Humming Is as Effective as Valsalva's Maneuver and Trendelenburg's Position for Ultrasonographic Visualization of the Jugular Venous System and Common Femoral Veins

Matthew R. Lewin, MD, PhD
John Stein, MD
Ralph Wang, MD
Marsha M. Lee, MD
Martin Kernberg, MD
Milana Boukhman, MD
In-Hei Hahn, MD
Resa E. Lewiss, MD

From the Division of Emergency Medicine (Lewin, Stein, Wang, Kernberg, Boukhman) and Department of Pediatrics (Lee), University of California, San Francisco, CA; the Department of Emergency Medicine, St. Lukes–Roosevelt Hospital (Hahn, Lewiss), New York, NY; and the Department of Radiology, Eastern Maine Medical Center, Bangor, ME (Kernberg).

Study objective: The purpose of this study is to compare ultrasonographic visualization of the jugular and common femoral veins by using a novel technique (humming) and 2 conventional techniques (Valsalva's maneuver and Trendelenburg's position). The Valsalva's maneuver and Trendelenburg's position are common methods for producing venous distention, aiding ultrasonographically guided identification and cannulation of the jugular and common femoral veins. We hypothesize that humming is as effective as either Valsalva's maneuver or Trendelenburg's position for distention and ultrasonographic visualization of these procedurally important blood vessels. Herein, we investigate a new method of venous distension that may aid in the placement of central venous catheters by ultrasonographic guidance.

Methods: Healthy, normal volunteers aged 28 to 67 years were enrolled. Each subject's internal jugular, external jugular, and common femoral veins were measured in cross-section by ultrasonograph during rest (baseline), humming, Valsalva's maneuver, and Trendelenburg's position. Three measurements were recorded per observation in each position. Subjects were used as their own controls, and measurements were normalized to percentage increase in diameter during each maneuver or position for later comparison.

Results: The study population consisted of 7 subjects, with a mean age of 47 years. Cross-sectional area was calculated for each vessel in 3 groups: baseline/control, Valsalva, Trendelenburg, and humming. The mean percentage change (±SD) relative to baseline cross-sectional area of the jugular vessels for each subject were external jugular vein: humming 134%±25% (95% confidence interval [CI] 124.9% to 146.9%), Valsalva 136%±23% (95% CI 121.3% to 147.5%), Trendelenburg 137%±32% (95% CI 120.7% to 156.9%); internal jugular vein: humming 137%±27% (95% CI 119.4% to 148.2%), Valsalva 139%±24% (95% CI 122.4% to 148.7%), Trendelenburg 141%±35% (95% CI 116.5% to 156.5%); common femoral vein: humming 131%±15% (95% CI 120.4% to 139.1%), Valsalva 139%±18% (95% CI 127.9% to 150.4%), Trendelenburg 132%±24% (95% CI 113.3% to 142.9%).

Conclusion: All 3 maneuvers distended the external jugular, internal jugular, and common femoral veins compared to baseline. There was no important difference in magnitude of cross-sectional area between any of the 3 maneuvers when compared with one another. Humming shares many physiologic similarities to Valsalva's maneuver and may be more familiar and easier to perform during procedures such as ultrasonographically guided central venous catheter placement and insertion of external jugular intravenous catheters. [Ann Emerg Med. 2007;50:73-77.]

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Editor's Capsule Summary

What is already known on this topic

Trendelenburg's position and the Valsalva maneuver are often used to facilitate central vein cannulation.

What question this study addressed

To what extent do these techniques and a new technique—having the patient hum a tune—distend internal jugular, external jugular, and common femoral veins as measured by bedside ultrasonography in 7 healthy volunteers?

What this study adds to our knowledge

All 3 maneuvers equally distended these central veins compared to baseline.

How this might change clinical practice

If the findings of this small study are confirmed in patients, humming may become a preferred method for maximizing vein distention because it might be better tolerated than Trendelenburg's position and more easily explained and sustained than the Valsalva maneuver.

INTRODUCTION

Background and Importance

In the United States alone, it is estimated that at least 5 million external jugular vein and central venous catheters are placed each year in emergency departments (EDs), radiology and surgical suites, hospital wards, and ICUs.[1,2] When available, ultrasonographically guided catheter placement is considered safer than blind anatomically based techniques, especially in ICU and emergency settings.[3,4]

The Valsalva maneuver and Trendelenburg's position are common methods for producing venous distension for ultrasonographic identification and puncture of large central veins. Though both have been shown to be effective for producing increases in venous cross-sectional diameter,[5-7] both positions are not without disadvantages and potential complications. For example, many dyspneic patients are unable to tolerate Trendelenburg's position for sustained periods, and some patients have syncopal episodes from Valsalva or soil themselves.[8-10] According to the authors' experience, it is often difficult to explain how to perform a Valsalva maneuver[8,9] but relatively easy to coax a patient into humming even if physician and patient do not speak the same language.

A Valsalva maneuver is an attempted exhalation against a closed glottis or against a closed mouth and nose, as is experienced in coughing or straining during a bowel movement or lifting heavy weights. Antonio Maria Valsalva (1666 to 1723), the Italian anatomist, physician, and surgeon, first described the technique as a means of expressing pus from the middle ear.[11] Friedrich Trendelenburg (1844 to 1924) described positioning patients supine with head down and feet elevated between 30 degrees and 45 degrees during a variety of surgical procedures.[12] In World War I, Walter Cannon popularized Trendelenburg's position as a method of increasing venous return to the heart, though its value in this regard is now considered dubious.[13]

Understanding the mechanism of humming provides additional insight into its use as a forced expiration technique. During humming, the glottis opens and closes intermittently to help generate sound during the vocal-fold vibratory cycle. The increased intrathoracic pressure and forced expiration required by humming resemble those of Valsalva. According to the observation that opera singers' external jugular veins distend during held notes, one of us has frequently asked patients to take a breath and hum to distend external jugular veins for peripheral intravenous cannulation. Similarly, this method has been used for ultrasonographic visualization (but not cannulation) of central veins for several years by one of the authors (M.R.L.). Our systematic search of the National Library of Medicine (PubMed) did not reveal any reports of humming as a method for ultrasonographically guided visualization of veins commonly accessed for central venous catheterization. The purpose of this article is to demonstrate the feasibility of humming as a new maneuver to distend venous targets for central venous catheterization.

MATERIALS AND METHODS

Study Design, Setting, and Selection of Participants

This was a prospective trial performed on a convenience sample of healthy volunteers. Four male and 3 female volunteers, aged 28 to 67 years, were enrolled in the study. For each volunteer, right and left veins were studied using each maneuver, for a total of 10 vessels measured in each category (below).[14] Volunteers were emergency department personnel, and the Committee on Human Research agreed that verbal rather than signed consent was sufficient, given the education level of the volunteers. Bilateral internal, external jugular, or common femoral veins were measured in cross-section by ultrasonography during rest and in the following conditions: "loud" or "deep" humming, maximum Valsalva while supine, 30-degree Trendelenburg to measure external jugular and internal jugular veins, and 30-degree reverse Trendelenburg to measure the femoral veins.

Data Collection and Processing

The skin was marked and rotation angle of the head was fixed at 45 degrees to ensure reproducibility of probe placement. For all maneuvers, each vessel was measured 3 times in the transverse plane perpendicular to the vessel's longitudinal axis, with determination of the major (A) and minor (B) axis length to calculate the elliptical cross-sectional area (Figure 1). The probe when the measurement was made was placed in the same manner as if a central venous catheter were being placed (ie, the apex of the sternocleidomastoid triangle). High-resolution, real-time, 2-dimensional ultrasonography[14] with gray-scale imaging was performed for all measurements by using the Sonosite Titan with standard 7.5-MHz linear probe. Measurements were made with the electronic caliper function of

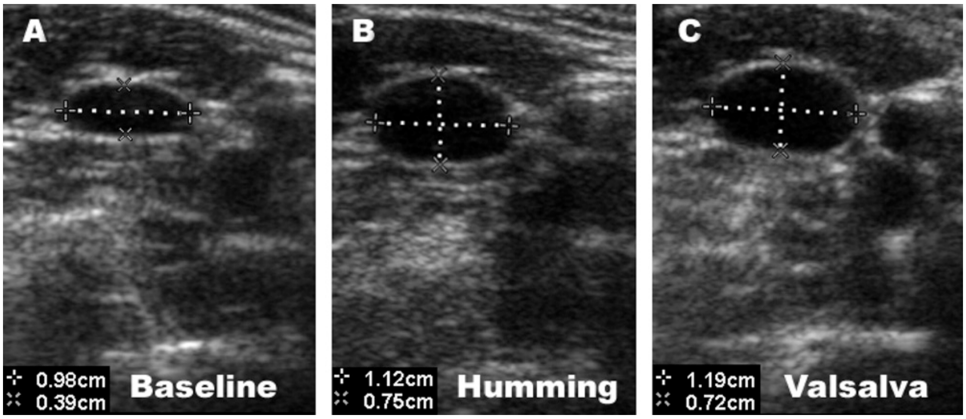

Figure 1. Changes in cross-sectional area as demonstrated by 2-dimensional ultrasonography during (A) rest, (B) loud humming, and (C) maximal Valsalva. Cross-sectional area was determined as a function of the major axes.

the Sonosite Titan and recorded on each image. The measurements were performed by 3 attending emergency physicians credentialed in ED bedside ultrasonography (one of 3 being fellowship trained: R.W.).

Primary Data Analysis

Mean cross-sectional area was calculated for each vessel (3 measurements for each maneuver) compared to the baseline in the resting supine position, with the head positioned as described above. The test response of each maneuver was expressed as the ratio of the average cross-sectional area evoked by each maneuver divided by the average baseline cross-sectional area for each vessel. Data were analyzed with 1-way ANOVA followed by 2-tailed Newman-Keuls tests (for all between-group comparisons) or Dunnett's tests (comparing each group to a single reference group). Comparisons of only 2 groups were made with *t* tests (2-tailed) on the raw data before normalization. The study was powered according to the prediction that vessels would distend more than 25% for Valsalva and Trendelenburg's position, as has been demonstrated in other studies.

RESULTS

Mean percentage change (±SD) relative to baseline cross-sectional area of the jugular vessels for each subject were as follows (Figure 2): external jugular vein: humming 134%±25% (95% confidence interval [CI] 124.9% to 146.9%), Valsalva 136%±23% (95% CI 121.3% to 147.5%), Trendelenburg 137%±32% (95% CI 120.7% to 156.9%); internal jugular vein: humming 137%±27% (95% CI 119.4% to 148.2%), Valsalva 139%±24% (95% CI 122.4% to 148.7%), Trendelenburg 141%±35% (95% CI 116.5% to 156.5%); common femoral vein: humming 131%±15% (95% CI 120.4% to 139.1%), Valsalva 139%±18% (95% CI 127.9% to 150.4%), Trendelenburg 132%±24% (95% CI 113.3% to 142.9%). All 3 maneuvers distended the external jugular, internal jugular, and common femoral veins compared to baseline ($P<.05$). There was no difference in magnitude of cross-sectional area between any of the 3 maneuvers when compared with one another.

LIMITATIONS

All volunteers were health care professionals, so we did not test comprehension, because of likely biases. Both Valsalva's maneuver and humming are effort dependent. However, our Valsalva and Trendelenburg data are consistent with previously published data,[5-7] and subjects were instructed to give their maximum effort during Valsalva's maneuver, our primary comparison of interest. Comparisons of central venous pressure were not made. We do not know the effect this maneuver might have with regard to protection or promotion from air emboli, a rare but serious complication of central venous catheter placement,[15] but awareness of the physiology of air embolism during venipuncture would be key to prevention when using this or any standard technique of central venous catheter placement.[16] Another limitation of this study is that only healthy volunteers were studied. Our results may not be valid for patients with poor cardiopulmonary reserve or vascular collapse. However, we have observed that the percentage of increase in central venous cross-section is greater in dehydrated patients (unpublished data), and one of us (M.R.L.) uses the technique regularly for external jugular venipuncture. Thus, our study probably underestimates the true increase in cross-sectional area for any of the 3 positions studied because all subjects in our study were normal and healthy adults. There are many readily testable hypotheses that can be generated from our report.

DISCUSSION

We describe a new but remarkably simple method of distending and visualizing external, internal jugular, and common femoral veins. During both maneuvers (humming and Valsalva), contraction of the thoracic cage and ascension of the diaphragm cause an increase in intrathoracic pressure and force the air out of the lungs. This increase in intrathoracic pressure leads to the

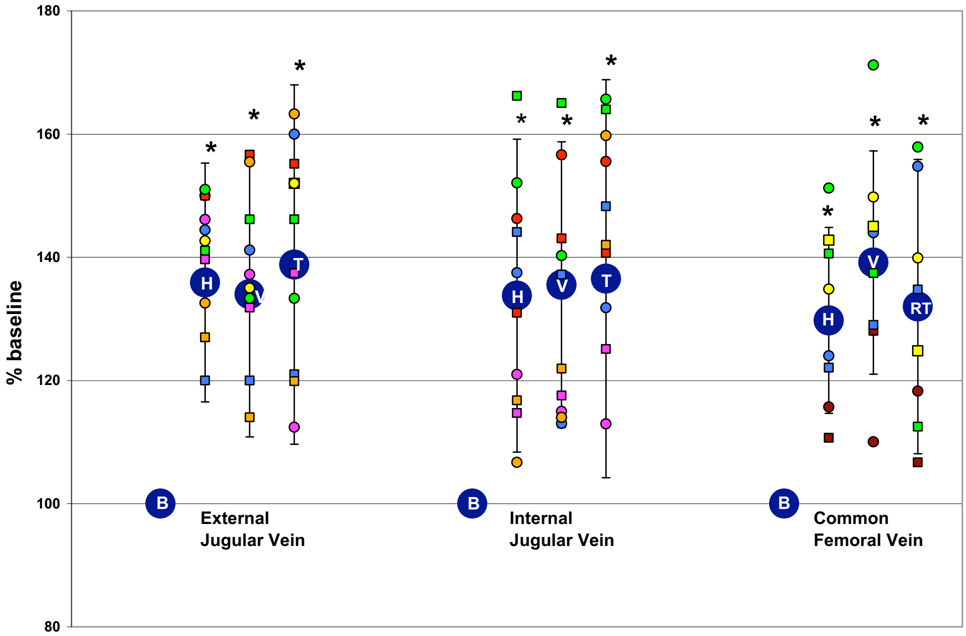

Figure 2. Humming is as effective as Valsalva's maneuver or Trendelenburg's position for increasing the cross-sectional area of the jugular and common femoral veins. N=10 External and internal jugular veins; N=8 common femoral veins. Data points for each of 7 volunteers are shown. Each colored square or circle represents the average of 3 measurements of the designated vessel and volunteer. Not every volunteer volunteered to have all 3 vessels measured. Large blue dots with error bars represent average percentage diameter increase from baseline and SD, respectively. *B,* Baseline (supine, resting); *H,* humming; *RT,* reverse Trendelenburg; *T,* Trendelenburg; *V,* maximal Valsalva. Neither humming nor Valsalva was tested in combination with Trendelenburg's positions.
* $P \leq 0.05$. Squares represent male subjects. Circles represent female subjects.

contraction of the lungs, cardiac chambers, and the superior and inferior vena cava and to an increase in central venous pressure. According to measured cross-sectional area, humming is as effective as Valsalva's maneuver and Trendelenburg's position for visualization of the jugular venous system and common femoral veins.

In conclusion, humming may be considered a new technique, among other time-honored, commonly used maneuvers and positions used to increase the cross-sectional diameter of the jugular venous system and femoral veins, to aid ultrasonographically guided central venous visualization. As a new technique, it is in need of further study before being used in common practice. Our anecdotal clinical experience is that the technique is much easier for patients to understand, and it is more comfortable to hum, especially if there is a language barrier or painful abdominal, pelvic, musculoskeletal, or motor neuron pathology (eg, Parkinson's disease) limiting the ability to perform Valsalva's maneuver. We note, without irony, that patients tend to hum with greater urgency when they feel pressure from the first needle and, thus, need little prompting to "hum louder."

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Author contributions: MRL was responsible for the study concept and article and study coordination. MRL, JS, RW, MML conducted data collection. JS conducted protocol development. RW and MK were responsible for methodology. MML conducted statistical analysis. MK conducted radiology. MB, I-HH, and REL were responsible for scholarship and the pilot study. MRL takes responsibility for the paper as a whole.

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Address for correspondence: Matthew R. Lewin, MD, PhD, University of California, San Francisco, Box 0208, 505 Parnassus Ave, San Francisco, CA 94143; 415-353-8309, fax 415-353-1799; E-mail aplysia99@yahoo.com.

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