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Brief Reports

NO EFFECT OF VALSALVA MANEUVER OR TRENDELENBURG ANGLE ON AXILLARY VEIN SIZE

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☐ Abstract—Background: A new technique for establishing ultrasound-guided central access involves the use of the axillary vein, the distal projection of the subclavian vein, via the lateral chest. Objective: To examine the effects of Valsalva maneuver and Trendelenburg positioning on axillary vein cross-sectional area (CSA). Methods: Using a group-sequential design, we enrolled stable emergency patients and measured their axillary veins sonographically. Patients were measured while supine, then after a Valsalva maneuver, and then at 5°, 10°, 15°, and 17° of Trendelenburg positioning, pausing 2 min after each change. We asked patients to score their discomfort from 0 to 10 in each position. Results: We enrolled 30 adult patients with a median age of 39 years (range, 20–66 years). Treating physicians considered 11 of these patients to have hypovolemia. The Valsalva maneuver decreased CSA (Mean difference = −0.03 cm^2), (95% confidence interval [CI] −0.10–0.04). Trendelenburg positioning did not statistically increase CSA. The 5° position caused the largest increase, that is, 0.04 cm^2 (95% CI −0.04–0.12) in the entire group and 0.1 cm^2 (95% CI −0.07–0.28) in the hypovolemic subgroup. At greater degrees of Trendelenburg positioning, patients reported higher discomfort scores or simply dropped out. Conclusion: The Valsalva maneuver and Trendelenburg angles above 10° do not increase axillary vein area but do increase patient discomfort. Our data suggest optimal positioning in the supine resting position or at a 5° Trendelenburg position. © 2013 Elsevier Inc.

☐ Keywords—catheterization; central venous; ultrasonography; interventional; axillary vein; head-down tilt; Valsalva maneuver

INTRODUCTION

Ultrasound guidance via the internal jugular vein has been shown to require fewer attempts and less time than landmark-based access to the subclavian vein (1). However, the internal jugular approach is uncomfortable for some patients and might be associated with a higher infection rate than the subclavian approach (2). Recently, some investigators described a novel approach to central access via the axillary vein, which feeds into the subclavian vein but can be imaged using ultrasound transpectorally (3). Ultrasound-guided infraclavicular access to the subclavian vein has been more frequently successful than landmark-guided access (4).

Because the success rate for central venous line placement should correlate with the cross-sectional area (CSA) of the vein, physicians perform maneuvers, or ask their patients to do so, to increase venous filling to optimize the likelihood of success. Trendelenburg positioning and the Valsalva maneuver increase internal jugular vein CSA significantly and thus increase the chance of successful cannulation (5). No similar studies for the

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axillary vein have been reported. The purpose of this study was to estimate the effects of Trendelenburg positioning and the Valsalva maneuver on the CSA of the right axillary vein, as assessed by ultrasound.

METHODS

Study Design

In this cross-sectional study, we used ultrasound to measure axillary vein dimensions in stable emergency patients while they performed the Valsalva maneuver and in various degrees of Trendelenburg positioning. This study was approved by the medical center's Institutional Review Board, including the obtaining of verbal consent.

Setting and Participants

This study was performed in an urban tertiary care hospital. We included a convenience sample of adult patients who were able to provide verbal informed consent, excluding those with any of the following: hemodynamic instability; central venous catheterization; upper-extremity arteriovenous shunt or fistula; a history of chest wall, clavicular, or upper-extremity trauma, surgery, or deformity; or a history of upper-extremity deep venous thrombosis.

Data Collection

After consent was obtained, orthostatic blood pressures and heart rates were measured in supine and standing positions, separated by a 1-min interval. We asked the treating physician whether the patient was normovolemic or hypovolemic. Treating physicians were not routinely shown the study orthostatic vital signs. Subjects were then placed in a supine position, with the right shoulder abducted at 90° and the hand lying next to the patient's head. An ultrasound image of the cross section of the right axillary vein was obtained using a two-dimensional 7.5-MHz linear transducer with a 45 × 9 mm footprint, aligned in the short-axis, about 2 cm lateral to the mid-clavicular point. This location was chosen because it has less axillary artery overlap than points more medial, as well as a more shallow vein depth than points more lateral (6). This image was obtained at the same location while the patient underwent six changes: supine, supine with Valsalva maneuver, 5° Trendelenburg, 10° Trendelenburg, 15° Trendelenburg, and 17° Trendelenburg (the maximum incline the bed would allow). The degree of Trendelenburg positioning was determined by using an inclinometer. A pause of 2 min was taken before each measurement to allow blood redistribution. The same investigator obtained all six ultrasound images for a given patient. At each position, the patient was asked to rate discomfort, using a 0–10 scale, with 0 representing complete comfort and 10 the most discomfort. Patients could stop the study at any point in response to discomfort.

Data Analysis

All static images of the axillary vein were measured for horizontal and vertical diameters by two investigators blinded to the patient and degree of Trendelenburg positioning. We used the diameters to calculate the CSA using the geometric formula for oval area ($\text{diameter}_1 * \text{diameter}_2 * \prod/4$).

For each patient's measurements, we calculated a mean difference in CSA for each position, comparing the Valsalva maneuver and 5° Trendelenburg with the supine resting position (0° Trendelenburg) and then comparing each increment of increasing Trendelenburg angle with the previous angle: 10° vs. 5°, 15° vs. 10°, and 17° vs. 15°. We examined the distribution of mean differences at each position for normality and evaluated the biasing effects of extreme values. Seeing good approximation to normality and minimal effects of extreme values, we used parametric methods for comparisons. We calculated confidence intervals for mean differences using the *t*-distribution. We calculated mean differences in subgroups defined as hypovolemic or euvolemic as determined by physician assessment. We also analyzed data in groups defined by the ratio of orthostatic vital signs (ROSI) according to the following criteria: negative, ROSI < 1, which has 98% to 99% sensitivity to detect a 450-mL acute blood loss; indeterminate, ROSI 1–1.6; and positive, ROSI > 1.6, which exceeds the 95th percentile in euvolemic individuals (7,8). We characterized hypovolemia by both physician assessment and orthostatic vital signs because a research standard for hypovolemia does not exist. We chose physician assessment because a variety of findings of hypovolemia, including dry mucous membranes or poor skin turgor, are best assessed by physician observation and depend on physician skill and experience, and we chose orthostatic vital signs because they are not dependent on physician skill or experience and are therefore generalizable to other settings (9).

To describe discomfort levels for the various positions, we combined scores according to the following scheme: low, 0–3; medium, 4–7; high, 8–10. We constructed a histogram to display these data.

Our sample size was based on pilot data to estimate standard deviation (SD). Given an SD of 0.14, with a desired effect size of 0.1 and power of 0.9 and the definition of significance at 0.05, our study required a minimum of 23 patients. We increased our sample size to 30 to allow for potential drop-outs and the possible need for non-parametric methods.