MEDD 422 Clinical Skills
2016-2017
Vascular Ultrasound for Volume Assessment Student Guide

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ACKNOWLEDGEMENTS

We are indebted to:

Members of the Ultrasound Working Group

ORGANIZATION

Scheduling and organization may vary slightly across sites.

- Students will be divided into groups of 4-8
- In the 1st hour, a tutor will demonstrate bedside ultrasonographic volume assessment including neck vessels for JVP and major abdominal vessels (IVC and aorta). Students will have the opportunity to perform limited bedside ultrasound for volume assessment
- In the 2nd hour, students and tutors will use the cases provided to review volume assessment and consolidate with bedside ultrasound techniques presented in the previous ultrasound sessions

PREPARATION

Required Readings / Review

- MEDD 422 Volume Assessment Ultrasound Student Guide
  MEDD 421 Cardiac Ultrasound Student Guide
  MEDD 412 Abdominal Ultrasound Student Guide

Required Viewing

- *Neck Ultrasound*. U of Florida. Dr. Giuliano De Portu (5 minutes)
  - https://www.youtube.com/watch?v=3KNtnTBtwmk
- *Aorta and IVC*. UC Irvine. Dr. J. Christian Fox (29 minutes)
  - https://itunes.apple.com/ca/itunes-u/emergency-ultrasound/id429668403?mt=10
- *IVC Ultrasound*. UWO. Dr. R Arntfield (15 minutes)
  - https://www.youtube.com/watch?v=xgCGrICzdLg

Suggested Resources (including other texts, websites, course material, etc.)

- The following online references will enhance your understanding of bedside volume assessment ultrasound. You are not required to review them prior to the session, but you will find your image recognition to be much faster if you do.
  - *Identification of congestive heart failure via respiratory variation of the inferior vena cava diameter*. DJ Blehar *et al*. AJEM 2009:27(1);71-75
  - *Examination of the Abdominal Aorta*. U of SC School of Medicine (6 minutes)
    - https://www.youtube.com/watch?v=08fF1OUcecM&list=PLGEKJJ3ekUkzFqY2SFfAodP_NJUPV0qqF&index=1
  - The RUSH Exam - http://emcrit.org/rush-exam/
  - *RUSH*. UC Irvine. Dr. J. Christian Fox (19 minutes)
    - https://itunes.apple.com/ca/itunes-u/emergency-ultrasound/id429668403?mt=10

OBJECTIVES

On completion of this session, students should be able to:

- Describe the indications for, and limitations of, bedside ultrasonographic volume assessment
- Recognize and differentiate vascular structures of the neck (i.e. internal jugular vein vs. carotid artery) using ultrasound
- Estimate the JVP using ultrasound
- Recognize and differentiate major vascular structures of the abdomen (i.e. IVC and aorta) using ultrasound
- Estimate IVC diameter and abdominal aortic diameter using ultrasound
- Integrate physical examination skills and bedside ultrasound findings in a patient with shock/hypotension

EQUIPMENT

- Students must wear professional dress and wear UBC student ID.
- Students should bring their stethoscopes
- Portable ultrasound machines are provided.

ASSESSMENT & EVALUATION

Student Assessment

Students will be formally assessed during Clinical Skills using Workplace Based Assessment (WBA) Forms in conjunction with the Clinical Skills Milestones (located in students' Clinical Experiences Green Book) to inform the WBAs.

Each Clinical Skills session or block of sessions have associated milestones which we ask students to review with their tutor at the start of the session/block. At the end of each session or block, students will be required to review with their tutors whether they are progressing at their expected level (see Milestone description and education level). Students will then be responsible for asking their tutor to sign off on completed milestones in their Green Books.

The associated milestone(s) for this session/block is below:

Clinical Skills Session(s):	**Volume Assessment Ultrasound**
Milestone title:	**"Bedside Ultrasound Skills" & "Peripheral Vascular Exam"**
Page:	**Page 57 & 60 of Green Book**
Competency Level:	**"At the end of preclinical studies (TICE)"**

An example of how to use your Milestones is included below:

Clinical Skill	At First Encounter various times during 1st/2nd year	By End of 1st Year (MEDD 412)	By Middle of 2nd Year (MEDD 421)	At the end of preclinical studies (TICE)
Bedside Ultrasound Skills	Students have read the basics of ultrasound physics and "knobology."	Students have described the indications and limitations of portable ultrasound to their tutors.	Students have been observed using a portable ultrasound machine for scanning procedures.	Students have described how to integrate bedside ultrasound findings (from cardiac or volume assessment ultrasound) into their overall clinical assessment of a patient.
Tutor Initial & Date			EG 7 Oct 2016	AS 12/1/17
Tutor Initial & Date				
Tutor Initial & Date				
Tutor Initial & Date				
Notes:				

This student had their Cardiac Ultrasound tutor sign off their Bedside Ultrasound Milestone in MEDD 421 (first term, second year.

When this student gets to second term, second year (MEDD 422) and attends their Volume Assessment Ultrasound session, they will have their tutor sign off in this column (as shown).

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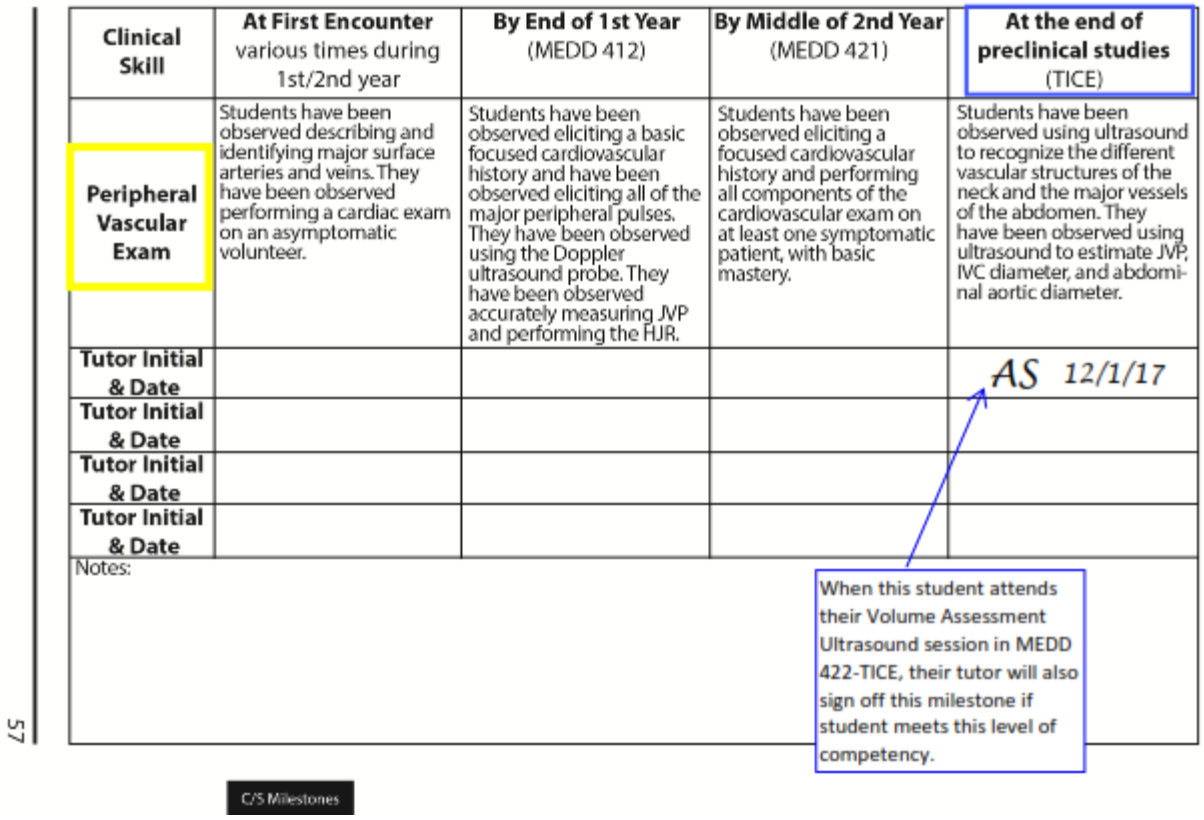
C/S Milestones



Clinical Skill	At First Encounter various times during 1st/2nd year	By End of 1st Year (MEDD 412)	By Middle of 2nd Year (MEDD 421)	At the end of preclinical studies (TICE)
Peripheral Vascular Exam	Students have been observed describing and identifying major surface arteries and veins. They have been observed performing a cardiac exam on an asymptomatic volunteer.	Students have been observed eliciting a basic focused cardiovascular history and have been observed eliciting all of the major peripheral pulses. They have been observed using the Doppler ultrasound probe. They have been observed accurately measuring JVP and performing the HJR.	Students have been observed eliciting a focused cardiovascular history and performing all components of the cardiovascular exam on at least one symptomatic patient, with basic mastery.	Students have been observed using ultrasound to recognize the different vascular structures of the neck and the major vessels of the abdomen. They have been observed using ultrasound to estimate JVP, IVC diameter, and abdominal aortic diameter.
Tutor Initial & Date				AS 12/1/17
Tutor Initial & Date				
Tutor Initial & Date				
Tutor Initial & Date				
Notes:				

When this student attends their Volume Assessment Ultrasound session in MEDD 422-TICE, their tutor will also sign off this milestone if student meets this level of competency.

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C/S Milestones

**We recognize that the milestones are somewhat unclear so please note we are actively working on improving this process in future.*

Please refer to the Year 2 Assessment Package on Medicol to access student assessment information for Clinical Skills:

- Year 2 > MEDD 421 > Exam & Assessment Resources

At the end of term, student competency will be further assessed through written Multiple Choice Exams and a Summative OSCE (Objective Structured Clinical Examination) on Sunday, April 9, 2017. Material from the Volume Assessment Ultrasound session in MEDD 422 will be examinable on the Year 2 OSCE and Year 2 MCQ Exam held at the end of MEDD 422.

As part of your professional commitment, you may be required to complete an online assessment of your tutor and a course evaluation on one45.

TECHNIQUE

Indications/Limitations

View	Key Anatomic Structures	Clinical Indications	Limitations
IJ	• Internal jugular • Carotid artery • Thyroid • Sternocleidomastoid	• Volume (JVP) assessment • Central vein catheter placement	• Even minimal probe pressure can distort anatomy
IVC	• Liver • Right atrium • Junction of hepatic veins and IVC	• Volume assessment	• Correlates with central venous pressure, but not necessarily with fluid responsiveness • Difficult to interpret if increased intra-abdominal/intra-thoracic pressure • Difficult to interpret if altered right heart pressure (e.g. pulmonary HTN)
Aorta	• Anterior vertebral column • Aorta from crux to iliac bifurcation	• Suspected AAA •	• Body habitus and bowel gas • Poor to detect rupture (usually retroperitoneal)

NECK VESSELS/JVP

- Position the patient supine with the head of bed elevated ~ 30-45 degrees
    - The patient should rotate their head slightly to the left to expose the right neck
    - Only the angle of mandible to the sternal notch needs to be exposed – drape the patient appropriately (figure 1)

Figure 1 – Appropriate position and draping for neck scanning.

- Ensure the stretcher is adjusted to an ergonomic height
- Minimal initial depth is required as the vascular structures are superficial
- Gain should initially be set mid-range; adjust as the scan proceeds
- Gel is applied directly to the patient
- Use a linear high-frequency probe for this scan:
    - Grip the probe similar to how you would grasp a large pencil (figure 2)

Figure 2 – Probe grip for the linear high frequency probe.

- Initially place the probe in transverse orientation within 2 cm of the clavicle with the probe indicator toward patient right (figure 3)

Figure 3 – Initial probe placement for transverse scanning of the neck. Note probe marker pointing to patient right.

- In transverse, you should immediately see two circular, anechoic (black), fluid-filled structures – the carotid and the internal jugular (figure 4)
- You should also be able to identify the thyroid (to screen right) and the sternocleidomastoid

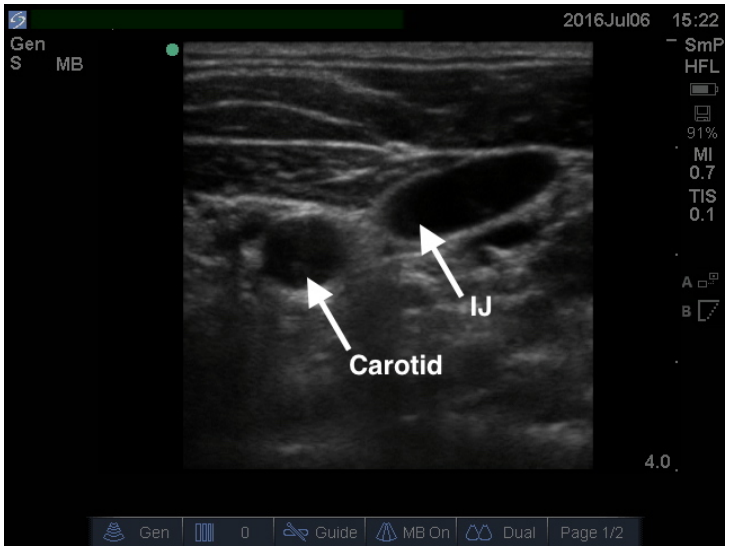

Figure 4 – Transverse ultrasound of the major neck vessels.

- Recall from anatomy that the IJ should lie lateral to the carotid – this is usually, but not always, the case (figure 5)

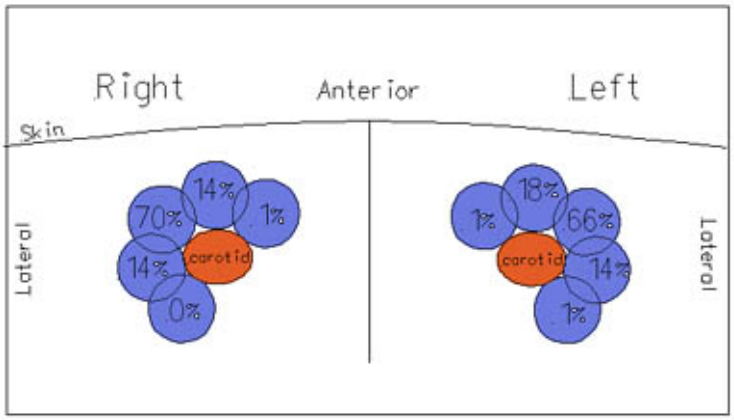

Figure 5 – Variable anatomic relationship of internal jugular and carotid vessels.

- In addition to anatomic location, the IJ can be differentiated from the carotid by:
  - Wall thickness – arteries have thicker, more muscular walls than venous structures
  - Shape – arteries are circular, whereas venous structures are often oval or irregular-shaped
  - Compressibility – venous structures are easily compressed, whereas arteries generally retain a circular shape until significant pressure is applied
  - Respiratory variability – central venous structures will fluctuate in size with respiration, whereas arteries will not
- After identifying the IJ and carotid in the transverse plane, rotate the probe 90 degrees clockwise into longitudinal; the probe marker should point at the patient's head (figure 6)

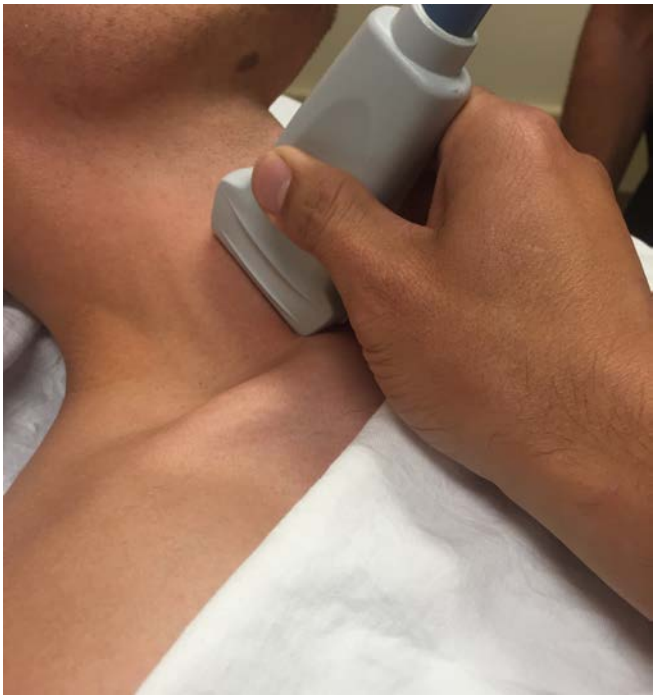

Figure 6 – Longitudinal scan of the neck. Note probe marker pointing to patient head.

- Identify the IJ and carotid in longitudinal; they will now appear as anechoic, fluid-filled, tubular structures stretching across the screen from left to right (figure 7)

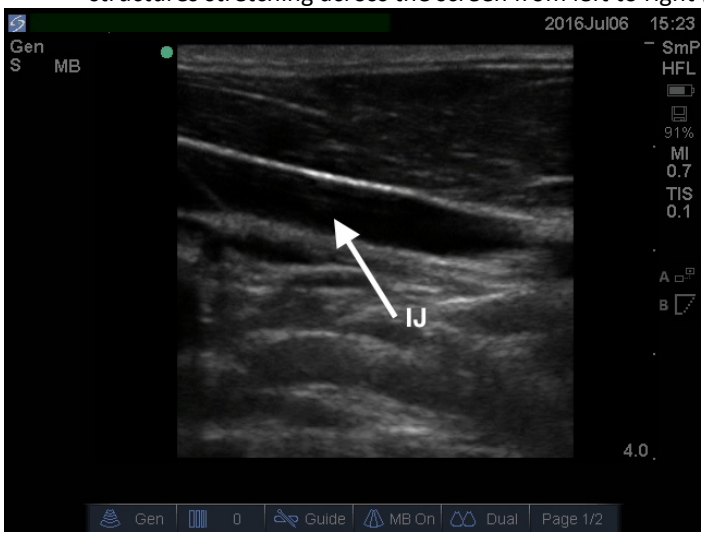

Figure 7 – Ultrasound of the internal jugular in the longitudinal plane.

- Estimating the JVP:
    - Place the probe in the longitudinal plane initially just superior to the clavicle
    - Identify the IJ using the criteria above and attempt to find the point at it tapers (figure 8)

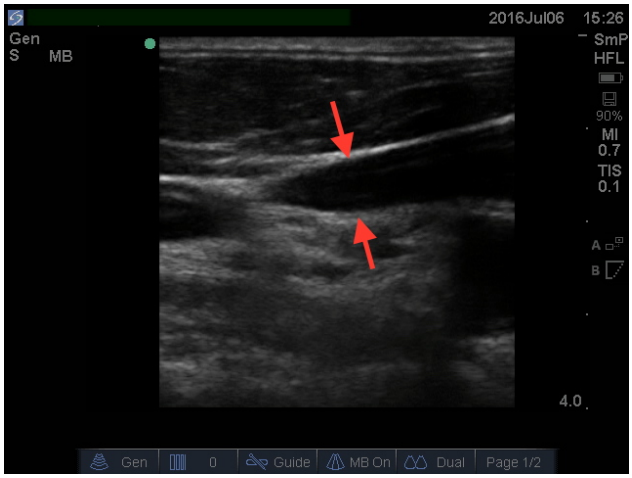

Figure 8 – Initial point of internal jugular taper (red arrows).

    - Center the probe over the taper, and mark the skin at the center of the probe (figure 9)

Figure 9 – Estimating the JVP using ultrasound. Mark the point of internal jugular taper on the skin and measure from there.

- Measure the JVP as you normally would from the mark
- For further explanation of this technique refer to Appendix 1 - **Defining normal jugular venous pressure with ultrasonography. Socransky *et al*. *CJEM* 2010;12(4):320-4**

- Tips & Tricks:
  - Start your scan just above the clavicle; if you are significantly more superior the IJ may be flat and much more difficult to identify
  - If the IJ is flat you can try lowering the head of the bed
  - If the taper of the IJ is difficult to identify, try raising the head of bed up 10 degrees
    - If IJ taper still cannot be identified, ensure you are not looking at the carotid, and check if there is clot in the IJ (inability to compress the vein)
- Pitfalls:
  - Too much probe pressure can compress the IJ, making it more difficult to identify – try to hold the probe on the neck with the least pressure possible

AORTA

- Position the patient supine on the stretcher and drape appropriately to expose the abdomen from costal margin to beltline (figure 10)

Figure 10 – Appropriate draping for aorta and IVC scans.

- Ensure the stretcher is adjusted to an ergonomic height
- Depth should be set to maximum initially so no important structures are missed
- Gain should initially be set mid-range; adjust as the scan proceeds
- Gel is applied directly to the patient
- A curvilinear probe is used to scan the aorta; grip the probe similar to how you would grasp a large pencil (figure 11)

Figure 11 – Probe grip for the curved (abdominal) probe.

- Begin your scan by placing the probe just inferior to the xiphoid process in the transverse plane with the probe indicator pointing to patient right (figure 12)

Figure 12 – Initial probe placement for the aorta scan. Note probe marker pointing to patient right.

- Identify the anterior border of the vertebral column – the aorta lies immediately anterior to this landmark (figure 13)
    - You may also be able to identify the IVC at this time, but this is not critical for the aorta scan

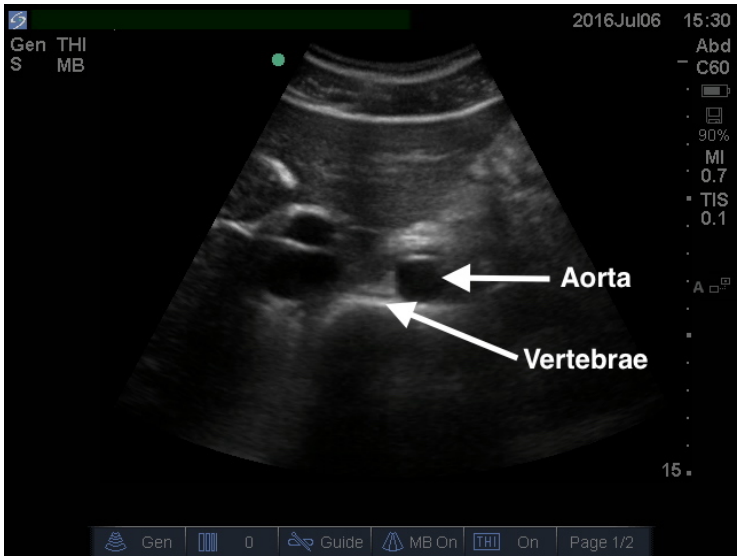

Figure 13 – Transverse ultrasound of the aorta with landmark (anterior border of vertebrae).

- Recall from above that arterial structures have the following ultrasonographic qualities :
    - Thicker, more muscular (echogenic/white) wall
    - Circular shape
    - Lack of compressibility
    - Lack of respiratory variability
- Once the aorta is identified, center it on the screen by sliding right-left, and decreasing the depth; this should result in a magnified view of the aorta near center screen (figure 14)

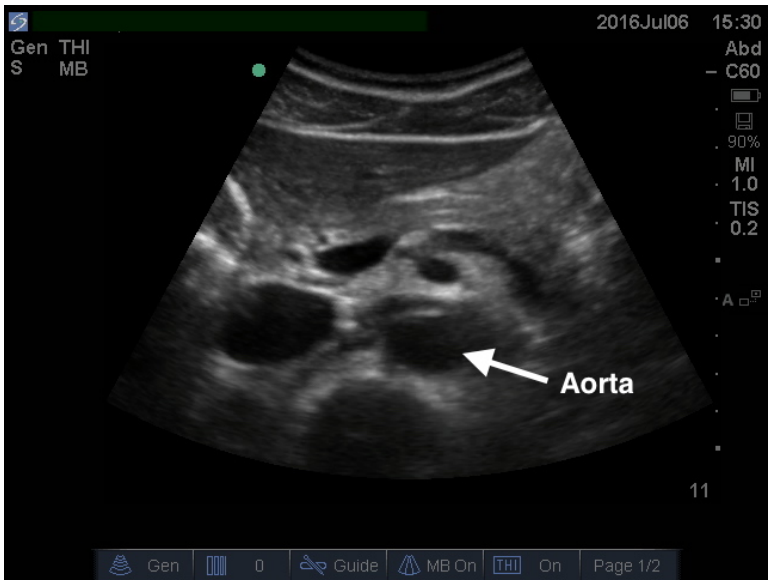

Figure 14 – Magnified/centered transverse view of aorta.

- Scan the aorta from diaphragm to iliac bifurcation by sliding the probe down the abdomen
- The iliac bifurcation is usually seen around the level of the umbilicus; at this point the single lumen of the aorta twins to form the iliac vessels (figure 15)
- Normal aorta diameter is ≤ 3cm - risk of rupture increases significantly at diameters

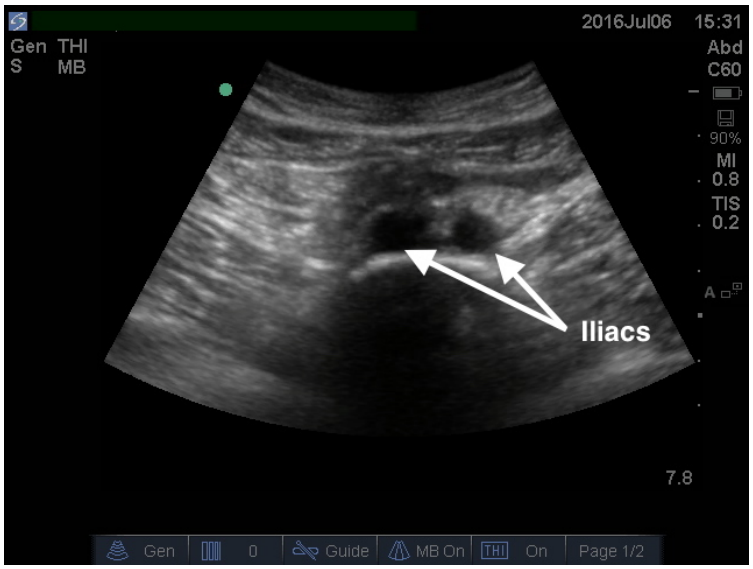

Figure 15 – Iliac bifurcation.

- Tips and Tricks:
  - Ensure your scan starts at the xiphoid process to avoid missing the superior-most portion of the aorta
  - Use probe pressure and/or patient respiration to work around bowel gas obscuring your view of the aorta – your tutor will demonstrate these techniques at the bedside
- Pitfalls:
  - Both bowel gas and patient body habitus (obesity) can impede the ability to visualize the entire aorta – If you are unable to visualize any portion > 1cm in length, your scan should be considered inconclusive

IVC

- Position and drape the patient similarly to the aorta scan above (figure 10)
- Ensure the stretcher is adjusted to an ergonomic height
- Depth should be set to maximum initially so no important structures are missed
- Gain should initially be set mid-range; adjust as the scan proceeds
- Gel is applied directly to the patient
- A curvilinear or phased array (cardiac) probe is used to scan the IVC; grip the probe similar to how you would grasp a large pencil (figure 11)
- Begin your scan by placing the probe just inferior to the xiphoid process in the longitudinal plane with the probe indicator pointing to the patient's head (figure 16)

Figure 16 – Initial probe position for the IVC scan. Note probe marker points to patient head.

  - You may need to slide the probe slightly to patient right to identify the IVC
  - The IVC can be identified by it's proximity to the liver, respiratory variability, and termination at the right atrium
  - The IVC is assessed at a point ~ 2cm distal to the junction with the hepatic vein (figure 17)

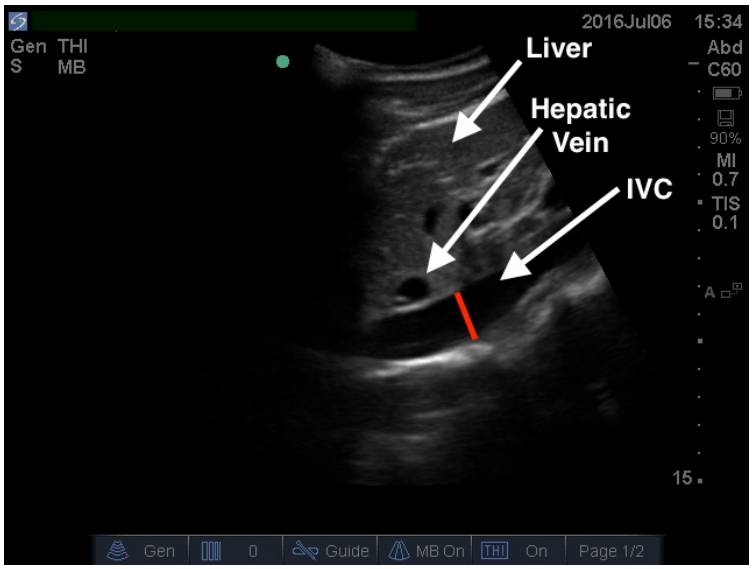

Figure 17 – Longitudinal scan of the IVC showing junction with hepatic vein. Red line represents correct point of IVC measurement.

- The IVC is assessed for two components: diameter and degree of inspiratory collapse
    - Diameter is measured at end-expiration in the antero-posterior direction (figure 18)

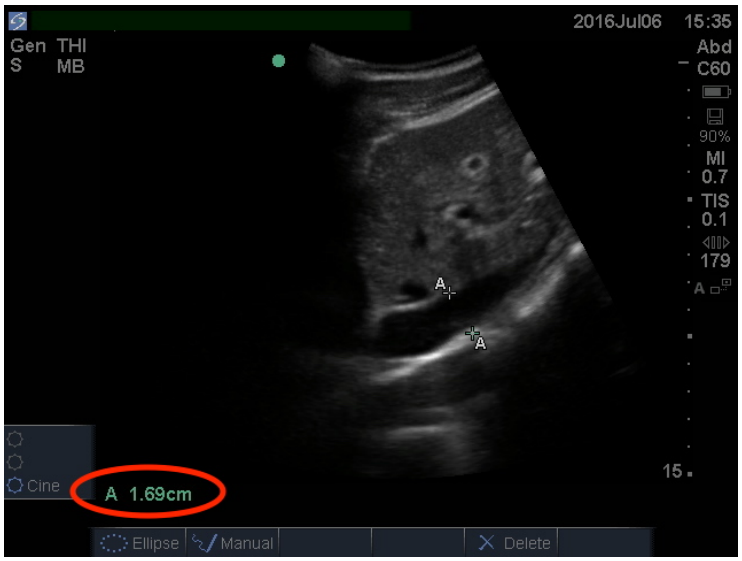

Figure 18 – Normal end-expiratory IVC diameter.

- **Normal end-expiratory IVC diameter is 1.5-2.5 cm**
- IVC diameter < 1.5 cm suggests low central venous pressure (CVP) and/or volume depletion (figure 19)

Figure 19 – Abnomally small IVC diameter, signalling low CVP and/or volume depletion.

- IVC diameter > 2.5 cm suggests high CVP and/or volume overload (figure 20)

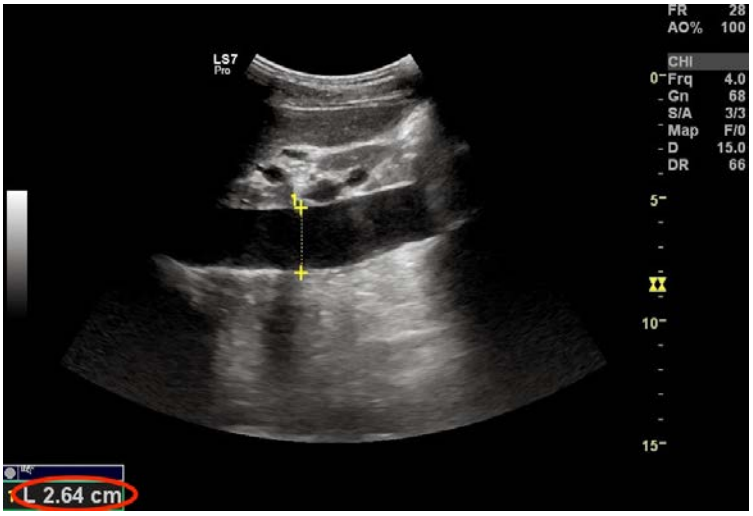

Figure 20 – Abnormally high IVC diameter, signalling elevated CVP and/or volume overload.

- Degree of inspiratory IVC collapse is also measured in the antero-posterior direction
    - The normal IVC collapses < 50% with inspiration
    - IVC collapse > 50% suggests volume depletion and/or fluid responsiveness
    - Minimal IVC collapse (<<50%) suggests high CVP and/or volume overload

- Tips and Tricks:
    - The junction of the hepatic vein and IVC can sometimes be difficult to distinguish; in such cases, measure the IVC ~ 3cm from the junction with the right atrium

- Pitfalls:
    - The IVC can move laterally and/or cranio-caudally with respiration; ensure changes in IVC diameter are related to intrathoracic pressure changes, and not simply to vessel movement
    - IVC diameter and collapsibility both exist on a continuum, and neither are used in isolation to make management decisions
    - IVC assessment provides information that should be integrated with other data points (vital signs, clinical exam, bedside echocardiography, etc) in decision making

CASES

CASE 1

A 65 year old man presents to the Emergency Department with increasing shortness of breath on exertion over the previous 4 days. He also reports orthopnea, leg edema, and a non-productive cough. His past medical history is significant for myocardial infarction 1 year ago, as well as hypertension and type 2 diabetes.

Based on the history consider the following questions:

1. What is the most likely diagnosis?
2. What specific clinical exam maneuvers could you perform to test you suspicion?

The JAMA rational clinical exam series excellently covers this topic in an evidence-based fashion: **Does this dyspneic patient in the emergency department have congestive heart failure? CS Wang *et al*. *JAMA* 2005;294(15): 1944-1956 (Appendix 2)**

3. How might point-of-care US be used to confirm or refute your clinical suspicion?

CASE 2

A 42 year old woman admitted to the Internal Medicine ward earlier in the day with pyelonephritis develops an altered level of consciousness. As the resident on call, you are asked to urgently reassess her condition. She presented with a four day history of dysuria and urinary frequency, followed by one day of fever, nausea, and right flank pain. Her medical history is significant for rheumatoid arthritis, for which she takes Methotrexate.

When you assess her she is confused (GCS 14) and has the following vital signs:
HR 148 BP 85/60 RR 32 O2 sat 92% Temp 40.1 °C

Based on the history consider the following questions:

1. What is the most likely diagnosis?
2. What (if any) specific clinical exam maneuvers could you perform to test your suspicion?
3. How might point-of-care US be used to confirm or refute your clinical suspicion?
4. How might point-of-care US be used to guide your management?

APPENDIX 1 – DEFINING NORMAL JUGULAR VENOUS PRESSURE WITH ULTRASONOGRAPHY

See next page.

EM Advances

Defining normal jugular venous pressure with ultrasonography

Steven J. Socransky, MD;* Ray Wiss, MD;* Ron Robins, MD;† Alexandre Anawati, MD;* Marc-Andre Roy, MD;* I. Ching Yeung, BSc*

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.

From the *Emergency Department, Hôpital regional de Sudbury Regional Hospital, Northern Ontario Medical School of Medicine, Sudbury, Ont., and the †Emergency Department, Woodstock General Hospital, Woodstock, Ont.

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

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

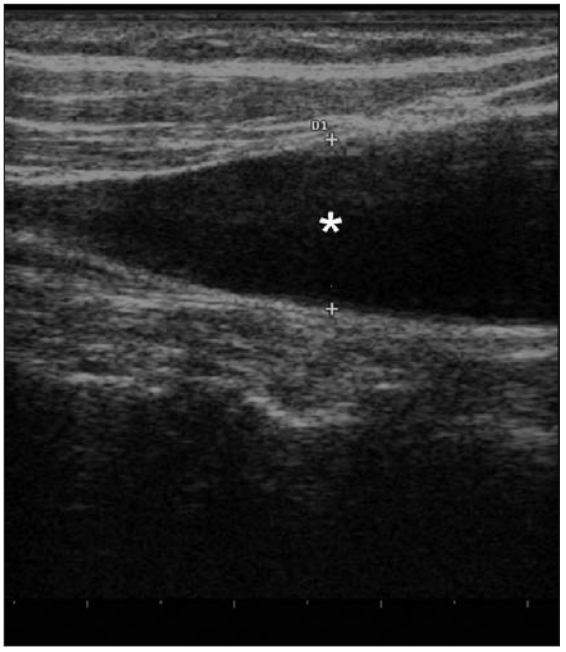

Fig. 1. Ultrasonography image showing a longitudinal view of the internal jugular vein with the probe indicator pointed toward the patient's head. The asterisk marks the beginning of the taper. Used with permission from The EDE 2 Course Inc.

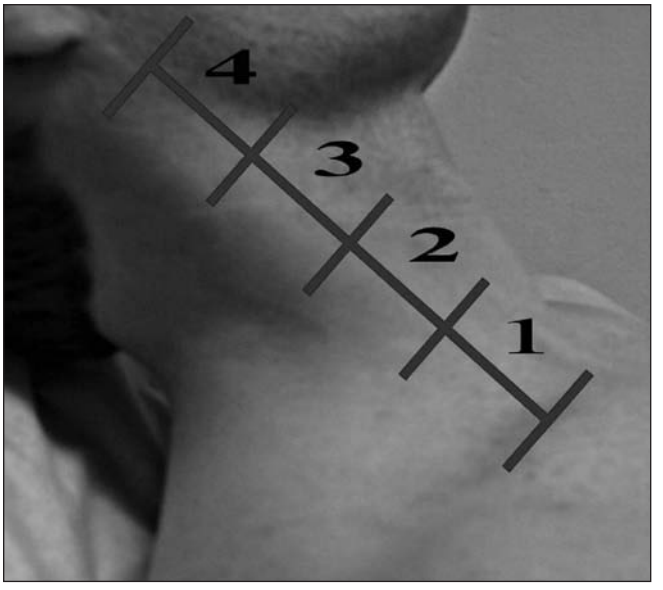

Fig. 2. The area between the clavicle and the angle of the jaw is visually divided into 4 quadrants to determine U-JVP by the quadrant technique. Used with permission from The EDE 2 Course Inc.

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-

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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APPENDIX 2

"Does This Dyspneic Patient in the Emergency Department Have Congestive Heart Failure" (handout)
JAMA. 2005;294 (15): 1944-1956. doi:10.1001/jama.294.15.1944