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The Accuracy of IJV/CCA CSA Ratio Measurement for Assessing Volume Status and CVP: A Systematic Review

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Abstract

Introduction: Intravenous fluid administration is commonly used in healthcare settings. Yet, there is no gold standard for evaluating the efficacy of fluid therapy. Ultrasound can assess the volume statically and dynamically. One proposed static method involves comparing the cross-sectional diameter of the internal jugular vein to that of the common carotid artery, allowing for normalization of the internal jugular size relative to the common carotid artery size. Here, we planned to assess the value of this method for evaluating volume status. **Method:** This systematic review followed PRISMA guidelines to examine the value of the internal jugular vein to common carotid artery cross-sectional ratio for assessing volume status. An extensive search was conducted in July 2025 across PubMed, Web of Science, Scopus, and Embase, with additional manual searches of Google Scholar and gray literature. The PICO framework was used to define inclusion criteria for original research studies that directly assessed the diagnostic accuracy of this ratio against a reference standard. Two independent reviewers extracted data and assessed study quality using the QUADAS-2 tool. Due to the limited number of studies, a planned meta-analysis was replaced by a narrative report of the results. **Results:** Five studies with a total of 183 patients were assessed. The mean age of participants ranged from 7 to 58.86 years. Most studies used CVP as the reference test. Two works reported a correlation between the IJV/CCA CSA ratio and CVP, with cutoff values of 2, while one study suggested a cutoff of 1.66. Another investigation proposed a cutoff of 1.8 when the patient was in a 45-degree position, and one study recommended varying cutoffs based on different physiological conditions influenced by respiratory status. **Conclusion:** The IJV/CCA CSA ratio demonstrates potential utility in assessing central venous pressure, with an estimated cutoff value near 2. However, the applicability of these findings is constrained by limited study sizes and considerable variability in both populations and research protocols.

Keywords: Internal Jugular Vein, Common Carotid Artery, Volume Status Assessment, Central Venous Pressure, Volume Responsiveness

1. Introduction

Intravenous (IV) fluid administration is one of the most common procedures performed in the healthcare setting. While it can be considered a lifesaving intervention, it could pose harm to the patient if it is inadequate or infused in large amounts (Guest et al., 2020). Experts state that IV fluid therapy should be performed based on the

indications and contraindications, and the exact amount of fluid and the type of fluid should be determined precisely (Hilton et al., 2008), therefore, it is necessary to have measurements to assess the adequacy of IV fluid. There is no gold standard for evaluating the efficacy of fluid therapy. Most of the time, it is determined by using various factors: the patient's signs and symptoms, laboratory findings, and some measurements (Nasa et al., 2022). These measures include invasive and non-invasive methods. Commonly invasive techniques are central venous pressure (CVP) determination and pulmonary capillary wedge pressure (PCWP) checked by central venous catheterization. However, they have been shown to be unreliable and have serious complications (Zampieri et al., 2023). Ultrasound examinations are accepted non-invasive methods that can evaluate the heart or vessels statically or dynamically. Fluid status can be measured statically by assessing the diameter of the central veins, heart ventricular size, or function, which measure a single point-in-time value (Millington et al., 2021). Dynamic sonographic assessments involve observing changes in certain parameters in response to a physiological maneuver or a fluid challenge, such as the venous collapsibility index, venous distensibility index, left ventricle outflow tract (LVOT) velocity-time integral (VTI), respiratory variation in VTI, carotid artery flow time, and changes in carotid doppler peak velocity (Evans et al., 2014). Among static sonographic tools, determination of the internal jugular vein (IJV) to common carotid artery (CCA) cross-sectional area (CSA) is one of the suggested methods, which by normalizing the IJV size to the CCA size, may help to account for individual patient anatomy and other confounding factors (Bailey et al., 2012). Various reviews and meta-analyses examined the accuracy of different invasive and non-invasive methods of volume responsiveness (Fatahi et al., 2025, Wang et al., 2022, Orso et al., 2020, Eskesen et al., 2016). Since there was no systematic review evaluating the accuracy of the IJV/CCA CSA ratio, we decided to examine the validity of this non-invasive method for assessing volume status.

2. Methodology

The study protocol was recorded in the International Prospective Register of Systematic Reviews (PROSPERO) with the registration number CRD20251118053. The research followed the PRISMA guidelines set by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Page et al., 2021).

2.1. Literature Search and Search Strategy

An extensive investigation was performed across the PubMed, Web of Science, Scopus, and Embase databases in July 2025. In addition, a comprehensive manual search was conducted utilizing Google Scholar alongside an exploration of gray literature sources. The objective was to identify studies assessing the accuracy of sonographic assessment of the IJV/CCA CSA ratio in predicting CVP. The search utilized MeSH terms, synonyms, and related keywords for IJV, CCA, and volume status. The full search strategy on different databases is provided in Table 1. Two independent reviewers examined and evaluated all identified articles to determine their eligibility.

Table 1: Search strategy on different databases

Search strategy on different datasets
PubMed: (Internal jugular vein*[tiab] AND common carotid artery*[tiab] AND ("central venous pressure"[mesh] OR Central venous pressure[tiab] OR Volume status[tiab] OR Volume responsiveness[tiab] OR CVP[tiab] OR Fluid therap*[tiab] OR Intravenous fluid*[tiab])
Embase: (‘internal jugular vein*’:ti,ab) AND (‘common carotid artery*’:ti,ab) AND (‘Central venous pressure’/exp OR ‘Fluid therapy’/exp OR ‘Fluid resuscitation’/exp OR ‘Volume status’:ti,ab OR ‘Volume responsiveness’:ti,ab OR ‘CVP’:ti,ab OR ‘Central vein pressure’:ti,ab ‘Central venous pressure’:ti,ab OR ‘Blood volume’:ti,ab OR ‘Fluid resuscitation’:ti,ab)
Web of Science: (TS= ("internal jugular vein*")) AND (TS= (common carotid artery*)) AND (TS= ("CVP" OR "Fluid therapy" OR "Fluid resuscitation" OR "Volume status" OR "Volume responsiveness" OR "CVP" OR "Central vein pressure" OR "Central venous pressure" OR "Blood volume" OR "Fluid resuscitation" OR "fluid therap*" OR "Intravenous fluid*"))

Scopus:

(TITLE-ABS (“internal jugular vein*”) AND (TITLE-ABS (“common carotid artery*”) AND (TITLE-ABS (“CVP” OR “Fluid therapy” OR “Fluid resuscitation” OR “Volume status” OR “Volume responsiveness” OR “CVP” OR “Central vein pressure” OR “Central venous pressure” OR “Blood volume” OR “Fluid resuscitation” OR “fluid therap*” OR “Intravenous fluid*”)))

2.2. Study Selection

We employed the PICO framework to assess the population, intervention, comparison, and outcome as a guided structure to clearly define eligibility criteria (Table 2).

Table 2: PICO framework for inclusion criteria

Component	Description
Population	Patients in various clinical settings who were assessed for volume status
Intervention	Ultrasound measurement of the internal jugular vein to the common carotid artery cross-sectional area ratio
Comparison	A validated standard for determining volume status
Outcome	Diagnostic accuracy of the method

Original research studies that directly assessed the diagnostic accuracy of the IJV/CCA CSA ratio and were designed to evaluate the ratio against a reference standard for volume status were included. The studies that did not assess the diagnostic accuracy of the IJV/CCA CSA ratio, those that did not calculate the ratio, or did not provide sufficient data were excluded. The detailed inclusion and exclusion criteria are summarized in Table 3.

Table 3: Inclusion and exclusion criteria for the study

Classification	Category	Specific criteria
Inclusion	Study design	Original research studies that directly assessed the diagnostic accuracy of the IJV/CCA CSA ratio against a reference standard for volume status.
	Population type	Individuals for whom volume status assessment is clinically relevant and conducted in a relevant clinical setting.
	Intervention	Ultrasound measures of the IJV and CCA CSA.
	Data reporting	Reported enough data and a clearly defined reference standard for assessing volume status.
	Language	No restriction on the language of the study.
Exclusion	Publication type	Editorials, letters, case reports, review articles, meta-analyses, and conference abstracts.
	Intervention	Studies that did not assess the diagnostic accuracy of the IJV/CCA CSA ratio.
	Reference standard	Studies that did not use a validated reference to define volume status.
	Data reporting	Studies that did not provide sufficient data for the outcome.

IJV: Internal jugular vein, CCA: Common carotid artery, CSA: Cross-sectional area

2.3. Data Extraction

Two reviewers were tasked with extracting data independently, with a clear focus on enhancing the quality of our work. The extracted data included baseline, IJV/CCA CSA ratio cut-off, sensitivity and specificity with 95% CI,

true positive (TP), true negative (TN), false positive (FP), false negative (FN), positive predictive value (PPV), negative predictive value (NPV), and the reference standard for volume assessment. Regarding the articles with insufficient data, emailing the authors was planned.

2.4. Quality Assessment

QUADAS-2 tool (Quality Assessment of Diagnostic Accuracy Studies) was used for examining the quality of studies. Any discrepancies in assessments were resolved through mutual agreement. Each criterion (patient selection, index test, reference standard, flow, and timing) was evaluated for risk of bias, categorized as high, unclear, or low (Schueler et al., 2012).

2.5. Data Analysis

A quantitative meta-analysis was initially planned to calculate the sensitivity and specificity. However, due to the limited number of studies, we decided to report the results narratively.

3. Results

3.1. Study selection

The search yielded a total of 60 records from various databases: PubMed (11), Embase (20), Web of Science (14), and Scopus (15). After removing 21 duplicates, 39 studies remained, which were then screened based on their titles and abstracts. During this screening process, 26 records were excluded, leaving 13 studies. Additionally, 8 studies were found manually through a Google search, resulting in a total of 21 studies selected for full-text screening. This process ultimately identified 5 studies, as illustrated in the PRISMA flow diagram in Figure 1.

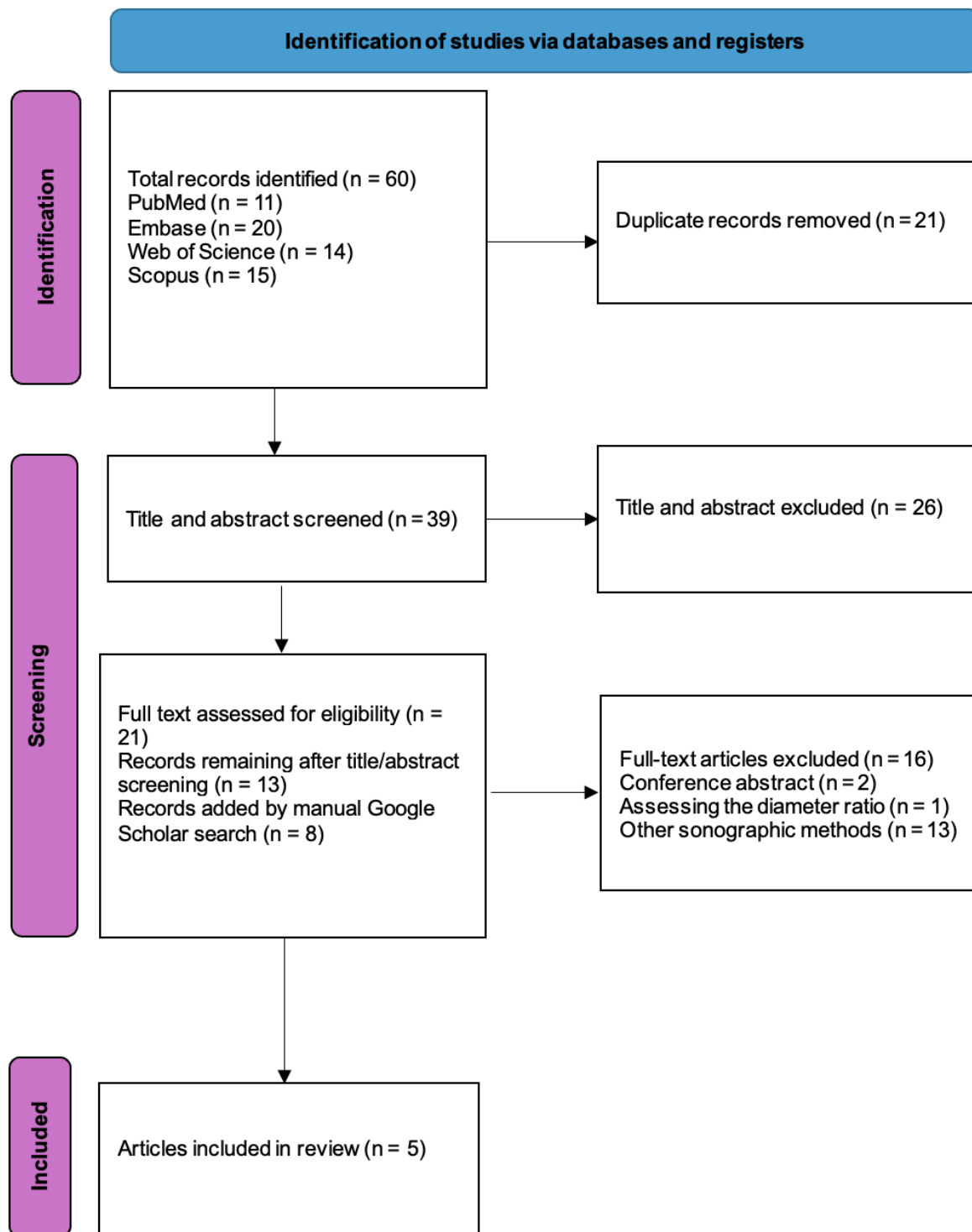


Figure 1: PRISMA flow diagram for the included articles

3.2. Study characteristics

Five studies involving 183 patients were evaluated in the included articles. The mean age of participants was between 7 to 58.86 years. Most studies considered the CVP as a reference test for assessing volume status. The characteristics of the included articles are provided in Table 4.

Table 4: Cardinal characteristics of studies

Author	Country	Study design	Number	Mean age	Setting	IJV/CCA CSA cutoff	Reference test and cutoff	Main findings
Kasem et al., 2021	Egypt	prospective	35	42.23 ± 9.27	Ill patients, spontaneous breathing	NS	CVP= 8-12	The IJV/CCA CSA ratio can be used for the evaluation of intravascular volume status.
Min et al., 2019	China	Cross-sectional	50	NS	Ill patients	1.66	CO= 15%	The IJV/ CCA CSA ratio is a reliable method to evaluate the volume responsiveness in critical patients.
Azapoglu et al., 2017	Turkey	Prospective	40	NS	ICU patients, mechanically ventilated	< 1.8	CVP< 10	The IJV/CCA CSA ratio at a 45-degree position was significantly correlated with a low CVP.
Hossein Nejad et al., 2016	Iran	Prospective	52	58.86 ±10.7	Ill patients, spontaneous breathing	2	CVP= 10	A cutoff of 2cm for IJV/CCA CSA ratio has the highest sensitivity and specificity for CVP.
Bailey et al., 2012	USA	Cross-sectional	6	7± 3.5	Children with thermal injury, mechanically ventilated	2	CVP= 8	The cross-sectional area of the vein at least twice that of the artery, may suggest the CVP> 8 mmHg.

CVP: Central venous pressure, CO: Cardiac output, IJV/CCA CSA: Internal jugular vein to common carotid artery cross-sectional area

3.3. Risk of bias assessment

In the patient selection area, two studies showed a significant risk of bias, while three others had an uncertain risk of bias. The risk of bias in other areas was low. Concerning applicability, in the patient selection domain, two articles indicated a high risk, one article showed a low risk, and two articles had unclear risk assessments (Figures 2, 3).

	Risk of bias				Applicability		
Study	Patient selection	Index test	Reference standard	Flow & timing	Patient selection	Index test	Reference standard
Kasem et al., 2021	?						
Min et al., 2019							
Azapoglu et al., 2017							
Hossein Nejad et al., 2016	?				?		

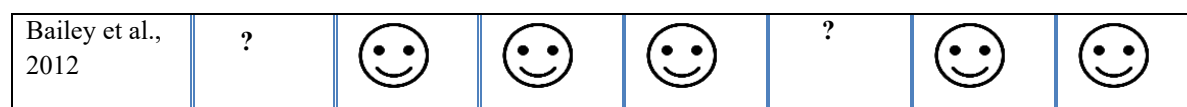


Figure 2: Risk of bias assessment based on the QUADAS-2 tool

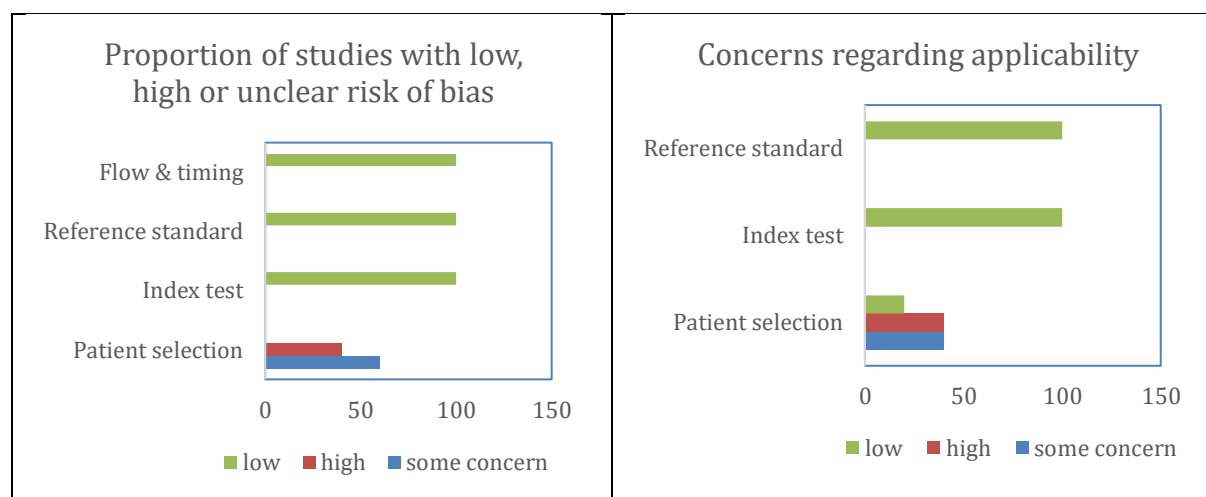


Figure 3: Risk of bias assessment

3.4. Narrative analysis

In 2012, Bailey et al. conducted a pilot study to investigate the relationship between the diameter and cross-sectional area ratio of the IJV and CCA, and its correlation with CVP. Their study found a poor relationship between the diameter ratio and the CVP. A notable connection was identified between the ratio of the cross-sectional area (CSA) and central venous pressure (CVP). Specifically, a ratio of 2 or higher showed a significant association with a CVP of 8 mm Hg or more ($P < 0.001$) (Bailey et al., 2012). Subsequently, a study by Hossein-Nejad et al. (2016) involved 52 participants. Their results indicated that the average IJV/CCA CSA ratio was 1.89 ± 0.83 during inhalation and 1.90 ± 0.83 during exhalation. A significant relationship was found between the IJV/CCA CSA ratio and CVP for both inhalation and exhalation, with optimal accuracy noted at a cutoff ratio of 2. They stated the correlation is not statistically affected by respiration. In their research on patients receiving mechanical ventilation, Azapoglu et al. (2017) found no significant differences between the IJV/CCA ratio and different CVP values when patients were in supine position. However, in the 45° position, a notable correlation was observed between a lower CVP and the ratio.

Min et al. (2020) examined how accurately this ratio can assess volume responsiveness, using a reference of at least a 15% increase in cardiac output (CO) to define volume status. Their findings indicated a negative correlation between the ratio of the IJV to CCA cross-sectional area and the change in ΔCO value, with a significance level of $P < 0.01$. Finally, Kasem et al. (2021) examined various cutoffs for the ratio of inspiration to expiration. Additionally, they reported a strong positive correlation of this ratio and the maximum diameter of the IVC before and after fluid infusion ($r = 0.923$, $P < 0.001$, and $r = 0.390$, $P = 0.021$, respectively). The main results of the included studies are provided in Table 5.

Table 5: Summarized results of the included articles

Study	Narrative analysis
Kasem et al., 2021	The IJV/CCA CSA ratio cutoff of 2.58 had a sensitivity and specificity of 65.2% and 75% for CVP=8-12 after fluid administration during inspiration. The ratio of 2.65 showed 52.2% sensitivity and 67% specificity during expiration. They also discovered a positive link between the inspiratory IJV/CCA CSA ratio and the minimum diameter of the inferior vena cava, both before and following fluid infusion, with correlations of $r = 0.605$ ($P < 0.001$) and $r = 0.496$ ($P = 0.002$), respectively.

Min et al., 2019	At the IJV/CCA CSA ratio of 1.66, the sensitivity, specificity, and the areas under the ROC curve were 87. 1%, 79. 6%, and 0.836(95%CI:0.710-0.952) for identifying volume responsiveness with a negative correlation between the ratio and the Δ CO value after PLR.
Azapoglu et al., 2017	A significant correlation in 45-degree position was documented between IJV/CCA CSA ratio less than 1.8 and CVP< 10mm Hg.
Hossein Nejad et al., 2016	There was a significant correlation between the IJV/CCA ratio and CVP during both inspiration ($r=0.728$, $p<0.0001$) and expiration ($r=0.736$, $p<0.0001$). Sensitivity, specificity, PPV, and NPV were 90%, 86.36%, 90%, and 86.36% for the prediction of CVP <10cm H ₂ O.
Bailey et al., 2012	A pilot study assessing the relationship of the IJV/CCA CSA ratio to the CVP, suggesting that a ratio of at least 2 states the CVP higher than 8 ($p< 0.001$).

CVP: Central venous pressure, CO: Cardiac output, IJV/CCA CSA: Internal jugular vein to common carotid artery cross-sectional area, PPV: Positive predictive value, NPV: Negative predictive value, PRL: Passive leg raising

4. Discussion

There have been limited studies exploring the connection between ultrasound measurements of the IJV/CCA cross-sectional area ratio and CVP. In this systematic review, two studies reported a correlation between the IJV/CCA CSA ratio and CVP (Hossen-Nejad et al., 2016, Bailey et al., 2012), whereas Azapoğlu Kaymak et al., 2017 found significance only in the 45-degree position. Kasem et al., 2017 evaluated different CSA ratio cutoffs at expiration and inspiration and described a positive correlation between the ratio and the IVC maximum diameter before and after fluid infusion.

The relationship between the IJV/CCA CSA ratio and CVP may not reliably translate into predicting fluid responsiveness. Meta-analytic data in related domains have shown a relatively weak relationship between static venous indices and the hemodynamic gains after fluid challenges (Eskesen et al., 2016, Marik et al., 2013). Consistent with this, Min et al. reported a negative correlation between the IJV/CCA CSA ratio and Δ CO following fluid administration, arguing against a simple linear relationship between the CSA ratio and volume responsiveness (Min et al., 2020).

Bano et al. (2018) found a notable relationship between the ratio of the IJV to CCA diameters and central venous pressure, specifically during the expiration phase. Their research indicated that the average IJV/CCA diameter ratio was 1.60 ± 0.55 at expiration compared to 1.41 ± 0.56 at inspiration. They observed a significant correlation between this diameter ratio and CVP at expiration ($r = 0.401$, $P = 0.004$). This correlation was also significant in patients who were not mechanically ventilated ($r = 0.439$, $P = 0.032$).

A notable strength of the current evidence is the demonstration of a statistically significant association between the IJV/CCA CSA ratio and CVP in some cohorts, with a frequently observed cutoff near a ratio of 2 associated with higher CVP. However, substantial heterogeneity across studies (regarding populations, imaging protocols, and measurement planes) constitutes a major limitation to generalizability. The IJV ultrasound assessment has shown a value in estimating CVP (Parenti et al., 2018); however, IJV diameter is affected by respiratory phase (Danahue et al., 2009), and by mechanical ventilation setting, particularly the level of end expiratory pressure (An et al., 2019). Overall, while CSA-based metrics may offer a more consistent reflection of venous filling status than diameter-based measures, their utility for predicting fluid responsiveness remains uncertain. The findings across studies are not uniformly concordant, and this limits their immediate clinical applicability. Standardized measurement techniques, breath-hold or respiratory phase, reporting both inspiration and expiration values, distinguishing spontaneous breathing from mechanically ventilated patients, and documenting patient positioning are necessary steps for conducting studies to evaluate this method. Additionally, the indices should be linked to a meaningful output such as Δ CO over CVP, with recognizing the limitations of each reference since introduction implies they could be unreliable. Finally, larger prospective studies are needed to validate a cutoff across diverse populations and settings to clarify its implications for predicting volume status.

5. Conclusion

The results indicate that the IJV/CCA CSA ratio may offer a more consistent association with CVP than diameter ratios, with a suggested approximate cutoff near 2 in several datasets. However, these associations are influenced by respiratory status, patient positioning, and ventilation mode; furthermore, the relationship with fluid responsiveness is not universally robust and remains unclear.

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Declaration of Generative AI and AI-assisted Technologies: This study has not used any generative AI tools or technologies in the preparation of this manuscript.

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