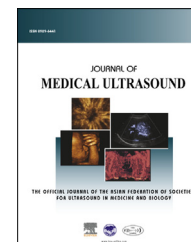


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## ORIGINAL ARTICLE

# The Imprecision of Sonographic Assessment of Jugular Venous Distension Among Novice Operators

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venous distension

**Objective:** To assess the precision of sonographic assessment of jugular venous distension (US-JVD).

**Methods:** Sixteen emergency physicians underwent a short training in US-JVD comparable to a previously described training module. Then, they each performed US-JVD on three healthy individuals: Participant 1 with a “long, thin neck,” Participant 2 with a “normal neck,” and Participant 3 with a “short, thick neck.” The criterion standard for US-JVD was the measurements by an expert sonographer who had previously performed 100 US-JVD exams.

**Results:** There were a total of 48 US-JVD measurements. Twenty-five measurements were within 1 cmH<sub>2</sub>O of the criterion standard (52%). Ten out of 16 operators were within 1 cmH<sub>2</sub>O for Participant 1, as opposed to six of out 16 and nine of out 16 for Participants 2 and 3, respectively. The range of values was largest for Participant 2 (4–11 cmH<sub>2</sub>O) and smallest for Participant 3 (6–10 cmH<sub>2</sub>O). Five measurements (10%) were wrong, indicating abnormally low measurements consistent with hypovolemia.

**Conclusion:** Physicians were the most precise while performing US-JVD on the participant with a “short, thick neck,” and the least precise in the participant with a “normal neck.” Ten percent of the measurements misidentified these healthy participants as having hypovolemia. © 2013, Elsevier Taiwan LLC and the Chinese Taipei Society of Ultrasound in Medicine.

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## Introduction

The sonographic assessment of jugular venous distension (US-JVD) can assess JVD with a predictive value for

pulmonary oedema and cardiac dysfunction [1–6], but may be imprecise when used by novice operators. The purpose of this study is to assess the precision of US-JVD performed by physicians with limited training.

## Methods

### Study design

This was an Institutional Review Board (IRB)-approved prospective, cohort study in September 2005 of US-JVD performed on similar individuals under identical situations to assess technique precision.

### Study setting

The study was conducted in an urban, academic emergency department (ED) with 75,000 annual adult visits.

### Selection of participants

Sixteen physicians without experience in US-JVD (Table 1) completed a lecture demonstration of US-JVD comparable to a previously described training module [4] prior to participation. Three healthy “participants” of varying builds were selected (Table 2) rather than actual patients because of concerns by the IRB that technique precision had not been previously established.

### Protocol

Each physician performed US-JVD on each participant in a randomly assigned order to avoid a “learning effect bias.” Results were recorded on standardized data sheets blinded to other physicians. The participating healthy individuals

**Table 1** Characteristics of physician-sonographers.

Physician	No. of prior exams <sup>a</sup>	PGY
1	55	2
2	60	3
3	20	1
4	24	2
5	15	1
6	20	2
7	35	3
8	56	4
9	5	1
10	100	4
11	90	4
12	30	2
13	43	2
14	110	3
15	78	3
16	89	4

PGY = post-graduate year.

<sup>a</sup> Number of prior exams determined by program training log.

**Table 2** Characteristics of volunteer participants.

Participants	Neck length (cm)	Neck circumference (cm)	BMI
1, “Long, thin neck”	16.5	27	20.3
2, “Normal neck”	12.5	35	26.6
3, “Short, thick neck”	10	40	32.9

BMI = body mass index.

were not allowed to drink or use the toilet for approximately 2 hours while the study was being conducted.

### Study measurements

US-JVD was done with a linear array probe as described previously [1–7]. Once the internal jugular vein (IJ) meniscus was localized, the vertical height of the meniscus was measured from the sternal notch with 5 cm added for a measurement of JVD in cmH<sub>2</sub>O (Fig. 1).

### Criterion standard

The criterion standard for US-measured JVD was the measurement of JVD obtained by a physician who previously completed an emergency ultrasound fellowship and over 100 prior US-JVD exams.

### Data analysis

Data were collected in an Excel database (Microsoft Excel, Microsoft Corporation, Redmond, WA, USA) and analyzed using SAS version 9.1 (SAS Institute, Cary, NC, USA).

## Results

Participant 1 with a “long, thin neck” had a JVD of 8 cmH<sub>2</sub>O by the criterion standard. The mean estimate by the physicians was 8.5 cmH<sub>2</sub>O (95% confidence interval (CI), 7.7–9.3) with a median of 8 [interquartile range (IQR): 7.8–9.3, range: 6–12.5]. Ten of the 16 operators (62.5%) obtained measurements within 1 cm of the criterion.

Participant 2 with a “normal neck” had a JVD of 7.5 cmH<sub>2</sub>O by the criterion standard. The mean estimate by the physicians was 8.1 cmH<sub>2</sub>O (95% CI, 7.1–9.1) with a median of 8.5 (IQR: 7.5–9.0, range: 4–11). Six of the 16 operators (37.5%) obtained measurements within 1 cm of the criterion.

Participant 3 with a “short, thick neck” had a JVD of 7 cmH<sub>2</sub>O by the criterion standard. The mean estimate by the physicians was 8.1 cmH<sub>2</sub>O (95% CI, 7.6–8.6) with a median of 8 (IQR: 7.5–8.5, range: 6–10). Nine of the 16 operators (56.3%) obtained measurements within 1 cm of the criterion.

Five measurements (10%) were ≤6 cmH<sub>2</sub>O, erroneously indicating low jugular venous pressure and hypovolemia in these healthy participants. Three of these errors occurred in Participant 2 with the normal neck, and 1 of these errors occurred in both Participants 1 and 3. These errors were

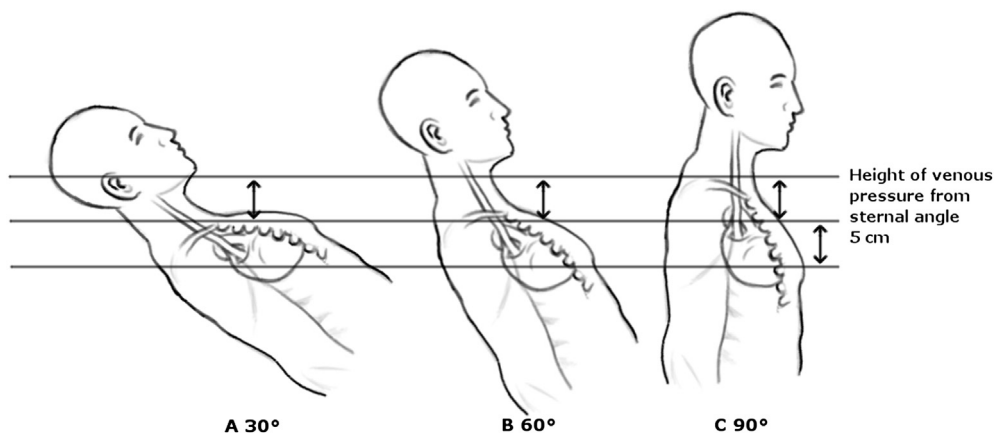


Fig. 1 Measurement of JVD and changes in position.

obtained by five separate operators (31% of our physician sample).

## Limitations

There were limitations to this study. First, it is unknown if US-JVD ranges differ between normal patients and those with renal or cardiac disease as chronic hypervolemia may occur at baseline in those patients. This should be assessed in future studies. Likewise, we assessed precision, which requires repeated measures on identical participants under identical circumstances, rather than inter-rater reliability, which may be more clinically relevant and is assessed by two measures per participant in patients under varying circumstances. This should be prospectively studied in patients being actively treated in the ED. Third, although our operators received training comparable to a previously described training module [4], we do not know how much training is required to develop competency in US-JVD. It is assumed that precision may improve with increased experience. This aspect needs to be studied further.

## Discussion

We expected US-JVD to be least precise in the participant with a “short, thick neck” because of presumed deeper vessels and more overlying tissue, but the physicians in our study were most precise in this participant as evidenced by the range of values obtained. It may be that more overlying tissue makes the vessel less prone to collapse from the weight of the probe.

Prior work used a “positive” value of US-JVD  $> 8$  cmH<sub>2</sub>O [4–6] to suggest pathology such as fluid overload, because one study suggested a normal range of 6–7 cmH<sub>2</sub>O [7], but this may not be the optimal cut off as the mean for each of our healthy participants was  $>8$  cmH<sub>2</sub>O. Given the range of measurements for each participant, our data suggest that determinations of JVD solely based on quantitative US-JVD measurements may not be prudent. One prior study demonstrated greater inter-rater reliability using qualitative assessment rather than quantitative measurements

with US-JVD (7). This should be studied further. If US-JVD overestimates JVD, it would still have good negative predictive value for pathology associated with elevated JVD (e.g., pulmonary edema and cardiac dysfunction), but could lead to inappropriate diuresis if clinicians are not careful.

By contrast, if US-JVD underestimates JVD, it would have good positive predictive value for elevated JVD, but could lead to inappropriate fluid administration in patients without volume overload. Thirty-one percent of the physicians misidentified at least one participant as having low jugular venous pressure, suggesting that a significant number of physicians might have difficulty in accurately performing US-JVD.

In conclusion, physicians were the most precise when performing US-JVD on the participant with a “short, thick neck,” and the least precise in the participant with a “normal neck.” Ten percent of measurements misidentified these healthy patients as having hypovolemia.

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