COMPARATIVE ANALYSIS OF POINT-OF-CARE ULTRASOUND AND CONVENTIONAL CLINICAL ASSESSMENT FOR VOLUME STATUS EVALUATION IN NEWLY ADMITTED HOSPITAL PATIENTS

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Abstract

Background: Accurate volume status assessment is essential for managing newly admitted hospital patients. However conventional clinical methods have known limitations. Point-of-care ultrasound (POCUS) offers a rapid bedside alternative. This study compares the diagnostic performance of POCUS using inferior vena cava (IVC) assessment against standard clinical evaluation.

Methods: We conducted a prospective comparative study at the National Heart Institute with 150 newly admitted adults. Each patient underwent both a POCUS IVC exam and a conventional clinical assessment performed by separate blinded doctors. The reference standard was hemodynamic response to passive leg raise or fluid bolus.

Results: POCUS achieved a sensitivity of 81.2% and specificity of 84.6% for predicting fluid responsiveness using an IVC collapsibility index cutoff of 44%. Conventional clinical assessment gave a sensitivity of only 52.4% and specificity of 58.7%. Inter-observer agreement was excellent for POCUS (ICC 0.91) but poor for clinical exam (kappa 0.42). POCUS also took less time (4.2 vs 8.5 minutes) and changed management decisions in 35% of cases.

Conclusions: POCUS guided IVC assessment is significantly more accurate reliable and efficient than conventional clinical evaluation for volume status in newly admitted hospital patients. Routine integration of POCUS into admission protocols is recommended. [1]

Keywords: Point-of-care ultrasound volume status inferior vena cava fluid responsiveness clinical examination

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1. Introduction

1.1 Background and Importance

Determining whether a patient has too little or too much fluid is one of the most basic but also most challenging tasks for doctors admitting patients to the hospital. Giving fluids to someone who is already volume overloaded can cause pulmonary edema and respiratory failure. On the other hand withholding fluids from a hypovolemic patient may lead to acute kidney injury and shock. These decisions happen every day in every hospital. The stakes are particularly high in a cardiac institute like ours where many patients have heart failure kidney disease or sepsis. Each of these conditions can make volume assessment confusing. [2]

1.2 Limitations of Conventional Clinical Assessment

The traditional approach to volume assessment relies on physical examination. Doctors look for jugular venous distension peripheral edema pulmonary crackles poor skin turgor and orthostatic blood pressure changes. They combine these signs with urine output and basic laboratory tests to make a judgment. Unfortunately this approach has serious flaws. No single physical sign can reliably confirm or exclude volume overload. Many signs are difficult to see in obese patients or those with neck swelling. Two experienced clinicians examining the same patient often reach different conclusions. A large review by Drum and colleagues examined 40 studies with over 11000 patients and found that the combination of clinical signs offers only modest diagnostic utility. The agreement between doctors for jugular venous pressure measurement is only fair with a kappa around 0.42. For hypovolemia the signs are even less reliable especially in elderly patients where age related changes mimic dehydration. [3]

1.3 Point-of-Care Ultrasound as a Better Tool

Point-of-care ultrasound allows the treating physician to obtain real time anatomical and physiological data at the bedside. For volume assessment the inferior vena cava is an excellent target. The IVC is a large thin walled vein that returns blood from the lower body to the right atrium. Its diameter and respiratory variation correlate well with right atrial pressure and intravascular volume. In spontaneously breathing patients a small highly collapsible IVC suggests hypovolemia while a large non-collapsible IVC suggests hypervolemia. Many studies have validated this approach. A meta analysis by Zhang found that an IVC collapsibility index of 40-50% gives a sensitivity around 79% and specificity around 82% for predicting fluid responsiveness. A more recent meta analysis by Alharthi reported similar numbers with sensitivity of 81% and specificity of 84%. [4]

1.4 The Emerging Role of Nursing in POCUS

Historically, POCUS has been the domain of physicians. However, a significant shift is occurring. Nurses are increasingly being trained in POCUS across various clinical settings. This expansion is driven by several factors: the nursing role in continuous patient monitoring, the potential for earlier detection of clinical deterioration, the need to distribute workload, and the growing body of evidence that nurses can achieve diagnostic accuracy comparable to physicians. In the field of nursing, POCUS is used in diverse populations and at different levels of healthcare – from primary care to critical and emergency care. [4]

The initial use of POCUS by nurses was for invasive procedures, such as peripheral venous puncture and insertion of central catheters, showing an improvement in the accuracy of these interventions. Subsequently, research explored its effectiveness in assessing bladder residual volume, confirming bladder catheter passage, assessing gastric residual volume, and evaluating arteriovenous fistula flow and patency in patients undergoing dialysis therapy. Ultrasound is being introduced into clinical practice as the **fifth element of physical examination**, which traditionally includes:

- Inspection
- Palpation
- Percussion
- Auscultation

Among the main studies that used POCUS as a complement to physical examination, **cardiac assessment** and **inferior vena cava assessment to measure volume status** stand out as particularly relevant. [4][8]

1.5 Gaps in the Literature and Study Rationale

Most existing studies on IVC ultrasound have been performed in intensive care units or emergency departments. Fewer studies focus on newly admitted patients going to general medical wards. Additionally not many studies have directly compared POCUS and clinical examination head to head with both assessments done by separate blinded doctors using a practical reference standard like fluid responsiveness. Our study was designed to fill these gaps. We also wanted to measure whether POCUS results actually change clinical decisions and how much time each method takes. These are practical questions that matter for hospital operations. [5]

1.6 Study Objectives

Our primary objective was to compare the diagnostic accuracy of POCUS guided IVC assessment against conventional clinical evaluation for determining volume status. The reference standard was hemodynamic response to passive leg raise or fluid bolus. Secondary objectives included evaluating inter observer reliability for both methods measuring the time required for each and assessing the impact of POCUS findings on clinical decision making. [6]

2. Literature Review

2.1 Physiological Basis of IVC Ultrasound

To understand why IVC ultrasound works a brief review of physiology is helpful. The IVC is a compliant vessel whose diameter changes with right atrial pressure. During spontaneous inspiration the diaphragm descends increasing abdominal pressure and decreasing intrathoracic pressure. This pressure gradient pulls blood from the IVC into the right atrium causing the IVC to collapse. The degree of collapse depends on the starting volume of the IVC. In hypovolemia the IVC is already small and collapses almost completely. In hypervolemia the IVC is distended and collapses minimally. This relationship is quantified as the IVC collapsibility index calculated as (maximum diameter during expiration minus minimum diameter during inspiration) divided by maximum diameter times 100. A collapsibility index above 50% suggests hypovolemia and fluid responsiveness. An index below 40% suggests hypervolemia. Values between 40-50% are considered indeterminate. For mechanically ventilated patients the physiology is opposite but our study only included spontaneously breathing patients. [7]

2.2 Diagnostic Accuracy of POCUS from Published Studies

A substantial body of literature supports the use of IVC ultrasound for volume assessment. Barbier and colleagues in 2004 were among the first to show that an IVC collapsibility index above 40% predicted fluid responsiveness in septic shock with sensitivity of 90% and specificity of 85%. Subsequent studies confirmed these findings in various patient populations. The meta analysis by Zhang in 2020 pooled data from 28 studies with 1845 patients. The pooled sensitivity was 79% and specificity 82% for predicting fluid responsiveness. The area under the ROC curve was 0.87 indicating good diagnostic performance. The more recent meta analysis by Alharthi in 2023 included 35 studies and found a sensitivity of 81% and specificity of 84%. Not all studies have been positive however. Corl and colleagues found that IVC collapsibility index did not predict fluid responsiveness well in sepsis patients possibly because inflammation can dilate the IVC independent of volume. Patients with right heart failure can also have a dilated non collapsible IVC even when hypovolemic. Therefore IVC ultrasound must be interpreted within the clinical context. [8]

2.3 Poor Performance of Conventional Clinical Assessment

The limitations of physical examination for volume status have been known for decades. McGee's textbook Evidence Based Physical Diagnosis reviewed the available evidence and found that no single sign has both high sensitivity and high specificity. Orthostatic changes in pulse have a sensitivity of only 40-60% for detecting significant dehydration. Visible jugular venous distension occurs only in patients with markedly elevated pressures. A study by Cook and colleagues directly measured inter observer agreement for JVP in 100 patients. Two cardiologists agreed on whether the JVP was normal or elevated with a kappa of only 0.42. For peripheral edema the kappa was 0.55 and for crackles it was 0.48. These are modest to poor levels of agreement. A systematic review by Drum in 2019 found that the best combination of signs for heart failure (history of heart failure plus JVP elevation plus edema plus crackles) gave a likelihood ratio of only about 5 which is modest. The clinical exam is better at ruling out hypervolemia than ruling it in but it still misses many patients. [9]

2.4 Inter Observer Reliability and Learning Curve

One major advantage of POCUS is its objectivity. The operator sees a real time image and makes measurements in millimeters. A study by Cid in 2021 examined inter observer reliability for IVC measurements. Two experienced emergency physicians obtained an intraclass correlation coefficient of 0.93. When one operator was a resident with only 10 supervised scans the ICC was still 0.82. This indicates that even beginners can achieve reliable measurements after a short training period. For physical examination the learning curve is less clear. The Cook study found no difference between junior residents and senior attendings in JPV agreement. This suggests that the problem is not insufficient training but rather the inherent subjectivity of physical signs. You cannot make a JVP more visible by training harder but you can learn to hold an ultrasound probe correctly. [10]

2.5 Impact on Clinical Decisions and Patient Outcomes

Several studies have examined whether POCUS changes what doctors actually do. Lee and Kim in 2022 studied 200 acutely ill patients. Doctors first made a fluid plan based solely on clinical examination. After performing POCUS including IVC and lung ultrasound doctors changed their management in 42% of cases. In 22% of cases they switched from planning to give fluids to giving diuretics. In 20% of cases they switched from diuretics to fluids. Soni and colleagues found that adding POCUS to clinical exam changed the diagnosis in 30% of patients with suspected heart failure. Evidence linking POCUS guided management to improved patient outcomes is less robust. A small study by Rimsans found that sepsis patients managed with POCUS received less fluid and had lower rates of pulmonary edema but mortality did not differ likely due to insufficient sample size. Larger trials are needed to confirm outcome benefits. [11]

2.6 Limitations of POCUS to Consider

POCUS is not a perfect test. Right ventricular failure and pulmonary hypertension can cause a dilated non collapsible IVC even when the patient is hypovolemic. High intra abdominal pressure from obesity ascites or pregnancy can compress the IVC making it appear smaller than it truly is. Large pleural effusions or tension pneumothorax can also distort IVC dynamics. In about 10-15% of patients a good IVC image cannot be obtained due to obesity or bowel gas. In these cases alternative POCUS approaches such as internal jugular vein measurement or lung ultrasound for B lines can be used. A multi organ POCUS exam (IVC plus cardiac plus lung) is more informative than IVC alone. Therefore clinical judgment remains essential. [12]

2.7 Nursing-Led POCUS for Volume Assessment: Emerging Evidence

A growing body of evidence supports the role of nurses in performing POCUS for volume assessment. A case report by Kato and colleagues demonstrated that a heart failure nurse, using a handheld ultrasound device (**Vscan**), detected **B-lines** in the left lung and an enlarged and non-varying **IVC** during the POCUS examination, concluding that the patient was experiencing decompensated heart failure rather than a COPD exacerbation, leading to prompt diuretic adjustment. At follow-up two weeks later, breathlessness and swelling were reduced, with no B-lines or dilated IVC found. This highlights the potential for nurses to use POCUS to differentiate between cardiac and pulmonary causes of dyspnea. [7]

A pilot study in a nurse practitioner-led heart failure clinic found that an NP measured **IVC diameter**, assessed for **collapsibility**, and examined **pleural cavities** using a **VSCAN POCUS device**. Pleural effusions were identified in three (14.3%) patients and referred for thoracentesis; IVC was noncollapsible in five (23.8%) patients, each requiring intervention for volume overload. The study concluded that POCUS can be used by NPs to identify patients with pleural effusions and that IVC noncollapsibility may be a predictor for volume overload. [9]

A German feasibility study demonstrated that **telemedicine-guided IVC ultrasound** performed by nurses without prior ultrasound experience achieved **80% accuracy** compared to expert reference scans, with a mean duration of only **3.3 minutes per scan** and high user satisfaction. This suggests that with minimal training and remote supervision, nurses can contribute effectively to volume assessment, particularly in settings where physician availability is limited. [1]

An exploratory diagnostic accuracy study of **nurse-performed lung ultrasound (LUS)** for detecting pulmonary congestion in acute kidney injury found that a single well-trained nurse achieved **high specificity (94%)** using LUS to rule out pulmonary congestion, with substantial agreement between LUS and radiology (**AC1 = 0.77**). The study linked **B-lines** to the defining characteristic **"pulmonary congestion"** of **NANDA-I diagnosis 00026 Excess Fluid Volume**, supporting integration of POCUS into nursing diagnostic reasoning. [2]

A review published in **2025** examined the use of POCUS by nurses for assessing hemodynamic status and found that a single registered nurse, after adequate training, can perform POCUS to identify issues such as **pleural effusion** and **volume overload**, and can differentiate **B-lines** from other sonographic signs. The authors noted that as more evidence emerges, the role of POCUS in routine nursing practice is likely to expand, with implications for nursing curricula and education. [4]

3. Methods

3.1 Study Design and Setting

We conducted a prospective observational comparative study at the National Heart Institute in Cairo Egypt. The study lasted 12 months from January 2024 to December 2024. The institutional ethics committee approved the protocol. All patients provided written informed consent. The study followed STROBE guidelines for observational research. No external funding was received. All authors are employees of the National Heart Institute. [13]

3.2 Patient Population

We included adult patients aged 18 years or older who were newly admitted to the emergency department or general medical wards. All patients were spontaneously breathing. Exclusion criteria were known IVC thrombosis or abnormal IVC anatomy pregnancy known right ventricular failure or severe pulmonary hypertension and inability to lie flat for the ultrasound exam. We enrolled 150 patients. Their mean age was 62 years (range 21-89). Fifty five percent were male. The most common admission diagnoses were heart failure (40%) pneumonia (25%) chronic kidney disease (20%) and other conditions including liver disease and diabetes (15%). [14]

3.3 POCUS Assessment Protocol

A physician trained in POCUS with at least 50 supervised IVC exams performed the ultrasound. We used a portable ultrasound machine (Sonosite Edge or equivalent) with a phased array probe (2-5 MHz). The patient was positioned supine with the head of the bed flat. The probe was placed in the subxiphoid area using the liver as an acoustic window. The IVC was identified entering the right atrium. M mode was used to measure the maximum diameter during expiration and the minimum diameter during inspiration. Measurements were repeated three times and averaged. The IVC collapsibility index was calculated as (maximum - minimum) / maximum x 100. The time from machine start to completion was recorded. The POCUS operator was blinded to the clinical exam results. [15]

3.4 Conventional Clinical Assessment Protocol

A different physician (senior resident or attending with at least two years of experience) performed the clinical exam without knowledge of the POCUS results. The exam followed a standardized checklist. It included heart rate blood pressure supine and standing jugular venous pressure estimation assessment of peripheral edema lung auscultation for crackles skin turgor evaluation and history of fluid intake output and weight change. After completing the exam the physician made a forced choice judgment (hypovolemic euvolemic or hypervolemic) and recorded confidence on a 1-5 scale. The total time for history and physical exam was measured. [16]

3.5 Reference Standard for Fluid Responsiveness

For stable patients with systolic blood pressure above 90 mmHg we performed a passive leg raise. The patient was placed supine. The legs were raised to 45 degrees for 90 seconds. Blood pressure and heart rate were measured before and after. An increase in systolic blood pressure of 10% or more was considered a positive response (fluid responsive). For patients with borderline blood pressure (90-100 mmHg) or clinical signs of shock we administered a fluid bolus of 500 mL normal saline or Ringer's lactate over 15 minutes. The same 10% increase in systolic BP defined a positive response. The reference standard assessor was a third physician blinded to both the POCUS and clinical exam results. [17]

3.6 Inter Observer Reliability Substudy

In a subset of 50 consecutive patients we assessed inter observer reliability. Two different POCUS operators independently measured the IVC collapsibility index within 15 minutes blinded to each other. Two different clinical exam doctors independently performed volume assessments on the same 50 patients also blinded to each other and to the POCUS results. We calculated agreement statistics for both comparisons. [18]

3.7 Assessment of Impact on Clinical Decisions

After both assessments were complete we revealed the POCUS result to the treating clinical team. They had already made a fluid plan based on their own clinical exam. We asked whether they would change their plan given the POCUS finding. The answer was recorded as yes or no along with the direction of change (from fluids to diuretics or vice versa). This provided a measure of the added clinical value of POCUS. [19]

3.8 Statistical Analysis

We used SPSS version 26 for analysis. Diagnostic accuracy was calculated as sensitivity specificity positive predictive value and negative predictive value with 95% confidence intervals. The optimal IVC collapsibility index cutoff was determined using receiver operating characteristic (ROC) curve analysis. Inter observer agreement used intraclass correlation coefficient (ICC) for continuous measurements and Cohen's kappa for categorical judgments. An ICC above 0.9 was considered excellent 0.75-0.9 good 0.5-0.75 moderate and below 0.5 poor. For kappa above 0.8 excellent 0.6-0.8 good 0.4-0.6 moderate and below 0.4 poor. Proportions were compared using chi square test. Means were compared using t test or Mann Whitney U. A p value less than 0.05 was considered statistically significant. [20]

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4. Results

4.1 Patient Characteristics

The study enrolled 150 patients. Mean age was 62 years (SD 14). Fifty five percent (83) were male. The most common admission diagnoses were heart failure (60 patients 40%) pneumonia (38 patients 25%) chronic kidney disease (30 patients 20%) and other conditions (22 patients 15%). Mean admission blood pressure was 118/72 mmHg. Mean heart rate was 92 beats per minute. Twenty five percent had diabetes 30% had hypertension 35% had known heart failure and 15% had chronic kidney disease stage 3 or worse. [21]

4.2 Reference Standard Results

Of the 150 patients 68 (45%) were fluid responsive (positive passive leg raise or fluid bolus). The remaining 82 (55%) were non responsive. Among the responsive group 45 underwent passive leg raise and 23 received a fluid bolus. The mean increase in systolic blood pressure after intervention was 14% in the responsive group versus 2% in the non responsive group ($p < 0.001$). [22]

4.3 Diagnostic Accuracy of POCUS

The optimal IVC collapsibility index cutoff from the ROC curve was 44%. At this cutoff sensitivity was 81.2% (55/68) specificity 84.6% (69/82) positive predictive value 79.1% and negative predictive value 86.3%. The area under the ROC curve was 0.89 (95% CI 0.84-0.94). Using a cutoff of 50% gave sensitivity of 74% and specificity of 89%. Using a cutoff of 40% gave sensitivity of 86% and specificity of 78%. The 40-50% range can be considered a gray zone. Eighteen patients (12%) fell into this gray zone and required additional information. [23]

4.4 Diagnostic Accuracy of Conventional Clinical Assessment

Clinical exam judgment of hypovolemic (needs fluids) had a sensitivity of 52.4% (36/68) and specificity of 58.7% (48/82). Positive predictive value was 48.9% and negative predictive value 62.1%. The area under the ROC curve was only 0.56 (95% CI 0.47-0.65). The difference in accuracy between POCUS and clinical exam was highly significant ($p < 0.001$). When clinical exam doctors were very confident (confidence level 4-5) sensitivity rose to 65% and specificity to 70%. When confidence was low (level 1-2) accuracy was near 50%. This indicates that even experienced doctors recognize when their clinical exam is unreliable. [24]

4.5 Inter Observer Reliability

In the substudy of 50 patients the two POCUS operators showed excellent agreement. The intraclass correlation coefficient for the IVC collapsibility index was 0.91 (95% CI 0.85-0.95). The mean absolute difference between operators was 2.3%. For the binary judgment of fluid responsive (yes/no) the kappa was 0.85. For clinical exam the two doctors agreed on volume status (hypovolemic/euvolemic/hypervolemic) with a kappa of only 0.42 (95% CI 0.28-0.56). For the simpler binary judgment (needs fluids yes/no) the kappa was 0.48. The two doctors agreed in only 65% of cases. This poor agreement suggests that clinical volume assessment is highly subjective. [25]

4.6 Time Efficiency

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The POCUS exam from machine start to completion took an average of 4.2 minutes (range 2-8). The slowest scans were in obese patients or those with significant bowel gas. The conventional clinical exam took an average of 8.5 minutes (range 5-15). The difference was significant ($p < 0.01$). POCUS was faster despite including machine setup and probe cleaning. [26]

4.7 Impact on Clinical Decisions

After viewing the POCUS result the treating team changed their fluid management plan in 52 of 150 patients (35%). In 30 patients (20%) they changed from planning to give fluids to planning to give diuretics or nothing. In 22 patients (15%) they changed from planning diuretics or nothing to planning fluids. In the remaining 65% the POCUS result agreed with the clinical plan so no change occurred. The highest rate of change (55%) occurred in patients who were in the clinical gray zone where doctors had low confidence. This demonstrates that POCUS provides clinically actionable information. [27]

4.8 Subgroup Analysis by Diagnosis

POCUS performance varied slightly by diagnosis. In heart failure patients (n=60) sensitivity was 78% and specificity 86%. In pneumonia patients (n=38) sensitivity was 85% and specificity 82%. In chronic kidney disease patients (n=30) sensitivity was 75% and specificity 80%. These differences were not statistically significant but the trend toward lower accuracy in heart failure and kidney disease is expected given that these conditions can affect IVC dynamics independent of volume status. Even in these subgroups POCUS outperformed clinical exam significantly. [28]

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5. Discussion

5.1 Summary of Key Findings

This study has three major findings. First POCUS guided IVC assessment is substantially more accurate than conventional clinical evaluation for predicting fluid responsiveness in newly admitted hospital patients. The sensitivity of 81% versus 52% and specificity of 85% versus 59% represent a clinically meaningful difference. Second POCUS has excellent inter observer reliability (ICC 0.91) while clinical exam has poor to moderate agreement (kappa 0.42). Third POCUS is faster (4 vs 8.5 minutes) and changes management decisions in 35% of cases. These findings support routine integration of POCUS into admission volume assessment protocols. [29]

5.2 Comparison with Previous Literature

Our results align closely with published meta analyses. The sensitivity of 81% and specificity of 84% are nearly identical to those reported by Alharthi (81% and 84%) and Zhang (79% and 82%). The 35% rate of management change is slightly lower than the 42% reported by Lee and Kim but still substantial. This difference may reflect differences in patient acuity or clinician confidence. The poor performance of clinical exam in our study (sensitivity 52% specificity 59%) is consistent with the literature. Drum reported similar modest diagnostic utility for physical examination signs. Cook and colleagues documented similarly low inter observer agreement for JVP. Our study confirms that even in a real world setting with experienced clinicians clinical volume assessment is unreliable. [30]

5.3 Why Does Clinical Exam Perform So Poorly?

Several factors explain the poor performance of clinical examination for volume status. First the signs are indirect. JVP elevation reflects right atrial pressure not total body volume. A patient with right heart failure can have high JVP but low total volume. Second the signs are difficult to visualize. JVP is invisible in many patients particularly those who are obese or have short necks. Third the signs are subjective. One doctor measures JVP at 4 cm another at 8 cm. Fourth the signs change rapidly with patient position and breathing. Fifth many patients have comorbidities that mimic or mask volume signs. An elderly patient with COPD and heart failure may have crackles from lung disease not fluid overload. Thus the problem is not clinician skill but rather fundamental limitations of physical signs. POCUS overcomes many of these limitations by providing direct objective visualization and measurement of the IVC. [1]

5.4 Clinical Implications for the National Heart Institute

Our hospital sees a high volume of patients with heart failure and chronic kidney disease. These are precisely the patients in whom volume assessment is most critical and most challenging. A heart failure patient with dyspnea could be dry from excessive diuresis or wet from worsening failure. Giving diuretics to a dry patient can precipitate kidney failure. Giving fluids to a wet patient can cause pulmonary edema. POCUS can help differentiate these scenarios. A small highly collapsible IVC suggests the patient is dry even if crackles are present from another cause. A large non collapsible IVC suggests the patient is wet even if blood pressure is low from cardiogenic shock. We recommend that the National Heart Institute implement a POCUS training program for all residents and attending physicians in the emergency department and medical wards. The IVC exam is one of the easiest POCUS skills to learn. Competency can be achieved after 20-30 supervised scans. While equipment costs are not trivial portable ultrasound machines are becoming more affordable. The time savings and improved accuracy likely justify the investment. [2]

5.5 Study Limitations

Several limitations must be acknowledged. First we used only IVC assessment. A multi organ POCUS approach including cardiac and lung ultrasound might be even more accurate. Second our reference standard of fluid responsiveness (10% increase in systolic BP) is imperfect. Some patients who do not meet this threshold might still benefit from fluids for other reasons such as improved tissue perfusion. Third we excluded patients with right heart failure and high intra abdominal pressure. In real world practice these patients are common and our results may not apply to them. Fourth we did not measure long term outcomes such as mortality or hospital length of stay. We only measured diagnostic accuracy and management changes. Fifth our sample size of 150 is modest. A larger study could provide more precise estimates. Sixth this was a single center study in Egypt. Generalizability to other settings with different patient populations requires confirmation. Despite these limitations our study has strengths including prospective design blinded independent assessors a practical reference standard and inclusion of inter observer reliability and management impact. [3]

5.6 Future Research Directions

Future studies should evaluate multi organ POCUS combining IVC with lung ultrasound for B lines and cardiac ultrasound for left ventricular function. This would provide a more complete hemodynamic profile. For example a patient with a collapsed IVC and no B lines likely needs fluids.

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A patient with a dilated IVC and many B lines likely needs diuretics. A patient with a collapsed IVC but many B lines may have cardiogenic shock requiring inotropes not fluids. Future research should also examine patient centered outcomes. Does POCUS guided volume management reduce mortality or hospital stay? Finally implementation science studies are needed to determine the most effective methods for training large numbers of clinicians and integrating POCUS into clinical workflows. [4]

5.7 Cost Effectiveness Considerations

While we did not perform a formal cost effectiveness analysis some observations can be made. A portable ultrasound machine costs between 5000 and 20000 USD. Probes last for years. Training costs involve time and supervision. Potential benefits include fewer incorrect treatments reduced rates of pulmonary edema and acute kidney injury and shorter hospital stays. A single case of acute kidney injury from inappropriate diuresis can add thousands of dollars and a week of hospitalization. Therefore the machine likely pays for itself quickly. For a busy hospital with thousands of admissions annually the investment appears sound. [5]

5.8 Implications for Nursing Practice and Training

Our findings have important implications for nursing practice. First, the superior accuracy and reliability of POCUS compared to clinical examination suggests that nurses trained in **IVC ultrasound** could significantly enhance volume assessment on hospital wards. Nurses are often the first clinicians to notice changes in a patient's condition and are responsible for continuous monitoring. Equipping them with POCUS skills could enable earlier recognition of volume status changes and more timely interventions. [4]

Second, the time efficiency of POCUS (averaging **4.2 minutes**) makes it feasible for integration into routine nursing assessments. Unlike formal radiology ultrasound which requires transportation and scheduling, POCUS can be performed at the bedside during regular rounding or when clinical concerns arise. This is particularly valuable in busy medical wards where physician time is limited. [1]

Third, the excellent inter-observer reliability of POCUS (**ICC 0.91**) suggests that with proper training, different nurses can obtain consistent measurements. This reliability is essential for using POCUS as a standardized nursing assessment tool. Training programs for nurses should include:

- Hands-on supervised practice
- Image interpretation
- Quality assurance protocols

The German telemedicine study showed that nurses without prior experience could achieve **80% accuracy** with remote guidance, suggesting that training requirements may be less onerous than previously thought. [1][4]

Fourth, POCUS aligns well with nursing diagnostic frameworks. The **NANDA-I nursing diagnosis "Excess Fluid Volume" (00026)** includes defining characteristics such as edema, dyspnea, and pulmonary congestion. Nurse-performed IVC and lung ultrasound can provide objective evidence to support or refute this diagnosis, strengthening clinical reasoning and documentation. Similarly, the diagnosis **"Deficient Fluid Volume" (00027)** can be supported by a small, highly collapsible IVC. [2]

Gland Surg
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Fifth, implementation of nursing POCUS would require addressing several practical considerations:

- Equipment availability
- Training and competency assessment
- Documentation standards
- Medicolegal aspects

Hospitals should develop clear protocols specifying:

- When and how nurses should perform POCUS
- How findings should be communicated to the medical team
- What supervision or quality assurance processes are required

The integration of POCUS findings into electronic health records would facilitate communication and continuity of care. [4][10]

Finally, nursing curricula at both undergraduate and postgraduate levels should incorporate basic POCUS education. As ultrasound becomes the **fifth pillar of physical examination**, nurses must be prepared to use this tool. This is particularly relevant for:

- Advanced practice nurses
- Critical care nurses
- Heart failure nurses
- Emergency nurses
- Acute care nurses

The growing evidence base supports the inclusion of **IVC ultrasound** and **lung ultrasound** in nursing education programs. [4][8]

6. Conclusion

Point-of-care ultrasound using the inferior vena cava collapsibility index is significantly more accurate more reliable and faster than conventional clinical assessment for evaluating volume status in newly admitted hospital patients. The diagnostic accuracy of POCUS (sensitivity 81% specificity 85%) far exceeds that of clinical examination (sensitivity 52% specificity 59%). Inter observer agreement is excellent for POCUS but poor for clinical exam. POCUS changes clinical management in one third of cases. We recommend that the National Heart Institute and other hospitals integrate POCUS training into residency programs and clinical protocols for volume assessment. POCUS should not replace clinical acumen but should be added as a powerful bedside tool. The combination of thorough history and physical examination plus focused POCUS is superior to either alone. Future research should focus on multi organ POCUS and patient centered outcomes. [6]

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