SITE OF CENTRAL VENOUS ACCESS IS NOT IMPORTANT FOR FLUID RESUSCITATION AND MONITORING

Muhammad Imran Ansari, Jawed Abubaker*, Syed Zia Ullah, Adeel Sohail*, Aziz Ur Rehman, Shazia Ahmad, Musa Karim

National Institute of Cardiovascular Diseases Karachi Pakistan, *Ziauddin Medical University Hospital Karachi Pakistan

ABSTRACT

Objective: To find the correlation between thoracic and femoral central venous pressure (CVP) and changes in femoral CVP, if any, incurred by intra-abdominal pressure.

Study Design: Cross sectional observational study.

Place and Duration of Study: Coronary care unit of National Institute of Cardiovascular Diseases Karachi, from Jul 2017 to Sep 2017.

Material and Methods: We randomly selected 90 patients who had a thoracic central catheter and another femoral catheter in place. A central venous pressure (CVP) pressure was recorded at both sites simultaneously with the same electronic transducer after zero calibration. An intra-abdominal pressure was also noted.

Results: Ninety patients participated in our study where mean age was 58.90 ± 11.34 years. The mean thoracic CVP was 11.22 ± 3.53 mmHg while mean femoral CVP was 11.38 ± 3.53 mmHg, with a mean pressure difference of -0.16 mmHg between the two. We also calculated intra-abdominal pressure with mean of 6.20 ± 2.47 mmHg. The reliability of the two methods was determined by intra class coefficient model where we got a higher value of 0.97 with significant *p*-value of <0.001. We analyzed the limits of agreement between the two approaches by Bland and Altman plot, where the mean difference between thoracic and femoral CVP was -0.16 mmHg (95 % CI -0.34 - 0.02).

Conclusion: Central venous pressure can be reliably and accurately measured through femoral site.

Keywords: Central venous pressure, Critical illness, Femoral vein, Intra-abdominal pressure, Superior vena cava.

INTRODUCTION

Central venous access is frequently done in any critical care units with multiple indications and assessment of central venous pressure (CVP) in critically ill patients is considered as keystone of management[1,2].

Most of the intensive care units with training programs and community hospitals are not always staffed by senior physicians or intensivists; thus, obtaining a central venous access at internal jugular or sub-clavian site is associated with frequent complications if not performed by experienced hands. The main reason for avoiding femoral access has been the infection and misconception that this site cannot be relied for central venous pressure monitoring[3,4]. Literature is clear about the femoral site infection but if appropriate care is provided with bundle during insertion and maintenance thereafter, its rate of infection is similar to internal jugular site[5,6].

Although there are many small studies in literature comparing central venous pressure monitoring between internal jugular and femoral site, yet most of them demonstrate the fact that central venous monitoring from either site is reliable[7-10]. Being a cardiac institute, it was a different scenario in our institute as there was no clear supportive literature about the reliability of femoral central venous pressure in patients with either left ventricular or right ventricular dysfunction and especially with biventricular dysfunction. We did a small in house survey which demonstrated that even the senior cardiologists were hesitant to use femoral site for CVP monitoring.

Correspondence: Dr Syed Zia Ullah, N-187, Block-12, Gulistan-e-Jauhar Karachi Pakistan *(Email: syedziaullah23@yahoo.com)*
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We proposed a study in critical care unit of our institute on patients with two central venous accesses; a femoral and either a sub-clavian or internal jugular site for either dialysis or pacemaker to monitor CVP simultaneously. We also measured intra-abdominal pressure (IAP) with the presumption that in the absence of any condition affecting intra-abdominal pressure, CVP measured by femoral site would be as reliable as internal jugular or any other thoracic site.

PATIENTS AND METHODS

We conducted a cross sectional observational study in coronary care unit (CCU) of National Institute of Cardiovascular Diseases, Karachi, from July, 2017 to September, 2017 after approval of Ethics Research Committee of the institute, reference no; ERC-23/2017. The committee waived the informed consent as a general consent had been already taken for routine purposes including research study. We randomly selected 90 adult patients older than 20 years who had a thoracic central venous catheter and another femoral venous catheter in placed, one of which was meant for fluid and nutrition and the other for different purposes like renal replacement therapy or temporary pacemaker. Non probability convenient sampling approach was adopted. Sample size for the study was calculated using G*Power sample size calculator version 3.1.9.2. Taking correlation of 0.87 between both approaches, 75% level of significance and 80% power of test against one sided hypothesis of more than 0.75, sample size was calculated to be 50 patients. Taking 1.8 as study design factor in account for potential selection bias, a total of 90 patients were included in this study. We did not insert any catheter for research purpose. Our CCU has standard CVCs of 20cm length including double lumen renal replacement catheters. CVC positions were confirmed by radiography and adjusted, if necessary. We excluded patients having such conditions like femoral site trauma or infection, where femoral CVC placement was not possible.

A CVP was recorded at thoracic (TCVP) as well as femoral (FCVP) site simultaneously with the same electronic transducer after zero calibration referenced at mid chest level. We tried to record the sustained pressure reading obtained at least for 30 seconds after zero calibration. An intra-abdominal pressure was also noted at the same time through the urinary catheter using method described by Iberti *et al*[11] and patients with high abdominal pressure (>12 mmHg as concluded in guideline of World Society of the Abdominal Compartment Syndrome) were also included in the study[12]. We also included patients having respiratory disease and patients with cardiovascular disease having congestive cardiac failure especially high right sided pressures. All the recordings were made in 0 degree supine position.

SPSS version 21 (SPSS inc. Chicago, IL) was used for data analysis. All continuous variables were expressed as mean and standard deviation while categorical variables as frequencies and percentages. Shapiro-Wilk test was applied to test the hypothesis of normality of distribution for continuous variables. Chi square and student t-test were applied for categorical and continuous variables respectively, where a p-value of ≤ 0.05 was considered as statistically significant. A correlation between FCVP and IAP was derived by calculating Pearson's correlation. Bland and Altman plot was used to analyze the limits of agreement between the two approaches i.e. femoral & thoracic at 0 degree[13]. An intra-class correlation coefficient (ICC) was derived for the analysis of correlation between the two methods of measuring CVP and ICC >0.8 was referred as an excellent agreement.

RESULTS

A total of 90 patients participated in our study where mean age was 58.90 ± 11.34 years with 69 (76.7%) mechanically ventilated patients. While most of the patients (43 out of 90; 47.8%) had cardiac disease, renal failure appeared to be the 2nd common (25.6%) diagnosis. 13 (14.4%)

patients had sepsis leading to multi organ failure as shown in table-I.

We noticed that 11 (12.2%) patients had biventricular failure. A simultaneous recording of Femoral as well as Thoracic CVP was taken with the same transducer which showed that mean TCVP was 11.22 ± 3.53 mmHg while mean FCVP was 11.38 ± 3.53 mmHg, with a mean pressure difference of -0.16 ± 0.86 mmHg between the two. We also calculated IAP with a mean of 6.20 ± 2.47 mmHg. A detailed description of these pressures is shown in table-II.

We noticed that only one patient had intra-abdominal hypertension i.e. IAP > 12 mmHg (25 mmHg) which was an outlier.

Table-I: Primary diagnosis of the patients.

Diagnosis	Frequency (%)
Cardiac	43 (47.8%)
Renal	23 (25.6%)
Pulmonary	6 (6.7%)
Multi-organ	13 (14.4%)
Miscellaneous	5 (5.6%)

Table-II: Central venous and intra-abdominal pressures.

Measures	Range (Max – Min)	Mean ± SD	Median (IQR)	SW Test (*p*-value)
Thoracic central venous pressure (TCVP)	18.5 – 4.5	11.22 ± 3.53	11.0 (13.0 – 8.5)	0.048*
Femoral central venous pressure (FCVP)	24.0 – 5.0	11.38 ± 3.53	11.5 (13.6 – 9.0)	0.058
Intra-abdominal pressure	25.0 – 3.0	6.2 ± 2.47	6.0 (7.0 – 5.0)	<0.001*
Difference between TCVP and FCVP	1.5 – -6.0	-0.16 ± 0.86	-0.5 (0.5 – -0.5)	<0.001

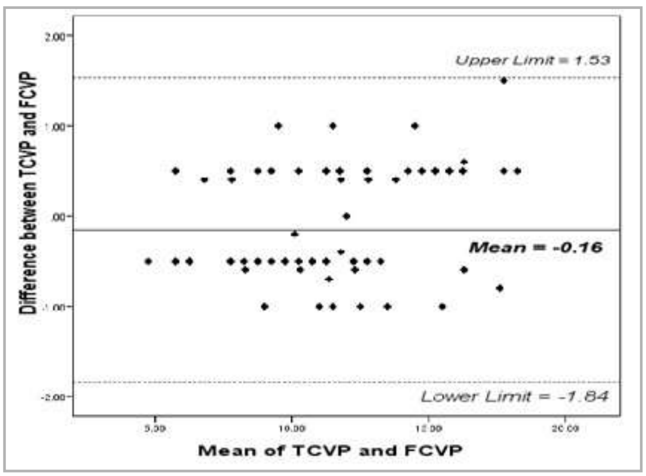
*Statistically significant at 0.05 level of significance
Max = Maximum, Min=Minimum, SD = Standard Deviation, IQR=Interquartile Range, SW = Shapiro-Wilk

A relation between the FCVP and IAP was determined by Pearson correlation with coefficient of 0.39 and a *p*-value of <0.001 was obtained. The reliability of two methods of measuring CVP was determined by intra class correlation coefficient (ICC) model where we got an excellent reliability of 0.97 (95% CI 0.95-0.98) with a significant *p*-value of <0.001.

We analyzed the limits of agreement between the two approaches by Bland and Altman plot, where the mean difference or bias between thoracic and femoral CVP was -0.16 mmHg (95 % CI -0.34 - 0.02). The difference was normally distributed around the mean and limit of agreement was -1.84 to +1.53 as shown in fig-1.

DISCUSSION

With these results, we prove that femoral CVP can be used to measure central venous pressure with excellent agreement between the two approaches. Our findings are similar to the results published by previous work done on the same issue. These findings also proved that femoral CVP appeared as a reliable alternative to thoracic CVP in contrast to popular belief of most of our staff. Joynt *et al*. reported in 1996 that CVP could be reliably measured through a long femoral catheter placed in abdominal inferior vanacava near the right atrium especially in critically ill, mechanically ventilated adult patients[5]. In 2001, Dillon and colleagues claimed a similar relation between superior venacaval pressure and femoro-iliac venous pressure with acceptable clinical agreement in mechanically ventilated patients using standard short 20cm femoral CVC catheters[6]. We also used short 20cm CVC catheters, reached at the same conclusion and found the excellent agreement between femoral and thoracic CVPs. A study conducted by Salem and colleagues stated the mean difference of 1.64 mmHg between superior and inferior CVP as calculated by Bland and Altman plot, in contrast to our minimal difference of -0.16 mmHg between the two approaches[7]. The femoral site is, thus, actually a better site than thoracic site for measuring CVP as thoracic sites have established major complications including pneumothorax and carotid artery cannulation. This hypothesis is favored by rather a more established fact that some of the complications of thoracic CVP like pneumothorax proves to be more fatal in mechanically ventilated patients. Hsu ans sun wrote in their article that the progression of pneumothorax to tension pneumothorax appeared to be rapid and common in mechanically ventilated patients owing to the particular dynamics of the positive pressure ventilation[14]. Hence, we believe that the CVP monitoring through a femoral approach may be recommended in mechanically ventilated patients, especially where inexpertise of the physician limits the selection of the CVP site.



TCVP = thoracic central venous pressure; FCVP = femoral central venous pressure

Figure: Bland-Altman plot for agreement between TCVP and FCVP.

One of the concerns in measuring femoral CVP is that an intra-abdominal pressure must be normal (<12mmHg). Ghattas concluded his result that femoral CVP pressure was equivalent to the superior venous approach in mechanically ventilated adult patients where intra-abdominal pressure was also normal[15]. One of our patients had intra-abdominal hypertension (25 mmHg, probably due to ascites) and we were unable to find any similarity between his femoral and thoracic CVP. Ait-Oufella *et al*. studied the influence of IAP on femoral CVP and claimed an IAP cut off of 14 mmHg, below which both TCVP and FCVP were having a good agreement[10]. However, the intra-abdominal pressure of most (99%) of our patients stayed within the limit of 12 mmHg and we were not in a position to conclude about the effects of intra-abdominal hypertension on the femoral CVP. Yet a good correlation was found between IAP and FCVP in our results.

Our data is collected from CCU, where cardiac patients are supposed to have a different hemodynamics particularly related to pump failure. As a matter of fact, a pump failure alters the right a trial pressure as well as venaecaval pressure. Walsh *et al*. and Pacheco *et al*. tried to select the cardiac patients in their study and found a good correlation between superior and inferior approaches[16,17]. We noticed that mean CVPs of patients with biventricular dysfunction were slightly higher (Thoracic CVP= 11.90, Femoral CVP= 12.50) in comparison with the other patients (Thoracic CVP= 11.12, Femoral CVP= 11.22). However, we also came to the same conclusion and found a good agreement between femoral and thoracic CVP in cardiac patients as in rest of the patients. An interesting feature of our data was the inclusion of respiratory patients having conditions like obstructive and restrictive lung disease that were once supposed to cause alteration of femoral and thoracic CVP. Desmond and Megahed their proved in his meta-analysis that right a trial pressure could be reliably measured through inferior venous approach, even in ventilated patients with high PEEP or high mean airway pressures[18]. We saw a good correlation between FCVP and TCVP in our data despite the inclusion of respiratory patients. Yet, large clinical trials may be warranted at this time to address this issue especially in cardiac and respiratory subgroup of patients. Due to increased risk of infection associated with femoral approach, it should not be a routine policy but it can be reliably and accurate approach in acute setting where CVP line is not accessible.

Although our data was collected from a large tertiary care center but it has few limitations. We selected 90 patients and hence we recommend larger trials to endorse the same agreement between femoral and thoracic CVPs as we concluded. One of the limitations was the use of short 20cm CVC catheters for measuring femoral CVP, and thus, we are not in a position to extrapolate our data to the conditions where long catheters are used for femoral CVP measurement. We did not specifically register the effects of fullness of stomach and intestines on IAP and femoral CVP, as these may alter the femoral hemodynamics. This matter needs to be dug out in further studies. Finally, we used an intra-vesical pressure as a measure of intra-abdominal pressure but indirect measurement of intra-abdominal pressure through intra-vesical pressure is considered as an established method of measuring intra-abdominal pressure since decades.

CONCLUSION

Central venous pressure can be reliably and accurately measured through femoral site.

Author's Contribution

J. A. and S. Z. U. are the guarantors of the contents of this manuscript including data acquisition take responsibility and accuracy of the data and its analysis and had full access to all of the data. M. I. A. and A. U. R. contributed in the protocol and design of this study. A. S. and S. A. collected the data and M. K. contributed in the statistical analysis. All of the authors critically revised the content and approved the final version of this manuscript.

CONFLICT OF INTEREST

This study has no conflict of interest to be declared by any author.

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