EM Advances

Defining normal jugular venous pressure with ultrasonography

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ABSTRACT

Objective: Determination of jugular venous pressure (JVP) by physical examination (E-JVP) is unreliable. Measurement of JVP with ultrasonography (U-JVP) is easy to perform, but the normal range is unknown. The objective of this study was to determine the normal range for U-JVP.

Methods: We conducted a prospective anatomic study on a convenience sample of emergency department (ED) patients over 35 years of age. We excluded patients who had findings on history or physical examination suggesting an alteration of JVP. With the head of the bed at 45°, we determined the point at which the diameter of the internal jugular vein (IJV) began to decrease on ultrasonography ("the taper"). Research assistants used 2 techniques to measure U-JVP in all participants: by measuring the vertical height (in centimetres) of the taper above the sternal angle, and adding 5 cm; and by recording the quadrant in the IJV's path from the clavicle to the angle of the jaw in which the taper was located. To determine interrater reliability, separate examiners measured the U-JVP of 15 participants.

Results: We successfully determined the U-JVP of all 77 participants (38 male and 39 female). The mean U-JVP was 6.35 (95% confidence interval 6.11–6.59) cm. In 76 participants (98.7%), the taper was located in the first quadrant. Determination of interrater reliability found κ values of 1.00 and 0.87 for techniques 1 and 2, respectively.

Conclusion: The normal U-JVP is 6.35 cm, a value that is slightly lower than the published normal E-JVP. Interrater reliability for U-JVP is excellent. The top of the IJV column is located less than 25% of the distance from the clavicle to the angle of the jaw in the majority of healthy adults. Our findings suggest that U-JVP provides the potential to reincorporate reliable JVP measurement into clinical assessment in the ED. However, further research in this area is warranted.

Keywords: jugular veins, ultrasonography, heart failure, central venous pressure

RÉSUMÉ

Objectif : La détermination de la pression veineuse jugulaire (PVJ) par un examen physique (PVJ par examen) n'est pas fiable. La mesure de la PVJ par échographie est facile à réaliser, mais la plage normale est inconnue. L'objectif de cette étude était de déterminer la plage normale pour la PVJ par échographie.

Méthodes : Nous avons réalisé une étude anatomique prospective sur un échantillon de commodité de patients de plus de 35 ans s'étant présentés à l'urgence. Nous avons exclu les patients dont les antécédents ou l'examen médical suggéraient une altération de la PVJ. En positionnant la tête du lit à 45 degrés, nous avons déterminé par échographie le point où le diamètre de la veine jugulaire interne (VJI) commence à se rétrécir (point de rétrécissement). Les assistants de recherche ont utilisé deux techniques pour mesurer la PVJ par échographie chez tous les participants : 1) mesure de la hauteur verticale (en cm) du point de rétrécissement au-dessus de l'angle sternal, plus 5 cm; 2) détermination du quadrant du trajet de la VJI, de la clavicule à l'angle de la mâchoire où le point de rétrécissement a été repéré. Différents examinateurs ont mesuré la PVJ par échographie de 15 participants pour déterminer la fiabilité inter-évaluateurs.

Résultats : Nous avons mesuré avec succès la PVJ par échographie chez tous les participants (77, dont 38 hommes et 39 femmes). La valeur moyenne de la PVJ par échographie était de 6,35 cm (intervalle de confiance [IC] de 95 %, de 6,11 à 6,59 cm). Chez 76 patients (98,7 %), le point de rétrécissement a été localisé dans le premier quadrant. Les valeurs de Kappa relativement à la fiabilité inter-évaluateurs étaient respectivement 1,0 et 0,87 pour les techniques 1 et 2.

Conclusion : La valeur normale de la PVJ par échographie est de 6,35 cm, une valeur légèrement inférieure à la valeur normale publiée. La fiabilité inter-évaluateurs concernant la mesure de la PVJ par échographie est excellente. La partie supérieure de la VJI est située à moins de 25 % de la distance entre la clavicule et l'angle de la mâchoire chez la majorité des adultes en santé. Nos résultats suggèrent que la PVJ par échographie offre la possibilité de réintégrer une mesure fiable de la PVJ dans l'évaluation clinique dans les services d'urgence. Cependant, des recherches plus poussées dans ce domaine sont nécessaires.

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Submitted Mar. 11, 2009; Revised Aug. 19, 2009; Accepted Sep. 1, 2009

This article has been peer reviewed.

CJEM 2010;12(4):320-4

INTRODUCTION

The evaluation of jugular venous pressure (JVP) is considered to be a standard component of the physical examination in patients suspected of having acute congestive heart failure.[1] Other acute cardiorespiratory conditions such as pericardial tamponade and tension pneumothorax may also be present with elevated JVP. Unfortunately, bedside assessment of JVP by visualization of jugular venous pulsations has been found to be inaccurate and unreliable.[2] Factors such as short or obese necks make the visualization of jugular venous pulsations difficult.[3] Connors and coauthors[4] found a low sensitivity and specificity among clinicians asked to determine whether central venous pressure (CVP) was low, normal or elevated. Similarly, Eisenberg and colleagues[5] found that physicians were correct only 55% of the time in assigning CVP to low, normal or high groupings. Finally, Cook[6] found only modest agreement between the JVP measurements of residents and staff physicians. As a result of these limitations, the assessment of JVP may be underused by emergency physicians (EPs). This is unfortunate, as the assessment of right-sided heart pressures via JVP may have diagnostic utility.

The measurement of JVP by ultrasonography (U-JVP) represents an alternative to JVP determination by physical examination (E-JVP). The internal jugular vein (IJV) is readily identified by ultrasonography. The use of ultrasonography to determine JVP was first described by Lipton[7] in 1999. Jang and colleagues[8] found elevated U-JVP to be more accurate than chest radiography in diagnosing congestive heart failure. However, the normal range for U-JVP has never been established. The objective of this study was to determine the normal range for U-JVP.

METHODS

Study design, setting and population

This prospective anatomic study was conducted on a convenience sample of patients presenting to the emergency department (ED) at Hôpital regional de Sudbury Regional Hospital (HRSRH). The HRSRH ED is the sole ED for Sudbury, Ont., (population of 160 000) and has an annual ED census of approximately 60 000 visits. The hospital functions as the tertiary care referral centre for northeastern Ontario. The ED is the base hospital for a College of Family Physicians of Canada emergency medicine residency program. The study took place from June through August 2007. Study enrolment took place from 9 am to 10 pm, 7 days a week. Study approval was obtained from the HRSRH Research Ethics Committee.

Study protocol

A research assistant (RA) approached potentially eligible patients for possible study inclusion. Inclusion criteria were well-appearing adults 35 years of age or older. Exclusion criteria are provided in Box 1 and were established to capture a study population likely to have a normal JVP. The RA determined and documented the age, sex, height and weight of eligible patients who provided informed consent. Body mass index was also calculated.

The RAs were first- or second-year medical students. All had received medical school training in JVP mea-

Box 1. Exclusion criteria

Chief complaint(s)
- Cardiorespiratory
  - Dyspnea, chest pain, palpitations, syncope or presyncope
- Gastrointestinal
  - Epigastric pain, anorexia, diarrhea, vomiting
- Trauma
  - Any trauma of the head, neck, chest or abdomen
- Complaint suggesting hypovolemia

Medical history
- Cardiac
  - Angina, myocardial infarction, heart failure, valvulopathy, cardiac myxoma, pericarditis, pericardial effusion
- Neck-related issues
  - Neck surgery, neck radiation, neck burn, previous central line placement in neck
- Metabolic
  - Uncontrolled diabetes mellitus, diabetes insipidus
- Superior vena cava syndrome
- Hypervolemia

Medications
- Angiotensin-converting enzyme inhibitors
- Angiotensin receptor blockers
- Loop diuretics
- Thiazide diuretics

Physical examination
- Respiratory distress
- Abnormal vital signs
- Oxygen saturation < 95%
- Heart murmur

Other
- Inability to maintain the position needed to have jugular venous pressure evaluated

https://doi.org/10.1017/S1481803500012409 Published online by Cambridge University Press

surement by physical examination. One of the study authors (S.J.S.) provided the RAs with a half-day of training in ultrasound physics, ultrasound machine use and U-JVP measurement. In addition, each RA performed 10 supervised training scans for U-JVP measurement before enrolling patients.

Research assistants measured U-JVP with the head of the bed (HOB) at 45° and the participant's legs parallel to the ground. A goniometer was used to ensure accurate HOB angulation. A linear array probe set at a frequency of 15 MHz (The Esaote Group) was used to visualize the IJV. The top of the IJV was located in the longitudinal view (i.e., probe indicator pointed toward the participant's head). The transverse view (i.e., probe indicator pointed toward the participant's right) was used as needed to confirm findings on the longitudinal view. The RAs noted the point at which the diameter of the IJV began to decrease (the "taper") at end-expiration (Fig. 1) and identified the corresponding point on the skin.

Research assistants determined U-JVP in 2 ways: the "ruler technique" and the "quadrant technique." Using the ruler technique, the height in centimetres of the IJV taper (rounded to the nearest centimetre) above the sternal angle was measured with a ruler; U-JVP was calculated by adding 5 cm to this height.[9] Although the addition of 5 cm to determine JVP has been questioned,[10,11] it is, to our knowledge, the most commonly used method to calculate E-JVP.

The RAs then determined U-JVP by the quadrant technique. With the participant's head at 45°, the RA visually divided (i.e., "eyeballed") the area between the clavicle and the angle of the jaw into 4 quadrants (Fig. 2). The RA subsequently determined in which quadrant the taper of the IJV was located. In a subset of 15 participants, 2 RAs measured U-JVP to determine interrater reliability.

Data analysis

Data was collected using a standardized form and transferred by each RA to an Excel spreadsheet (Microsoft Corp.). Descriptive statistics were used as appropriate. We employed multivariate linear regression to determine whether an association existed between the U-JVP and age, sex, height, weight or body mass index. We used the κ statistic to determine interrater reliability. For the purposes of determining interrater reliability for U-JVP measured by the ruler technique, measurement differences between RAs of 1 cm or less were considered identical and deemed to be in agreement.

RESULTS

Seventy-seven patients (38 male and 39 female) were enrolled, and U-JVP was successfully determined in all

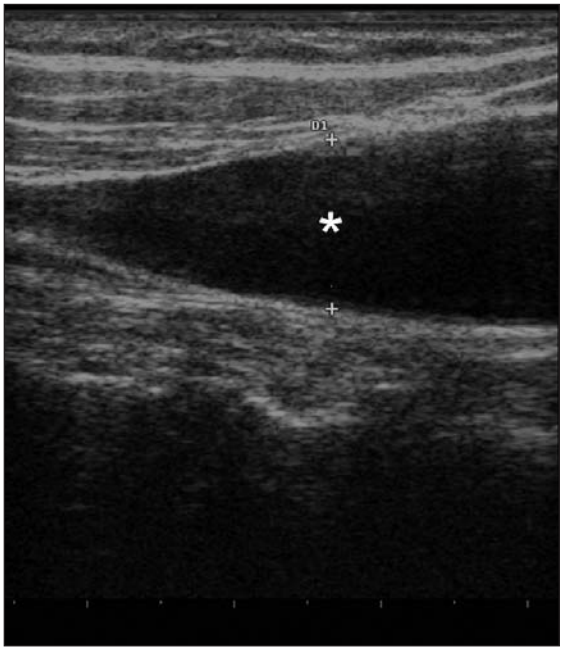

Fig. 1. Ultrasonography image showing a longitudinal view of the internal jugular vein with the probe indicator pointed toward the patient's head. The asterisk marks the beginning of the taper. Used with permission from The EDE 2 Course Inc.

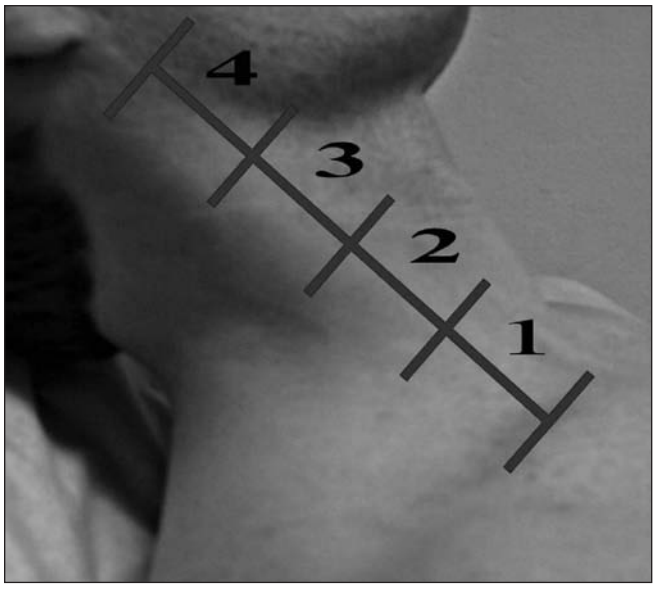

Fig. 2. The area between the clavicle and the angle of the jaw is visually divided into 4 quadrants to determine U-JVP by the quadrant technique. Used with permission from The EDE 2 Course Inc.

https://doi.org/10.1017/S1481803500012409 Published online by Cambridge University Press

participants. The mean age was 49.6 (standard deviation [SD] 11.0, range 35–86) years. Three participants did not consent to the collection of height and weight data. The mean height of consenting participants was 170.0 (SD 8.0, range 155–193) cm. The mean weight was 82.8 (SD 27.0, range 41–218) kg. The mean body mass index was 28.6 (SD 9.4, range 14.5–73.1). Mean U-JVP was 6.35 (95% confidence interval 6.11–6.59) cm as determined by the ruler technique. In 76 participants (98.7%), the IJV taper was located in the first quadrant when measured by the quadrant technique. There was no statistically significant association found on regression analysis between U-JVP measured by either technique and participant age, sex, height, weight or body mass index. Fifteen participants had their U-JVP measured by 2 RAs. Interrater reliability determination found κ values of 1.00 and 0.87 for the ruler technique and quadrant technique, respectively.

DISCUSSION

With the use of the ruler technique, our study found a normal mean U-JVP of 6.35 cm with a narrow 95% confidence interval. This is slightly lower than the upper limit of normal (8–9 cm) cited in a commonly used physical examination text.[9] We suspect most EPs do not carry rulers or tape measures, and are thus more likely to visually estimate JVP. Because of this, we also sought to determine normal U-JVP based on a quadrant technique consistent with how EPs are likely to make such estimates in the ED.

With the use of the quadrant technique, all but 1 of the 77 participants had an IJV taper in the first quadrant. Said another way, the taper was located no more than 25% of the way from the clavicle to the angle of the mandible in the vast majority of participants. For both techniques, no significant association was found between U-JVP and participant sex, age, height, weight or body mass index. Interrater reliability was excellent for both techniques.

Limitations and future directions

Several limitations should be considered when interpreting our findings. The 3 RAs who measured U-JVP had never performed ultrasonography before receiving the training required to perform this study. As U-JVP is a novel technique, training guidelines do not exist. The training of the RAs included 10 training scans; although this number is arbitrary, we felt it was adequate.

Fine points in ultrasonography technique were highlighted during RA training but were a potential source of variability in U-JVP measurement. The amount of pressure applied with the probe was not standardized. During their training, RAs were encouraged to use light probe pressure to avoid falsely lowering U-JVP. The longitudinal view was preferred over the transverse view because it is easier to appreciate the IJV taper in this view. However, it is possible to underestimate the U-JVP in the longitudinal view by inadvertently obtaining an oblique or tangential view. For this reason, RAs were encouraged to hold the probe perpendicular to the skin. In addition, RAs were taught to slide the probe left to right and rotate the probe to ensure an optimal view of the IJV. Finally, RAs were permitted to use the transverse view to corroborate their findings on the longitudinal view, as it is easier to centre the IJV on the screen with the transverse view. It is not known how often the RAs used the transverse view for this purpose.

It was not possible to obtain the gold standard of CVP measurement in this cohort of healthy participants. Although participants' true CVP could not be known with precision, we believe our exclusion criteria were sufficient to ensure enrolment of a study group with normal CVP.

The interrater reliability of U-JVP determination was found to be excellent. However, the vast majority of the participants, who were selected for their likelihood of having a normal JVP, had the taper of their IJV fall 0, 1 or 2 cm above the sternal angle. The potential for spectrum bias from this narrow range of values makes the excellent interrater reliability we found less impressive. Future studies with a mix of participants with normal and elevated U-JVP may provide more accurate estimates of the interrater reliability of U-JVP determination.

Future studies should focus on the training required to perform U-JVP. Beyond this, it would be useful to determine the feasibility of its use in the ED and its diagnostic test characteristics in conditions associated with elevated JVP.

CONCLUSION

The normal U-JVP is 6.35 cm, a value that is slightly lower than the published normal E-JVP. Interrater reliability for U-JVP determination is excellent. The top of the IJV column is located less than 25% of the distance from the clavicle to the angle of the jaw in the majority of healthy adults. Our findings suggest U-JVP provides the potential to reincorporate reliable JVP measure-

https://doi.org/10.1017/S1481803500012409 Published online by Cambridge University Press

ment into clinical assessment in the ED; however, further research in this area is warranted.

Competing interests: Drs. Socransky and Wiss are editors of The EDE 2 Course, which includes a chapter on the measurement of jugular venous pressure using bedside ultrasound. None declared for all other authors.

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https://doi.org/10.1017/S1481803500012409 Published online by Cambridge University Press