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Central venous pressure in femoral catheter: correlation with superior approach after heart surgery

Pressão venosa central em cateter femoral: correlação com acesso superior após cirurgia cardíaca

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Abstract

Objective: **It is common to obtain femoral venous approach in patients undergoing combined heart surgery or as an alternative to superior approach (internal jugular vein or subclavian vein). The aim of this study was to compare the measures of central venous pressure (CVP) at two different sites (superior versus femoral).**

Methods: **We prospectively and openly allocated 60 patients who underwent heart surgery between July from November 2006. Three measures were obtained from each patient at each site (admission, 6 and 12 hours after surgery) in two different inclinations of the headboard (zero and 30 degrees) totaling 720 measures.**

Results: **Fifty five percent of patients who underwent coronary artery bypass grafting, 38% heart valve surgery and 7% other surgeries. The mean of CVP ± standard deviation (SD) measured in superior approach was 13.0 ± 5.5 mmHg (zero degree) and 13.3 ± 6.1 mmHg (30 degrees) while the measures in inferior approach were 11.1 ± 4.9 mmHg (zero degree) and 13.7 ± 4.6 mmHg (30 degrees). The linear correlation (r) between the measures in both sites was 0.66 (zero degree) and 0.53 (30 degrees), both with p value < 0.0001.**

Conclusion: **The CVP can be measured with accuracy in the femoral venous approach in the immediate postoperative period of heart surgery with better linear correlation obtained with the measures made with the headboard positioned at zero degree.**

Descriptors: **Central venous pressure. Femoral Vein. Thoracic Surgery. Cardiovascular surgical procedures.**

Resumo

Objetivo: **É comum a obtenção de acesso venoso femoral em pacientes submetidos a cirurgia cardíaca em associação ou como alternativa ao acesso superior (veia jugular interna ou veia subclávia). O objetivo deste estudo foi comparar as medidas de pressão venosa central (PVC) em dois sítios diferentes (superior vs. femoral).**

Métodos: **Estudo prospectivo e aberto com 60 pacientes submetidos a cirurgia cardíaca no período de julho a novembro de 2006. Foram obtidas três medidas de cada paciente em cada sítio (admissão, 6 e 12 horas após a cirurgia) em duas inclinações diferentes da cabeceira do leito (zero e 30 graus), totalizando 720 medidas.**

Resultados: **Cinqüenta e cinco por cento dos pacientes foram submetidos a revascularização do miocárdio, 38% a cirurgia valvar e 7% a outras cirurgias. A média de PVC ± desvio padrão (DP) medida no acesso superior foi de 13,0 ± 5,5 mmHg (zero grau) e 13,3 ± 6,1 mmHg (30 graus), enquanto que as medidas no acesso inferior foram 11,1 ± 4,9 mmHg (zero grau) e 13,7 ± 4,6 mmHg (30 graus). A correlação linear (r) entre as medidas nos dois sítios foi de 0,66 (zero grau) e 0,53 (30 graus), ambas com p < 0,0001.**

Conclusão: **A PVC pode ser medida com acurácia no acesso venoso femoral no pós-operatório imediato de cirurgia cardíaca, com melhor correlação linear obtida com as medidas feitas com a cabeceira do leito posicionada em zero grau.**

Descritores: **Pressão venosa central. Veia femoral. Cirurgia cardíaca. Procedimentos cirúrgicos cardiovasculares.**

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INTRODUCTION

Central venous pressure (CVP) is an important clinical parameter in patients undergoing heart surgery [1], and the proper implementation of this measurement requires a good understanding of the interaction between cardiac function and the venous return [2]. Usually, this measurement is obtained by inserting a catheter in the intrathoracic central vein with a good correlation between the measurements of internal jugular vein and right atrium [3-5].

The measurement of CVP obtained through a femoral approach can be an alternative to a superior approach (internal jugular or subclavian) [6]. In 60 patients undergoing hemodynamic study, Walsh et al. showed that the mean pressure of the abdominal inferior vena cava is essentially the same right atrial pressure measured at the end of breathing in adults under spontaneous ventilation [7]. A number of other studies showed a high correlation between the femoral or iliac venous pressure and the pressure of internal jugular vein, superior vena cava and right atrium in children, severely ill patients and patients on a ventilator with low rates of complications and infection [8 -20], but there are few studies comparing the accuracy of measurements of superior CVP with femoral internal approach in adult patients undergoing heart surgery [21].

The aim of this study was to correlate measurements of CVP obtained at two different sites (internal jugular vein or subclavian vs. femoral vein) and two inclinations of the headboard (zero and 30 degrees) in patients undergoing heart surgery.

METHODS

Prospective open study in patients over 18 years old who underwent heart surgery in the period from July to November 2006 totaling 60 randon patients.

The mean age of the patients was 56 years old, with 55% of them undergoing coronary artery bypass grafting, 38% valve surgery and 7% other surgeries. Thirty-eight patients (63%) were male, 53% were hypertensive patients and 17% diabetic (Table 1).

We obtained three CVP measurements from each patient at each site (admission, six and twelve hours after surgery) in two different angles of the headboard (0º and 30º), totaling 720 measurements.

The catheters used in the study were included in the operating room for clinical purposes. No catheter was included solely for this research and the CVP measurements were obtained using the same electronic pressure transducer used in the ICU. The superior central venous approach was completed by puncturing the subclavian or the jugular vein with a double-lumen catheter 16/18 gauges in diameter and 20 cm in length or though venous dissection of the basilic vein with a nelaton catheter number 8 or 10 and 30cm in length. The inferior venous approach was completed by puncturing the femoral vein with a percutaneous introducer of 8.5Fr and 15cm in length or through direct catheterization with a nelaton catheter number 8 or 10 and 20 cm in length during dissection and saphenous vein isolation. 3 CVP measurements were obtained in the two sites (superior and inferior) with the headboard positioned at 0º and 30º, with the pressure transducer reset to zero in the middle axillary line in the fifth intercostal space in each catheter, and with a minimum of 6 hours between measurements.

Because this study evaluated patients undergoing elective heart surgery, and because the pressure measurements were obtained soon after the procedure (12 hours), intra-abdominal pressure was not evaluated.

We analyzed demographic data such as age, gender, body mass index (BMI), type of surgery, history of diabetes mellitus (DM), arterial hypertension (AH), chronic obstructive pulmonary disease (COPD), pulmonary arterial hypertension (PAH), left ventricular function and the presence of mechanical ventilation at the time of CVP measurement (Table 1). Clinical variables, such as blood pressure (systolic, mean and diastolic), heart rate, and the use of vasoactive drugs at the time of the measurements were also analyzed.

This study was approved by the Research Ethics Committee of the institution and all patients signed the written informed consent.

Table 1. Demographic data

	CVP Superior vs. Inferior
Demographic data	N = 60
Age (mean ± SD)	56 ± 13,7
Men [n (%)]	38 (63,3)
BMI (mean ± SD)	27,6 ± 5,0
CABG [n (%)]	33 (55,0)
Valve surgery [n (%)]	23 (38,3)
Other surgeries [n (%)]	4 (6,7)
Arterial hypertension [n (%)]	32 (53,3)
Diabetes Mellitus [n (%)]	10 (16,7)
COPD [n (%)]	4 (6,7)
PAH (RVSP ≥ 60 mmHg) [n (%)]	4 (6,7)
Mild/severe LV dysfunction [n (%)]	19 (31,7)

SD- Standard deviation; COPD - chronic obstructive pulmonary disease; PAH – pulmonary arterial hypertension; BMI – body mass index; mean; RVSP – right ventricular systolic pressure; CVP – central venous pressure; LV – left ventricle

Statistical analysis

The categorical data are presented in absolute numbers and percentages, and continuous variables in mean ± standard deviation. Continuous variables were analyzed using the Kruskal-Wallis test, and categorical variables were analyzed using the chi-square test (2 by K without trend) as indicated. Correlation between measurements of central venous pressure was calculated by examining the Pearson correlation coefficient (r). The Pearson correlation coefficient is a measurement of the relationship between two variables with values between - 1 and 1. A positive correlation indicates that both variables increase or decrease together whereas a negative correlation indicates that while one variable increases the other decreases, and vice versa. A coefficient close to zero indicates no correlation between the variables. The t-test is used to establish whether the correlation coefficient is significantly above or below zero, suggesting a correlation between two variables.

Bias and limits of agreement (95%) between superior and inferior CVP measurements at 0º and 30º of inclination of the headboard were calculated using the Bland and Altman method [22]. *P* values <0.05 were considered significant (bicaudal). The software programs used for statistical analysis were the GraphPad Instat v. 3.00, GraphPad Prism v. 4.00 and Stats Direct Statistics Software v. 2.6.5.

RESULTS

There was no statistically significant differences between the measurements of systolic or diastolic blood pressure, heart rate, or use of vasoactive drugs at the time of the CVP measurements (Table 2). We analyzed three CVP measurements in each site (administered 6 and 12 hours after surgery) at two different inclines of the headboard (0º and 30º), totaling 12 measurements for each patient (720 measurements in total). Mean CVP ± standard deviation (SD) measured using the superior approach was 13.0 ± 5.5 mmHg (at 0º) and 13.3 ± 6.1 mmHg (at 30º) with p = 0.429, whereas the measurements using the inferior approach were 11.1 ± 4.9 mmHg (at 0º) and 13.7 ± 4.6 mmHg (at 30º) – *P* value <0.0001. The Pearson correlation coefficient (r) between the measurements was 0.66 (at 0º) and 0.53 (at 30º), both *P* <0.0001 and power for 5% significance level > 99.99% (Table 3 and Figures 1 and 2).

Bland-Altman graphics are shown in Figures 3 and 4. The mean difference between the superior and femoral CVP (Bias) at 0º and 30º were, respectively, -1.9 mmHg ± 4.3 mmHg (95% limit of agreement -10.3 to 6.5 mmHg) and 0.4 mmHg ± 5.3 mmHg (95% limit of agreement -10.0 to 10.8 mmHg).

Table 2. Clinical variables obtained at the time of CVP measurement

Clinical variables	Measurement 1 N=60	Measurement 2 N=60	Measurement 3 N=60	p
Systolic arterial pressure (mean ± SD)	121.6 ± 22.0	119.9 ± 19.8	124.7 ± 22.0	0.41
Diastolic arterial pressure (mean ± SD)	64.0 ± 11.5	63.0 ± 10.0	65.5 ± 11.2	0.28
Mean arterial pressure (mean ± SD)	83.2 ± 13.3	81.9 ± 11.4	85.2 ± 12.2	0.26
Heart rate (mean ± SD)	79.0 ± 14.0	81.0 ± 13.0	82.0 ± 11.0	0.61
Use of vasoactive drugs [n (%)]	37.0 (61.7)	40.0 (66.7)	35.0 (58.3)	0.64

SD – Standard deviation; mean; CVP – Central Venous Pressure

Table 3. The Pearson's correlation coefficient (r) between the CVP measurements obtained in the superior and inferior approach with inclinations at 0º and 30º

CVP measurements at 0° e 30° degrees	Superior approach N=180	Inferior approach N=180	r	p
0°	13.0 ± 5.5 mmHg	11.1 ± 4.9 mmHg	0.66	<0.0001*
30°	13.3 ± 6.1 mmHg	13.7 ± 4.6 mmHg	0.53	<0.0001*

**Power (for 5% significance level) > 99.99%*

CVP – Central Venous Pressure; r – The Pearson's correlation coefficient

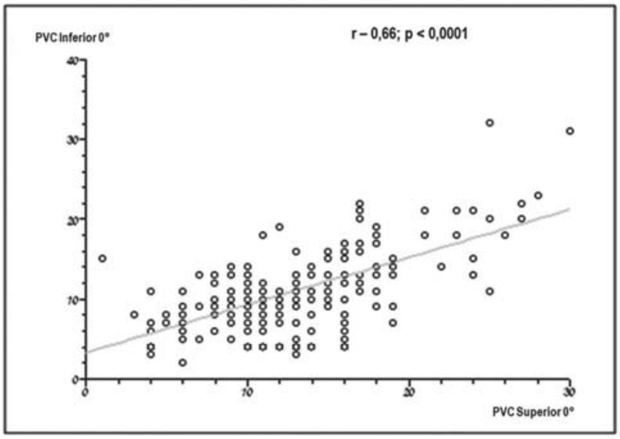

Fig.1 – Linear correlation between CVP (PVC) below and above zero degree position – Graph showing positive linear correlation between CVP (PVC) measurements with the headboard at 0º

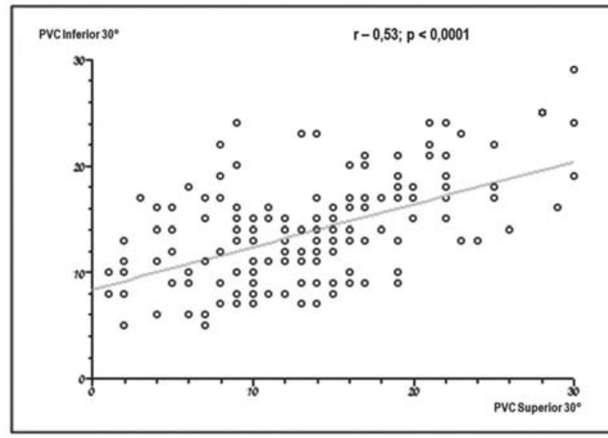

Fig. 2 – Linear correlation between CVP (PVC) below and above the thirty degree position - Graph showing positive linear correlation between CVP (PVC) measurements with the headboard inclined to 30º

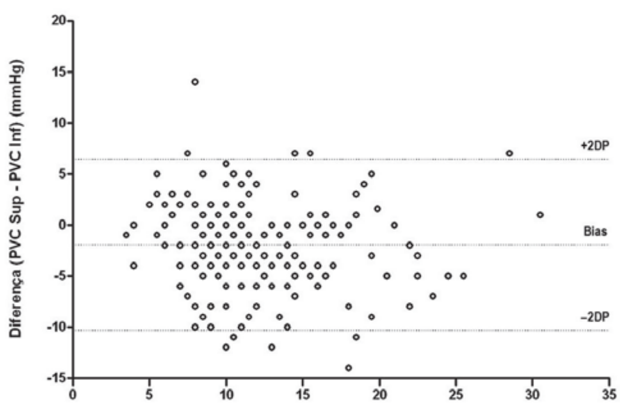

Fig. 3 – Mean superior vs. inferior CVP (PVC) at 0º incline - the Bland-Altman graph showing the mean difference between the superior and femoral central venous pressure (Bias) with the headboard at 0º; -1.9 mmHg with 95% limit of agreement (represented by ± 2SD) from -10.3 to 6.5 mmHg. SD - standard deviation

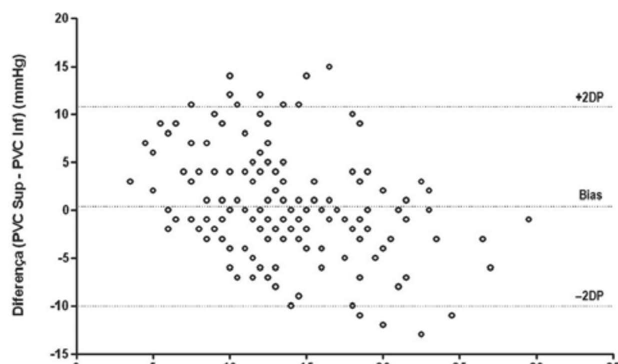

Fig. 4 – Mean superior vs. inferior CVP (PVC) with the headboard at a 30º incline - the Bland-Altman graph showing the mean difference between the superior and femoral central venous pressure (Bias) at 30º, 0.4 mmHg with 95% limit of agreement (represented by ± 2SD) from -10.0 to 10.8 mmHg. SD - standard deviation

DISCUSSION

The results presented herein show that, for a medical purpose, CVP measurements performed in a femoral approach, even when using short catheters (15 to 20 cm), correlate positively to the measurements obtained using the superior central venous approach (internal jugular or subclavian). Although we have found higher bias (Bias) and limits of agreement compared to other authors' studies [6-8], our measurements obtained a power of 99.99% at the 5% statistical significance level, showing that the correlation coefficient between the measurements of central venous pressure was significantly above zero.

Joynt et al and Alzeer et al showed similar results in critically ill patients on ventilators in terms of the measurements obtained using the femoral approach (abdominal) vs. jugular/subclavian (chest) approach [8-11]. Dillon et al. showed an excellent correlation between the measurements of venous pressure at the superior vena cava and such measurements obtained with a short femoral catheter (20 cm) in adult patients on ventilators who had been admitted to a General ICU. The measurements were not affected by the type of mechanical ventilation, despite having increased significantly in the inversion of the relantionship (i.e. inspiration/ expiration) [18].

In various clinical situations, such as sepsis, acute respiratory distress syndrome, or multiple organ dysfunction after elective or emergency hearty surgery, multiple sites of puncture may be needed. In patients on ventilators with high pressure ventilation, the risk of iatrogenic pneumothorax associated with superior central venous approach is higher, and in patients with coagulopathies, the risk of hemorrhagic complications increases substantially.

The main complications of a femoral approach are related with venous thrombosis and infection [19, 23, 24]. However, Deshpande et al. found no differences in bacterial colonization and infection in the comparison of three sites of puncture (jugular, subclavian and femoral) in patients under intensive care [14]. In a multicenter randomized study involving 750 patients requiring venous approach for hemodialysis, the jugular approach also did not reduce the risk of infection when compared to a femoral approach, except in patients with a BMI above 28.4 kg/m^2 or with higher risk of hematoma formation [25]. In this group of patients who underwent elective heart surgery, the length of time that these catheters were used was reduced, and clinical complications were not found.

Despite the established and universal use of CVP in the emergency room, operating room and ICU for estimates of preload and volume, as well as for fluid administration, both historical and recent data suggest that this approach may be imperfect. In a recent systematic review, Marik et al showed a poor correlation between CVP and volume, as well as the inability of CVP variation in predicting hemodynamic response to fluid replacement, with its usefulness intented for specific situations, such as right ventricular infarction or acute pulmonary embolism as a marker of right ventricular function and not the condition of the patient's blood volume [26].

CONCLUSION

CVP can be measured with accuracy in an femoral venous approach in the immediate postoperative period of heart surgery. The best linear correlation was obtained with the measurements calculated when the headboard was positioned at zero degrees.

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