Forces Medical College Pune, India.

Informed Consent

This study performed in humans was approved by the Institutional Review Board and written informed consent was obtained from all patients or parents of minors.

Conflict of Interest

No conflict of interest was declared by the authors.

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