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Correlation of Central with Jugular and Upper-limb Venous Pressure Measurements

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ABSTRACT

Background: Correlation data of different external reference points and methods used to measure venous pressures are scarce in the literature. We correlated central venous pressure with jugular venous pressure measured from sternal angle and with jugular and upper-limb venous pressures from zero level corresponding to mid-right-atrium level.

Methods: A hospital-based observational study in the medical and surgical intensive care units was conducted for period of one year." Central venous pressure was measured from right fourth intercostal space in mid-axillary line and jugular venous pressure from sternal angle and jugular and upper-limb venous pressures from horizontal plane through the midpoint of anteroposterior line from anterior end of right fourth intercostal space to back. We measured central venous pressure by central venous cannulation and jugular and upper-limb venous pressures clinically by JVP Meter®. Upper-limb venous pressure was indicated by collapse of visible veins in dorsum of hands as the arm was slowly raised from dependent position.

Results: Correlation coefficient (r) values were 0.61 between central venous pressure and jugular venous pressure from zero level, 0.48 between central venous pressure and jugular venous pressure from sternal angle, and 0.31 between central and upper-limb venous pressures; and 0.67 and 0.50 between central venous pressure measured from right internal jugular vein and jugular venous pressure from zero level and sternal angle respectively and0.52 and 0.44 between central venous pressure from right sub-clavian vein and jugular venous pressure from zero level and sternal angle respectively.

Conclusions: Different correlation values indicate the need to have future investigations and consensus on the common external reference point and methods to measure venous pressures.

Keywords: CVP; heart failure; JVP; JVP Meter; shock

INTRODUCTION

Jugular venous pressure (JVP) is traditionally measured from sternal angle level (SAL).[1] Though the right atrium is generally considered to be 5 cm below the SAL regardless of the body position, the distance from the SAL to the level of the mid-right atrium is reported to vary considerably, e.g. from 3 to 10 cm, between individuals and with patient position.[2-4] JVP can also be directly measured from the external reference point (ERP) of zero level (ZeL) as JVP ZeL. The venous pressure measured from the ZeL vary less than 1-2 cm with different postures.[5] Similarly when the arm is raised slowly from the dependent position, the veins in the upper limb collapse as they attain the height of CVP above the level of the right atrium. The vertical distance at which the veins collapse gives the indirect measurement of CVP,[4,6] as the upper-limb venous pressure (UVP). There is little in the literature about the correlations of CVP with JVP SAL, JVP ZeL, and UVP.

METHODS

We conducted the hospital-based observational study in the medical and surgical intensive care units (ICUs) of Bir Hospital, National Academy of Medical Sciences, Kathmandu, Nepal. Conscious cooperative hemodynamically stable patients aged 18 or more who were already on central venous cannulation for the purpose of their treatment in ICUs were included in the study. The patients were excluded if they had a history of neck or body radiotherapy or previous or active upper-extremity deep venous thrombosis or injury to upper extremity. Patients who had large cervical lymph node or goiter causing venous distension or features of

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superior venacaval obstruction, who were very sick, or who did not give consent were also excluded. Similarly the patients who were on mechanical ventilation were excluded. Informed consent was taken from each participant. Data collection was done from June 2010 to December 2011. Before commencement of the study, ethical approval was granted from the Institutional Review Board of the National Academy of Medical Sciences, Bir Hospital, Kathmandu, Nepal. .

The biasness in measuring the venous pressure data was addressed in possible ways. The first author measured the JVP and UVP with the help of the JVP Meter®.[6,7] Immediately after that, the measurements of CVP were independently done by the doctors from the department of anesthesia and intensive care who were regularly measuring the CVP. They were not aware of each other's measurement values. The measurements of CVP were collected in one proforma and kept in an envelope till the end of this study. The values of the JVP and UVP measured along with the demographics and clinical data recorded in another proforma by the first author were kept in separate envelope.

Two baselines were used as external reference points (ERPs), sternal angle level (SAL) and zero level (ZeL), for the clinical measurements of venous pressures. Thus there were three external reference points (ERPs) used as baselines for measurement of different venous pressures; they were: i) Fourth intercostal space in mid-axillary line for measurement of central venous pressure (CVP), ii) Sternal angle level (SAL) for measurement of jugular venous pressure (JVP SAL), and iii) Zero level (ZeL) for measurement of JVP ZeL and upper-limb venous pressure (UVP). The zero level (ZeL) was measured in the sitting position from the anterior end of right fourth intercostal space which is at the mid-right atrium level in the surface marking in sitting position[8] in the patients who could sit and whose jugular venous pulsations were seen in the neck. It was measured in other patients in the reclining position from the marked zero level position, in the lateral chest wall, of the horizontal plane through the midpoint (where the center of right atrium is considered to be located) of antero-posterior line (drawn in the erect or supine position) from the anterior end of right fourth intercostal space to the back[4]. Five centimeter was added to the reading from the SAL to obtain the JVP SAL.[1] Similarly, the three upper levels for measurement of different venous pressures were: i) the upper level of water column in the manometer for measurement of central venous pressure (CVP), ii) the highest point of pulsations of right internal jugular vein for measurement of JVP SAL and JVP ZeL, and iii) the level at which the visible veins in dorsum of hand collapse as the arm is slowly raised from the dependent position[4,6] for measurement of upper-limb venous pressure (UVP).

The vertical height of JVP between the ERP, SAL or ZeL, indicated by the Base Indictor and the upper level of jugular venous pulsations indicated by the Top Horizontal Plane of the JVP Meter® was measured by looking at its calibrated Central Frame (Figure 1).[6,7] UVP was measured by keeping the forearm and hand on the Top Horizontal Plane of JVP Meter®. The Top Horizontal Plane was slowly raised until the height where the distended veins in the dorsum of hand collapsed and the vertical distance from the ZeL as indicated by the Base Indicator to the level of Top Horizontal Plane was measured as UVP by looking at the calibrated Central Frame of JVP Meter®.[6,7]

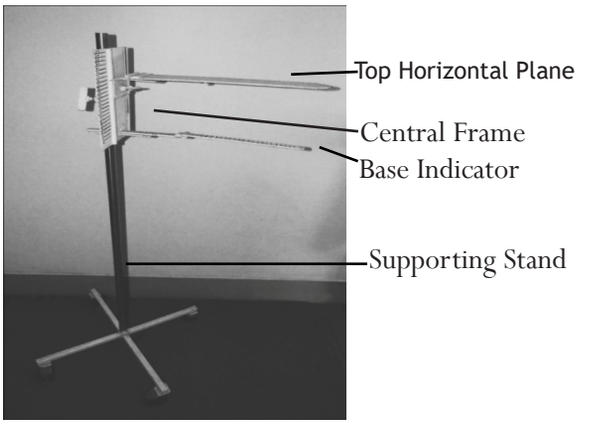


Figure 1. JVP Meter® used for the measurement of jugular venous pressure (JVP) and upper-limb venous pressure (UVP).[9,13]

Data obtained was entered and analyzed in SPSS (Statistical Package for Social Studies) version 19. The frequency distribution of categorical variables were calculated and numerical data were presented as mean (SD). Linear regression analysis between different venous pressure measurements was performed and Person's correlation coefficient (r) was calculated to study the correlation between continuous variables.

RESULTS

Total 70 patients fulfilling the inclusion and exclusion criteria were included in the study. Thirty six patients (51.4%) were admitted in the medical intensive care units and 34 (48.6%) in the surgical ICUs. Sixty three percent of the participants were male and 38.6% smokers. The mean (SD) of age was 43.67 (20.11) and body mass index (kg/m2) 22.86 (3.25). Out of total 70 patients, 15.7% were admitted due to pneumonia, 8.6% due to poisoning and 7.1% respiratory failure due to

chronic obstructive airway diseases and 20% were due to various causes like upper gastrointestinal bleeding, septic shock, decompensated chronic liver disease, chronic renal failure with sepsis, and pericardial effusion and they were admitted in the medical ICU. Similarly, out of total 70 patients, 24.3% were admitted after laparotomy for various indications like duodenal perforation, obstructed femoral hernia, intestinal obstruction and ileal perforation and 24.3% were due to peritonitis, gastrectomy, pancreatitis, biliary injury, craniotomy, road traffic accident, and post-splenectomy and they were admitted in the surgical ICU.

JVP from right internal jugular veins could not be estimated in 9 (12.9%) patients as the upper levels of venous pulsation were not identified. Thus out of total 70 patients with CVP measurement, JVP could be estimated in 61 (87.1%) of the patients from both sternal angle (JVP SAL) and zero (JVP ZeL) levels. Correlation of CVP with JVP SAL and JVP ZeL is shown in the Figure 2.

Out of the total 70 patients with CVP measurements, central venous catheter was inserted from right internal jugular veins in 37 patients (53%) and from right subclavian vein in 33 patients (47%). The correlations of JVP SAL and JVP ZeL were more with the CVP measured from right internal jugular vein than with the CVP measured from right subclavian vein (Figure 3). The correlations of CVP from both veins were more with JVP ZeL than with JVP SAL.

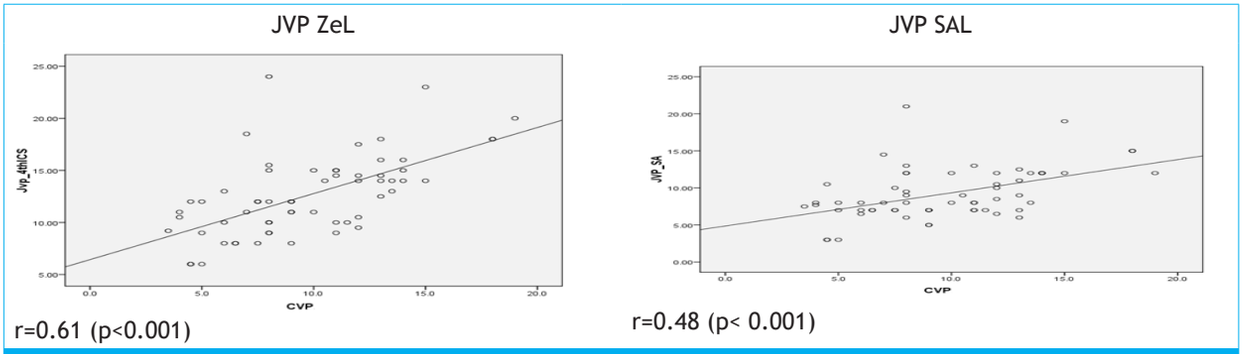


Figure 2. Linear regressions between the central venous pressure (CVP) and the jugular venous pressure (JVP) measured from sternal angle (JVP SAL) and from zero level (JVP ZeL) along with Pearson's correlation coefficient (r) values

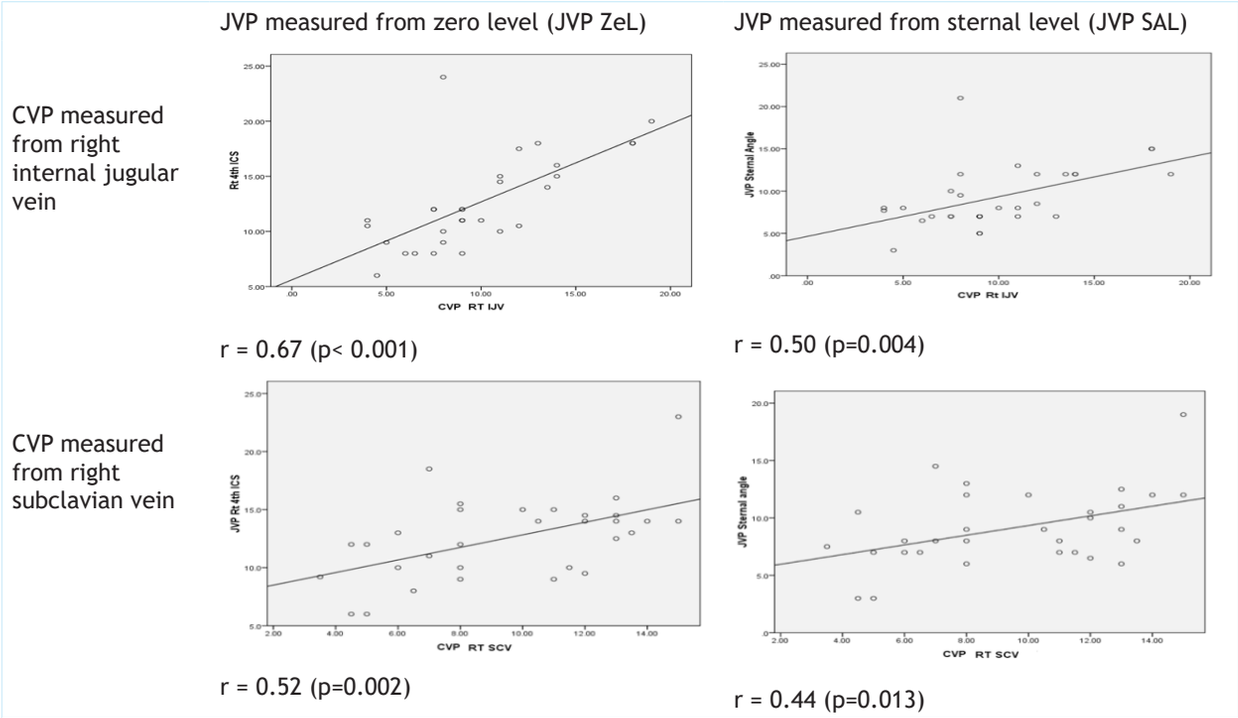
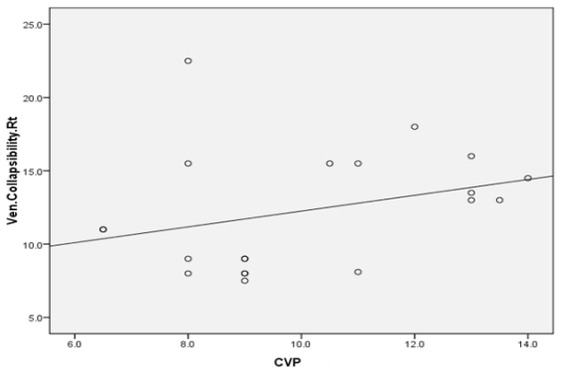


Figure 3. Linear regression between central venous pressure (CVP) and jugular venous pressure (JVP) along with Pearson's correlation coefficient (r) values.

Various reasons that caused difficulty in measuring UVP in 50 out of 70 patients with CVP (71.4%) were swollen hands, thrombosed vein on clinical examination, veins not prominent and veins prominent but did not collapse on raising the upper limb. The measurements of UVP were correlated with that of CVP (Figure 4).



r=0.31(p=0.18)

Figure 4. Linear regression between central venous pressure (CVP) and upper limb venous pressure (UVP) along with Pearson's correlation coefficient (r) values.

DISCUSSION

The study correlated the clinical measurements of JVP SAL, JVP ZeL and UVP with the CVP measured by central venous catheter in a blinded fashion. The upper level of venous pulsations in internal jugular vein could not be examined in 12.9% of the patients in the present study. This is consistent with the reports that the clinicians can identify the internal jugular veins in 72% to 94% of patients.[9,10] The major observation in our study is different correlation of CVP with JVP ZeL than that with JVP SAL. Demeria et al. (2004) reported the overall correlation coefficient r value of 0.301 between CVP and JVP SAL.[11]Other studies also report limited relation between CVP and JVP SAL.[12,,13]

The variation in the ERPs could similarly have affected the correlation between CVP and JVP ZeL. In our study the JVP ZeL was measured from the zero or 'phlebostatic' level as specified in the method. The CVP was measured from the fourth intercostals space in the mid-axillary line as the zero level,[14,15] however this reference may not be accurate in patients not in the supine position.[14]The two ERPs of measurement of CVP and JVP ZeL may not match exactly in different patients in different positions.

The correlation study of UVP and CVP is scarce in the literature. In the present study, in many participants, thrombosed veins, swollen hands and other reasons caused difficulty in measuring UVP and the limited samples could have contributed to the weaker correlation between the CVP and UVP. Such problems appeared to be related to multiple puncture and cannulation of veins of the upper limbs required for various diagnostic and therapeutic procedures in the patients in the ICU. Considering the potential advantages of the measurement of the UVP, further study of correlation of UVP with JVP ZeL and JVP SAL in patients without central venous cannulation and without multiple peripheral vein puncture is required. One of the advantages of UVP is its ease of measurement for all health professionals especially if there is difficulty in identifying jugular venous pulsations. UVP measurement may also be particularly useful in the situation like hypovolemia when there may be difficulty in visualizing JVP due to lower CVP.[6]

The third notable observation in the present study is the different correlation values of JVP with the CVP measured from the right internal jugular vein (RIJV) and that from the right subclavian vein (RSCV). The relationship between two centrally inserted (CI) CVP or between CICVP and a peripherally inserted (PI) CVP is difficult to assess, because two such CVP catheters are seldom inserted concomitantly in one patient.[16]Such data of two CICVP are scarce in the literature. We could only get such observation due to the comparison of similar clinical JVP measurements made with two different CICVP measurements in different patients in our study. The straight course of RIJV, along with the central venous cannula inside, to the superior venacava (SVC), in contrast to the curved, almost right angled, course of RSCV, along with the cannula inside, to the SVC could be related to the higher correlation of CVP with JVP measured from RIJV observed in the study.

The results of present study indicate the importance of ERP in the measurement of venous pressures. Ultrasound could be used to identify the highest point of oscillation of the jugular vein; however, the key factor for the disagreement and inaccuracy between the studies of CVP measurement is the difference in the ERP of right atrium in patients with various positions.[17] In the measurement of CVP, different anatomic landmarks used and selection of suitable external landmarks vary significantly.[18] The importance of defining an exact anatomic zero level for CVP measurement is thus emphasized.[17,18] New non-invasive CVP measurement method by accurate location of the collapse point of the internal jugular vein and the center of the right atrium using ultrasound imaging is recently reported.[17] The most important point the present study also highlights is the need to have further evidences and the consensus on the common ERP to measure venous pressures including CVP, JVP and UVP.

There are limitations in our study. This is a single institution study and the venous pressures were measured by one observer clinically by the locally made JVP Meter®. The participants in the study were admitted in intensive care units (ICUs) for their treatment and the difficulty in the UVP measurement could thus be related to multiple punctures of veins of the upper limbs required for various diagnostic and therapeutic procedures in the patients in the ICU. In the study the proper placement of the central venous catheter tip was not confirmed by the imaging study. The catheter tip should be confirmed to be located by chest radiograph in the lower superior vena cava or slightly into the right atrium at the level of tracheal carina.[16,19] Similarly, the measurement of CVP was made in the study with a water column manometer, not with an electronic transducer. Manometric measurements are on average 2 cm higher, partly because of a meniscus effect and partly because of the difficulty of identifying the mean pressure in the manometer's bobbing saline column.[20,21]

CONCLUSIONS

The present indicates that the estimation of venous pressure whether by clinical or central vein cannulation methods depends on the ERP selected. There is need of further study and consensus on having the common ERP for measurement of venous pressures including CVP, JVP and UVP. Further study of the UVP is also required especially in the participants without venous cannulation and multiple venous punctures. The different correlation values of JVP with the CVP measured from the right internal jugular vein and from right subclavian vein, the other notable observation in the present study, also deserves further investigations.

CONFLICT OF INTEREST

The first author SK does not have any conflicts of interest. The second author MDB had designed and published the paper of the JVP Meter® and registered it as indicated in the references and made a few JVP Meters® locally at his own expense with the help of available craftspeople. There is no other conflict of interest.

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