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Comparison of Conventional Central Venous Pressure with Peripheral Venous Pressure and External Jugular Venous Pressure in Patients with Sepsis

Rangadhamaiah Sreenidi[1], Suresh Kumar N[2]

[1]Post Graduate Resident, [2]Professor, Department of Anesthesiology, Sri Devaraj URS Medical College (SDUMC), Sri Devaraj URS Academy of Higher Education and Research (SDUAHER), Kolar, Karnataka 563101, India.

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Abstract

Context: Central venous pressures along with other dynamic and static variables are used to guide fluid therapy in patients with sepsis admitted to ICU. However, insertion of central venous catheter is associated with serious complications. We, therefore measured external jugular venous pressure (EJVP), peripheral venous pressure (PVP) and correlated with central venous pressure (CVP) measured by conventional technique and thus technical difficulty and complications can be avoided.

Aims: To evaluate the correlation between conventional CVP with EJVP and PVP values in patients with sepsis.

Settings and Design: Prospective observational study.

Methods and Material: Study done on 54 patients admitted with sepsis requiring fluid resuscitation. CVP, EJVP and PVP measurements were taken using a water column manometer in cm H_2O. All the three venous pressures were repeated 3 times following every fluid challenge of 250 ml.

Statistical analysis used: Pearson's correlation and Bland–Altman's analysis.

Results: The observations were analyzed by dividing the patients into 2 groups on the basis of CVP measurements

Group A (CVP ≤ 10)

Mean difference between CVP with PVP and EJVP is >2 cm H_2O and p value is insignificant.

Group B (CVP >10)

Mean difference between CVP with PVP and EJVP is <2 cm H_2O and p value ($p<0.001$) is strongly significant.

Conclusions: The present study concludes that, there is definite correlation between CVP, EJVP and PVP in a given patient. Further concludes the difference between CVP and EJVP/PVP was minimum (<2 cm H_2O) when the CVP was >10 cm H_2O.

Keywords: Central venous pressure; External jugular venous pressure; Peripheral venous pressure; Sepsis.

Introduction

According to Surviving Sepsis Campaign 2016 guidelines, central venous pressures along with other dynamic and static variables are used to guide fluid therapy in patients with sepsis admitted to critical care unit.[1] However, insertion of central venous catheter is associated with serious complications such as venous air embolism, pneumothorax, carotid artery puncture, arrhythmias, perforation

Corresponding Author: **Suresh Kumar N,** Department of Anesthesiology, Sri Devaraj URS Medical College (SDUMC), Sri Devaraj URS Academy of Higher Education and Research (SDUAHER), Kolar, Karnataka 563101, India.

E-mail: drskumar6@gmail.com

of right atrium, cardiac tamponade and catheter related blood stream infection.[2] Unlike central venous cannulation, patients with vasofix inserted into external jugular vein and peripheral vein are less likely to encounter any serious complications.

Till date, only few studies are done to show the association between central venous pressure and peripheral venous pressure.[3–5] Peripheral venous pressure monitoring is an easy procedure and also can be used as reserve to central venous pressure in governing fluid volume status among critically ill patients.[6]

At present, in most of resource limited ICU's still rely on conventional central venous pressure monitoring using water column manometer for managing fluid resuscitation in septic patients.[7]

Materials and Methods

Main objectives of the study includes to measure CVP, EJVP and PVP and to evaluate the correlation between conventional CVP with PVP and EJVP in patients with sepsis.

This is a prospective observational study conducted on 54 patients with sepsis requiring fluid resuscitation received to tertiary care hospital, ICU from January 2018 to May 2019 after obtaining clearance from institutional ethical clearance.

Patients of above 18 years of age with sepsis admitted in ICU requiring fluid resuscitation were included and exclusion criteria includes patients with h/o cardiovascular disease, coagulopathy, inability to cannulate central/peripheral vein and infection at the site of cannulation.

Study was started after obtaining written informed consent taken from patient or next of kin. Necessary investigations like complete blood count, bleeding time and clotting time were done in all patients prior to cannulation to rule out coagulopathy. Under strict aseptic precautions, each of the PVP, EJVP and CVP was measured simultaneously using water column manometer. Initially 10 observations were done under supervision before start of study. Peripheral venous pressure was measured from 16G or 18G vasofix sited in right/left cubital fossa, external jugular venous pressure measured from 16 or 18G vasofix sited in right/left external jugular vein and central venous pressure measured from 16G distal port of 7 French triple lumen central venous catheter of 15 cm length sited in right/left internal jugular vein/subclavian vein. Water column manometers were connected to all the three catheters and zeroed at mid–axillary line corresponding to sternal angle. The zero point was identified on the manometer that corresponds to the patient's right atrium.[2,10] Zero reference point for venous pressures in the thorax in a point on the external thorax where the fourth intercostal space intersects the mid-axillary line (the line midway between the anterior and posterior axillary folds). When the patient is in supine position, this point (phlebostatic axis) corresponds to the location of the right and left atrium Recordings of the measurements that corresponds with the lower meniscus of the normal saline was taken as reading for CVP, PVP and EJVP. The measurement is expressed in cmH_2O. If the patient is on mechanical ventilation, we subtracted the PEEP value above 5 cmH_2O from the actual measurement of CVP value. Before fluid challenge peripheral venous pressure, external jugular venous pressure and central venous pressure are measured in all patients admitted with sepsis. All the three venous pressures were repeated 3 times following every fluid challenge of 200 ml.

Following insertion of central line, patient was subjected for chest x-ray to rule out pneumothorax. After check x-ray, we also checked the catheter tip position. Catheter tip position should ideally above the level of carina. This is the joining of the right and left innominate veins with the superior vena cava (SVC). If the catheter tip is too high in position, those values are associated with inaccurate values of CVP measured, hence such values were not considered in our study. If the patient develops any arrhythmias 12 lead ECG would be recorded and arrhythmias will be analyzed. If there is doubtful of catheter related blood stream infection after 48 hours of following central venous cannulation, two blood cultures will be done. One sample taken from central line and another from peripheral site. Peripheral venous catheters were changed every 72 hours or earlier when the signs of phlebitis noticed according to institutional practice.

Statistical analysis

Statistical analysis was done using SPSS Version 22 software. Sample size was estimated based on correlation co–efficient between central venous pressure and peripheral venous pressure from the study by Kumar et al. at the baseline with 90% power, 99% C.I and Type 1 Error 1%. Calculated sample size of 53 was obtained.[3]

Correlation co-efficient was used to study the relation between continuous variables. p value <0. 05 will be considered as statistically significant. In the present study, descriptive and inferential statistical analysis has been carried out. Continuous measurements results are presented on Mean±SD (Min-Max) and results on categorical measurements are presented in Number (%) Assessment of significance is at 5% level of significance Pearson correlation co-efficient ranging between -1 to 1, -1 being the perfect negative correlation, 0 is the no correlation and 1 means perfect Positive correlation. The Bland–Altman method derives the mean difference between two methods of reading (the 'bias'), and 95% limits of agreement as the mean difference (2 SD) [or more precisely (1.96 SD)]. The better agreement is when there is small range between these two limits. Significant figures+ -Suggestive significance (P value: $0.05<P<0.10$),* Moderately significant (P value: $0.01<P \leq 0.05$),** Strongly significant (P value: $P\leq0.01$)

Results

Study was done on 54 patients, all of the study subjects were analyzed. Out of which 43 patients were male and 13 patients were female. In each patient 12 observations were made. Hence for a total of 54 patients 648 observations were made. The observations were analyzed by dividing the patients into 2 groups on the basis of CVP measurements.

Group A is patients with CVP ≤10 and Group B is patients with CVP >10. Out of 648 observations, 396 observations belonged to Group A and 252 observations under Group B.

In Group A

Total mean CVP was 7.88 cmH_2O, mean EJVP was 10.83 cmH_2O and mean PVP was 11.17 cmH_2O.

CVP and EJVP -mean difference was 3.9, r=0.386, p=0.192

CVP and PVP -mean difference was 4.3, r=0.137, p= 0.174

In Group A (CVP ≤10) mean difference between CVP with PVP and EJVP is >2 cmH_2O and p value is insignificant.

In Group B

Overall mean CVP was 11.90 cmH_2O, mean EJVP was 12.58 cmH_2O, and mean PVP was 13.52 cmH_2O.

CVP and EJVP-mean difference was 1.3, r=0.685, p<0.001

CVP and PVP –mean difference is 1.8, r=0.785, p<0.001

In Group B (CVP >10) mean difference between CVP with PVP and EJVP is <2 cmH_2O and p value (p<0.001) is strongly significant and comparable.

To evaluate the degree of agreement, Bland and Altman plots were done between CVP - EJVP and CVP –PVP with 95% limits of agreement as the mean difference (1.96SD).

We didn't appreciate any difference with regards to CVP measurements or technical difficulty with

Table 1: Distribution of CVP at baseline in patients studied

	No. of patients	%
<=10 (Group A)	33	61.1
>10 (Group B)	21	38.9
Total	54	100.0

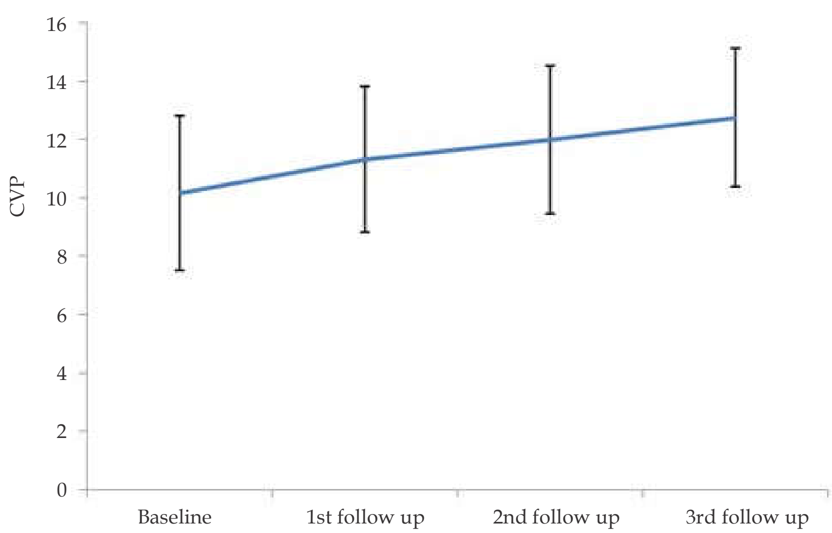

Fig. 1: Line diagram of CVP assessment among patients studied

the procedure regardless of the site (IJV/subclavain) or side of central venous catheterization (right side/left side). Out of 54 patients, 29 patients were on mechanical ventilation.

Among 54 patients, 2 patients developed phlebitis at the peripheral cannula site after 2 days, one patient had accidental subclavian arterial puncture and another patient developed hematoma while inserting right sided IJV due to carotid artery puncture which was subsided by giving local compression.

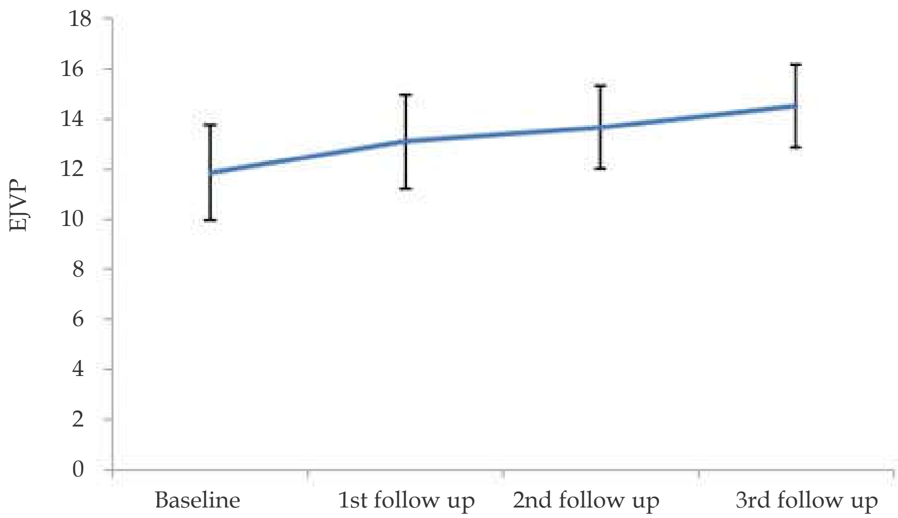

Fig. 2: Line diagram of EJVP assessment among patients studied

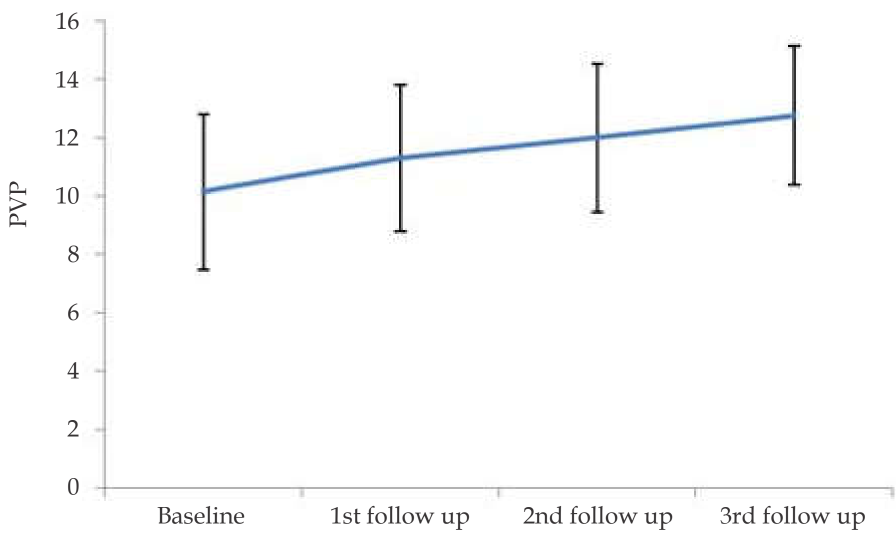

Fig. 3: Line diagram of PVP assessment among patients studied

Table 2: Bland altmnan plot statistics of CVP and EJVP

CVP vs EJVP	Baseline	1st follow-up	2nd follow up	3rd follow up
No of Patients	54	54	54	54
Mean Difference	1.68	1.76	2.33	1.74
SD-diff	1.97	1.85	2.18	1.89
Mean diff-1.96SD	-5.5	-5.4	-6.6	-5.5
Mean Diff+1.96SD	2.2	1.9	1.9	2.0
T value	6.287	6.979	7.863	6.749
P value	<0.001**	<0.001**	<0.001**	<0.001**
95% CI	1.14-2.22	1.25-2.26	1.73-2.93	1.22-2.26

Table 3: Bland altmnan plot statistics of CVP and PVP

CVP vs PVP	Baseline	1st follow-up	2nd follow up	3rd follow up
No of Patients	54	54	54	54
Mean Difference	2.37	2.40	12.50	2.20
SD-diff	1.67	2.07	2.09	2.08
Mean diff-1.96SD	-5.7	-6.5	-7.30	-6.30
Mean Diff+1.96SD	0.9	1.7	1.40	1.90
T value	10.403	8.510	43.762	7.76
P value	<0.001**	<0.001**	<0.001**	<0.001**
95% CI	1.91-2.82	1.84-2.97	11.93-13.07	1.63-2.77
Total	120			

Table 4: Correlation between CVP and PVP, CVP and EJVP in Group A and GROUP B

Pair	EJVP		Difference of CVP & EJVP	PVP		Difference of CVP & PVP
	r value	p value		r value	p value	
CVP ≤ 10						
• At baseline	0.504	<0.001**	2.67±1.71	0.137	0.448	3.12±1.49
• At 1st follow up	0.072	0.750	3.14±1.83	0.000	1.000	3.83±1.84
• At 2nd follow up	0.386	0.192	5.08±1.89	0.093	0.763	5.31±1.97
• At 3rd follow up	0.681	0.043*	4.78±1.56	0.179	0.644	5.22±1.86
CVP >10						
• At baseline	0.831	<0.001**	1.00±0.71	0.791	<0.001**	1.48±0.81
• At 1st follow up	0.685	<0.001**	1.19±0.74	0.801	<0.001**	1.75±1.29
• At 2nd follow up	0.646	<0.001**	1.75±1.01	0.709	<0.001**	2.41±1.43
• At 3rd follow up	0.637	<0.001**	1.40±0.96	0.732	<0.001**	1.78±1.33

Discussion

In hemodynamically unstable septic patients, it is important to optimize cardiac output and tissue oxygenation. Fluids remain the main line of treatment in patients with septic shock. Not all patients are fluid responsive i.e. respond to fluid challenge by increasing stroke volume and cardiac output.

Both inadequate fluid and excessive fluid administration would result in increasing morbidity and death in critically ill patients. Therefore accurate predictors of fluid responsiveness are essential for managing patients in septic shock.

For accurate prediction of fluid responsiveness, we need to monitor other dynamic variables/ parameters of fluid responsiveness such as systolic pressure variation, pulse pressure variation, stroke volume variation or echocardiographic measurement of stroke volume/cardiac output of left ventricle function or IVC (compressibility/ distensibility index) variation during respiration for fluid challenge which requires continuous arterial pressure monitoring, USG with cardiac probe and needs proficiency in using echocardiography.[8]

Cardiac output and pulmonary artery occlusion pressure can also be measured. As the procedure is more invasive and many complications associated with pulmonary artery catheterization, the procedure is not recommended for routine use.[9]

But in resource limited hospital, it would not be feasible to monitor the above mentioned parameters and would rely on CVP monitoring for guiding i.v fluids in septic patients. Therefore CVP still remains most routinely used parameter in guiding septic patients for fluid resuscitation.

Main advantage of CVP is easy to measure, minimal instruments are required and it is cheap. Main drawback of measuring CVP to guide fluid resuscitation is its inability to predict a response to fluid challenge, even when the CVP is within acceptable range of 8-12 cmH_2O.[10] Rather than isolated CVP value, trend of CVP measurement over time/change in response to fluid challenge may provide more reliable information regarding intravascular volume status.

As capillary blood flow depends on the gradient between mean arterial pressure(MAP) and central venous pressure(CVP), high CVP result in reduced capillary and organ blood flow. Infusing i.v fluids beyond CVP of 18 cmH_2O would worsen cardiac function and impair venous return and capillary blood flow. Hence CVP would guide the clinician in optimizing fluid administration in a given patient.

Studies proven that a patient who is hypovoluemic with good LV function would increase CVP not more than 2 mmhg and the CVP would return to baseline within 10 minutes and improvement of blood pressure for a fluid challenge of 200 ml suggest the patient is fluid responsiveness.

Major obstacle for CVP measurement is the requirement for appropriate location of central line placement. Nonetheless insertion of central line catheter is associated with serious complications such as venous air embolism, pneumothorax, cardiac tamponade, arrhythmias, carotid artery puncture, perforation of right atrium, and CLABSI. Less invasive alternatives to the traditional measurement for assessing intravascular volume status have been described which includes measuring PVP and EJVP.

At present, most of the resource limited ICU's still rely on CVP monitoring using water column manometer for managing fluid resuscitation with sepsis patients. In our study we measured EJVP, PVP and correlated pressures with CVP measured by conventional technique.[11]

Kumar et al. in 2015 studied on 50 critically ill patients on mechanical ventilation. Measurements were done between CVP and PVP using a water column manometer. The study arrived at a judgment of positive correlation between CVP and PVP with r=0.038, p=0.004 and Bland –Altman analysis showed 95% Limits of agreement to be -3.180 -11.350, whereas in patients with CVP>10 cmH_2O, the correlation was better with PVP r=0.766, p<0.0001 and Bland-Altman analysis showed 95%Limits of agreement to be 95% LOA to be -1.254-5.540[3]

Munis et al. concluded that the trends of PVP were parallel to the trends of CVP and that their relationship was independent of the patients. Between CVP and PVP, Analysis of variance indicated a significant relationship with p <0.001 with Pearson coefficient of 0.82.[6]

Leonard et al. concluded that EJVP was an acceptable estimate of CVP with mean difference of –0.3 mmhg in supine position and also concluded that though agreement was poor in lateral position but was stronger for trend rather than absolute values.[12]

Abdullah et al. did a prospective study which showed that EJVP and CVP recordings were parallel and also showed strong correlation with mean difference of <2 mmhg.[13]

In our study, we observed the patients in Group A (CVP ≤ 10) mean difference between CVP with PVP and EJVP was >2 cmH_2O and p value was insignificant and in Group B (CVP >10) mean difference between CVP with PVP and EJVP was <2 cmH_2O and p value (p<0.001) was strongly significant and comparable. This showed that PVP and EJVP strongly correlate with CVP at higher baseline CVP than at a lower baseline CVP.

Limitations of the study

This is an observational study with limited study population studied in limited duration. CVP is static parameter and hence cannot accurately predict volume responsiveness in a patient with septic shock and ultrasound guided central venous catheterization will definitely reduce complications associated with catheterization.

Strengths of the study

Study was conducted in rural setup, where monitoring dynamic indices for assessing fluid responsiveness is not feasible, CVP/EJVP/PVP will be surrogate marker for assessing fluid responsiveness in septic patient.

Conclusion

The present study concludes that, there is definite correlation between CVP, EJVP and PVP in a given patient. Further concludes the difference between CVP and EJVP/PVP was minimum (<2cmH_2O) when the CVP was >10 cmH_2O.

Key Messages

PVP and EJVP measurements can be used to predict central venous pressure as an easier surrogate measurement for the assessment for guidance of fluid therapy in patient with sepsis.

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Conflicts of interest: Nil

Permissions: Nil

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