

Clinical Competency in Inferior Vena Cava Assessment as a Part of Nurse-Initiated Sono Triage Among Emergency Nurses: A Quasi-Experimental Study

EMERGENCY NURSES' IVC SONOGRAPHY COMPETENCY

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ABSTRACT

Aim: To evaluate emergency nurses' clinical competency in Nurse-Initiated Sonography for Inferior Vena Cava (IVC) assessment before and after a structured competency-based educational intervention.

Background: Rapid assessment of haemodynamic status is fundamental in emergency care, particularly for patients presenting with trauma or suspected hypovolaemia. Inferior vena cava (IVC) ultrasonography is a focused point-of-care ultrasound technique that provides valuable information on intravascular volume status and fluid responsiveness. While IVC assessment is widely used by physicians, evidence regarding competency among emergency nurses remains limited. Nurse-Initiated Sono Triage (NIST) was developed to strengthen nurses' competency in focused ultrasound assessment during emergency triage; this study evaluated nurses' clinical competency in performing IVC assessment as a component of NIST.

Methods: A quasi-experimental one-group pre-test–post-test study was conducted among 30 emergency nurses working in the Yellow Area of the Emergency Department of a tertiary care hospital in New Delhi, India. This manuscript represents a predefined secondary analysis of a larger NIST study, focusing exclusively on IVC competency. Competency was assessed during 600 paired clinical observations using a validated observational checklist evaluating two domains – IVC diameter assessment and identification of IVC wall kissing – each scored on a five-point competency scale. Following baseline assessment, nurses underwent a structured competency-based educational programme comprising theoretical instruction, demonstration, return demonstration, and supervised bedside practice, after which competency was reassessed. Descriptive statistics and paired comparisons were used to evaluate change in competency.

Results: Baseline competency in IVC assessment was limited, with most observations demonstrating unsatisfactory performance. Following competency-based education and supervised clinical practice, competency scores improved substantially, with the majority of assessments shifting to satisfactory and good performance categories. Mean competency scores increased significantly from pre-intervention to post-intervention ($p < 0.001$), reflecting marked improvement in image acquisition, technical performance, and interpretation of IVC findings. The observational checklist demonstrated excellent reliability (Cohen's $\kappa = 0.90$), with expert agreement ranging from 0.86 to 0.96.

Conclusion: Emergency nurses demonstrated significant improvement in clinical competency for IVC assessment following implementation of the NIST programme. The findings support the feasibility of integrating focused IVC ultrasonography into nurse-initiated emergency assessment and highlight the potential of competency-based education to expand nursing roles in point-of-care ultrasound.

Keywords: Nurse-Initiated Sono Triage; point-of-care ultrasound; inferior vena cava; clinical competency; emergency nursing; haemodynamic assessment.

Introduction

Emergency departments operate in an environment where rapid assessment and timely clinical decision-making are essential to optimise patient outcomes. Trauma and critically ill patients often present with occult haemodynamic compromise that may not be readily identified through clinical examination alone. Although conventional trauma triage protocols rely on physiological parameters, mechanism of injury, and physical assessment, these approaches may not detect early internal bleeding or subtle circulatory instability. Consequently, there is increasing interest in incorporating point-of-care ultrasound (POCUS) into the initial assessment of emergency patients to provide objective, real-time information that complements traditional triage; POCUS utilisation and its range of clinical applications in the emergency department, from trauma to palliative symptom management, continue to expand internationally.^{6-9,10,13,16}

Among the focused POCUS applications, assessment of the inferior vena cava (IVC) has emerged as a practical bedside method for evaluating intravascular volume status and haemodynamic stability.² Measurement of IVC diameter together with assessment of respiratory variation, or “IVC wall kissing,” provides indirect information regarding right atrial pressure and circulating blood volume. These findings can assist clinicians in identifying hypovolaemia, monitoring fluid responsiveness, and supporting early clinical decision-making in trauma and critically ill patients. Because IVC ultrasonography is rapid, non-invasive, repeatable, and free from ionising radiation, it has become an increasingly valuable component of emergency and critical care ultrasound protocols.¹⁻³

Traditionally, focused ultrasound examinations have been performed by physicians. However, the expanding role of emergency nurses and the growing availability of portable ultrasound devices have created opportunities to extend selected ultrasound applications to trained nursing professionals. Previous studies have demonstrated that nurses can acquire competency in focused ultrasound through structured educational programmes, particularly for applications such as vascular access, bladder assessment, and components of the extended Focused Assessment with Sonography for Trauma (eFAST).⁴⁻¹⁴ More recently, nurse-performed protocols incorporating IVC and lung ultrasound have been used to guide fluid management decisions in septic and critically ill patients, providing early precedent for the application evaluated in the present study.¹¹ Despite these advances, survey data continue to indicate that many non-physician emergency staff, including registered nurses, have not received formal POCUS training, and evidence specifically evaluating nurses' competency in IVC ultrasonography remains limited, particularly in low- and middle-income countries where emergency departments frequently operate under high patient volumes and resource constraints.¹²

Nurse-Initiated Sono Triage (NIST) was developed to address this gap by integrating focused ultrasound assessment into emergency nursing practice. The NIST programme combines competency-based education with supervised clinical practice to enable nurses to perform structured bedside ultrasound assessments during the initial evaluation of trauma patients. Although the parent NIST study evaluated multiple ultrasound competency domains, this manuscript focuses exclusively on IVC assessment because of its clinical importance in haemodynamic evaluation and the relative paucity of nursing literature addressing this skill; this focused analysis was planned prior to data analysis and addresses a distinct research objective not previously reported.

Evaluating competency in IVC ultrasonography extends beyond determining whether nurses can perform a technical procedure. Competency encompasses accurate probe placement, optimisation of ultrasound images, correct identification of anatomical landmarks, measurement of IVC diameter, recognition of dynamic respiratory changes, and appropriate interpretation of findings within the clinical context. Demonstrating competency in these areas is essential before nurse-performed IVC assessment can be considered for integration into routine emergency practice.

Therefore, this study aimed to evaluate the clinical competency of emergency nurses in performing IVC assessment as part of the NIST programme before and after a structured competency-based educational intervention. The findings are intended to provide evidence regarding the feasibility of incorporating focused haemodynamic ultrasound into emergency nursing practice and to inform future educational and implementation strategies.

Methods

Study Design

This study employed a quasi-experimental one-group pre-test–post-test design to evaluate emergency nurses' competency in IVC assessment as part of the NIST programme. This manuscript represents a predefined secondary

analysis of a larger quasi-experimental study conducted to evaluate the effectiveness of NIS_t among emergency nurses. While the parent study examined multiple ultrasound competency domains, this paper reports only the findings related to IVC assessment competency.

Study Setting

The study was conducted in the Yellow Area of the Emergency Department of a tertiary care hospital in New Delhi, India. The department manages a high volume of trauma and emergency patients and functions as a major referral centre, providing an appropriate environment for competency-based ultrasound training and clinical assessment.

Participants

Thirty registered nurses working in the Emergency Department were recruited using total enumeration sampling. Nurses who had at least six months of emergency department experience, were directly involved in trauma triage, and provided written informed consent were included. Nurses who were unavailable during the study period or declined participation were excluded.

Educational Intervention

The NIS_t educational programme was developed by the researcher using current evidence on point-of-care ultrasound, the eFAST protocol, and emergency trauma triage guidelines, consistent with recently described approaches to integrating structured POCUS education into emergency department clinical practice.¹⁵ the intervention consisted of three integrated components.

1. Structured theoretical session: Conducted in a seminar room using a validated educational module supported by slide presentations. The session covered the principles of point-of-care ultrasound, ultrasound physics, probe orientation, image optimisation, anatomical landmarks of the IVC, assessment of IVC diameter, identification of IVC wall kissing, and interpretation of findings within emergency triage.

2. Hands-on demonstration: The researcher demonstrated the standardised scanning technique on a standardised patient. Nurses were divided into two batches of 15 participants (morning and evening sessions) to facilitate interactive learning and close supervision.

3. Return demonstration and supervised clinical practice: Each nurse performed the complete IVC assessment independently on the researcher's patient under direct observation. Following satisfactory return demonstration, nurses undertook supervised bedside practice in the emergency department, performing serial IVC assessments during routine clinical care. Supervision and feedback were provided throughout the practice period to reinforce competency and standardise technique.

Outcome Measure

Clinical competency in IVC assessment was evaluated using a validated observational checklist that formed part of the comprehensive NIS_t competency assessment tool. The IVC component comprised two domains: measurement of IVC diameter, and identification of IVC wall kissing (collapsibility). Each domain was assessed using the five-point competency rating scale shown in Table 1. The combined competency score ranged from 2 to 10, with higher scores indicating greater clinical competency in image acquisition, technical execution, and interpretation.

Table 1. Competency Rating Scale for IVC Assessment

Score	Competency Level
1	Unable to identify the structure
2	Identified with unsatisfactory technique
3	Identified with satisfactory technique
4	Identified with good technique
5	Identified with excellent technique

Data Collection Procedure

Baseline knowledge assessment was completed for all 30 nurses before commencement of the educational intervention. Pre-intervention competency assessment was subsequently performed during routine emergency care, with each nurse completing assessments on 20 trauma patients, yielding 600 pre-intervention clinical observations.

Following baseline assessment, nurses participated in the NISt educational programme and completed return demonstrations before entering the supervised clinical practice phase. Supervised bedside practice extended over a three-month period according to a structured rotation schedule, enabling each nurse to perform repeated IVC assessments under clinical supervision while managing routine emergency patients.

Post-intervention competency assessment commenced 14 days after completion of the educational intervention and followed the same procedure as the baseline evaluation. Each nurse again completed 20 independent clinical assessments, resulting in 600 post-intervention observations. Assessments were conducted using identical performance criteria during both periods.

Validity and Reliability

The observational checklist was developed following an extensive review of contemporary literature on point-of-care ultrasound and eFAST competency assessment. Content validity was established through review by a multidisciplinary panel of experts in emergency medicine, emergency nursing, trauma care, and ultrasound, yielding a Content Validity Index (CVI) of 0.85.

Inter-rater reliability of the checklist was evaluated during pilot testing using Cohen's kappa coefficient. The instrument demonstrated excellent agreement ($\kappa = 0.90$), with agreement among expert assessors ranging from 0.86 to 0.96, indicating a high degree of consistency in competency evaluation and supporting the reliability of the assessment tool.

Ethical Considerations

Ethical approval for the parent study was obtained from the Institutional Ethics Committee of the participating tertiary care hospital prior to commencement of data collection (Approval No. Ref No.IEC-994/13.01.2023, RP-37/2023, OP-3/16.05.2023). Administrative permission was obtained from the hospital authorities. Written informed consent was obtained from all participating nurses before enrolment. Patient confidentiality was maintained throughout the study, and ultrasound assessments were integrated into routine emergency care without interfering with standard clinical management.

Statistical Analysis

Data were analysed using IBM SPSS Statistics version 31 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarise participant characteristics and competency scores. Continuous variables are presented as mean $\pm$ standard deviation (SD) or median with interquartile range (IQR), depending on data distribution, while categorical variables are expressed as frequencies and percentages.

Changes in competency scores before and after the intervention were evaluated using the Wilcoxon signed-rank test, given the ordinal nature of the competency scale. The magnitude of improvement was further described using descriptive statistics and competency distribution across score categories. Statistical significance was set at $p < 0.05$.

Results

Participant Characteristics

A total of 30 emergency nurses participated in the study, and all completed both the pre-intervention and post-intervention assessments. Each nurse independently performed IVC assessments on 20 trauma patients before and 20 trauma patients after the educational intervention, so competency evaluation was based on 1,200 clinical observations, comprising 600 pre-intervention and 600 post-intervention assessments.

The mean age of participants was 28.2 ± 3.4 years, with most nurses having fewer than five years of emergency department experience. Only 10% had previously received formal education or training in point-of-care ultrasound, indicating limited baseline exposure to ultrasonography before participation in the NISt programme.

Clinical Competency in IVC Assessment

Clinical competency in IVC assessment was evaluated using a validated observational checklist comprising two skill components – identification and measurement of the IVC diameter, and identification of IVC wall kissing (collapsibility) – each scored on a five-point rating scale (1–5), resulting in a combined competency score ranging from 2 to 10, with higher scores indicating better clinical competency.

Table 2. Distribution of Combined IVC Competency Scores per Clinical Observation (n = 600 pre-intervention; n = 600 post-intervention)

Combined Competency Score	Pre-test n (%)	Post-test n (%)
2	560 (93.3)	1 (0.2)
3	19 (3.2)	0 (0.0)
4	21 (3.5)	42 (7.0)
5	0 (0.0)	46 (7.7)
6	0 (0.0)	66 (11.0)
7	0 (0.0)	313 (52.2)
8	0 (0.0)	85 (14.2)
9	0 (0.0)	46 (7.7)
10	0 (0.0)	1 (0.2)

At the level of individual clinical observations, the large majority of pre-intervention assessments (93.3%) recorded a combined competency score of 2, reflecting unsatisfactory technique across both domains; smaller proportions scored 3 (3.2%) or 4 (3.5%). Following implementation of the NIST programme, scores shifted markedly toward the upper end of the scale: 52.2% of post-intervention observations scored 7, with a further 14.2% scoring 8 and 7.7% scoring 9. A smaller proportion of post-intervention observations (7.0% scoring 4, 7.7% scoring 5, and single observations at 2 and 10) remained below or at the margins of the competency threshold, indicating that, while improvement was substantial and consistent, performance was not uniform across every assessment.

Table 3. Comparison of Nurse-Level Mean IVC Competency Scores Before and After the NIST Programme (n = 30; mean of 20 paired clinical observations per nurse)

Variable	Pre-test	Post-test
Mean ± SD	2.10 ± 0.34	6.82 ± 0.76
Median (IQR)	2.00 (2.00–2.05)	7.03 (6.58–7.20)
Minimum–Maximum	2.00–3.90	4.45–7.80

The mean nurse-level competency score increased by 4.72 points, demonstrating a marked improvement in nurses' ability to perform focused IVC ultrasonography following the intervention.

Table 4. Comparison of Nurse-Level Clinical Competency Scores Using the Wilcoxon Signed-Rank Test (n = 30)

Variable	Median (IQR)	Z value	p-value
Pre-test	2.00 (2.00–2.05)	-4.78	<0.001*
Post-test	7.03 (6.58–7.20)		

*Statistically significant at $p < 0.05$.

The Wilcoxon signed-rank test, applied to nurse-level mean scores to account for the repeated-measures structure of the data, demonstrated a statistically significant improvement in clinical competency following implementation of the NIST programme ($Z = -4.78$, $p < 0.001$). The shift in median competency score from 2.00 before the

intervention to 7.03 after the intervention indicates substantial improvement in emergency nurses' ability to perform focused IVC ultrasonography.

Competency Achievement

Competency was predefined as a mean combined score of ≥ 6 across a nurse's 20 paired observations.

Table 5. Competency Achievement Among Emergency Nurses (n = 30)

Competency Level	Pre-test n (%)	Post-test n (%)
Competent (≥ 6)	0 (0.0)	26 (86.7)
Not competent (< 6)	30 (100.0)	4 (13.3)

None of the nurses met the predefined competency criterion before the intervention. Following competency-based education and supervised clinical practice, the large majority of nurses (86.7%, 26/30) achieved the predefined competency threshold. Four nurses (13.3%) did not reach a mean score of 6 despite completing the full educational and supervised practice programme; this variability is addressed further in the Discussion and Limitations.

Reliability of the Competency Assessment Tool

Table 6. Validity and Reliability of the Observational Checklist

Parameter	Value
Content Validity Index (CVI)	0.85
Cohen's Kappa (κ)	0.90
Expert agreement	0.86–0.96
Percentage agreement	90%

The observational checklist demonstrated excellent content validity and inter-rater reliability, supporting the consistency and accuracy of competency assessment.

Overall, clinical competency in IVC assessment improved markedly following the NIS programme: scores shifted from predominantly unsatisfactory performance at baseline to predominantly satisfactory-to-good performance after the intervention, with 26 of 30 nurses (86.7%) meeting the predefined competency threshold post-intervention.

Discussion

This study evaluated emergency nurses' clinical competency in IVC ultrasonography following implementation of the NIS programme. Competency scores increased significantly from a mean of 2.10 ± 0.34 before the intervention to 6.82 ± 0.76 after the intervention ($p < 0.001$), and the large majority of participating nurses (86.7%, 26/30) achieved the predefined competency threshold. These findings support the feasibility of integrating focused IVC ultrasonography into emergency nursing practice through a structured competency-based educational approach, while also indicating that a minority of nurses required more than the standard programme to reach full competency.

The low baseline competency observed in the present study was expected, as none of the participating nurses had received formal education in focused IVC ultrasonography before enrolment. Although emergency nurses routinely participate in trauma assessment, conventional nursing education rarely includes structured training in POCUS, consistent with recent multi-professional survey data showing that a lack of training remains one of the most significant barriers to POCUS use among non-physician emergency staff.¹² Most participants accordingly had difficulty identifying the IVC and applying appropriate scanning technique during the pre-intervention assessment. Comparable findings have been reported internationally: novice clinicians without prior ultrasound exposure typically demonstrate limited baseline competency and a discernible learning curve before structured educational input, while prior ultrasound experience has been shown to strongly influence baseline performance and structured education to accelerate skill acquisition.^{4,7}

Following implementation of the NISt programme, nurses demonstrated marked improvement across both assessed domains – measurement of IVC diameter and identification of IVC wall kissing. This improvement is likely attributable to the multimodal educational strategy employed, which combined theoretical instruction, live demonstration, return demonstration, and supervised bedside practice. Competency-based education emphasises repeated deliberate practice with immediate feedback, allowing learners to progressively refine psychomotor performance and image interpretation; structured image acquisition, supervised scanning, competency assessment, and ongoing quality assurance are similarly recognised as essential components of ultrasound training and credentialing more broadly.⁸

The high rate of competency attainment observed after the intervention is clinically important: the large majority of nurses (86.7%) achieved a mean combined score of at least six, indicating satisfactory performance in both IVC measurement and recognition of IVC wall collapsibility. Competency in these two domains is fundamental, since accurate visualisation of the IVC and interpretation of respiratory variation are prerequisites for reliable assessment of intravascular volume status. At the same time, four nurses (13.3%) did not reach the predefined threshold despite completing the full educational and supervised practice programme, underscoring that a single standardised intervention may not bring every learner to competency at the same pace and that individualised remediation or extended supervised practice may be warranted for a subset of trainees. Focused IVC ultrasonography has previously been shown to provide valuable information regarding fluid responsiveness and haemodynamic compromise in trauma and critically ill patients, and can be rapidly incorporated into bedside clinical evaluation to facilitate early recognition of hypovolaemia and guide resuscitation decisions.⁵

These findings are consistent with growing evidence supporting the expansion of ultrasound competency beyond physicians. Nurses, paramedics, and advanced practice providers have been shown to achieve competency in focused POCUS applications following structured education and supervised clinical practice, and competency-based educational programmes have been associated with significant improvements in image acquisition, interpretation accuracy, and clinical confidence among non-physician healthcare professionals. Internationally, nurse-performed POCUS is increasingly discussed not as a niche skill but as an emerging core competency, with dedicated professional networks and research infrastructure now supporting its development.^{17,18} A recent scoping review mapping the clinical competencies required for nurses to use POCUS similarly found that, while technical and procedural performance is often well described, competencies related to clinical reasoning and autonomous decision-making remain inconsistently defined and rarely supported by structured assessment strategies – an observation that reinforces the value of the present study's use of a validated, reliability-tested observational checklist.¹⁸ This reinforces the concept that successful implementation depends more on structured competency assessment than on professional background alone.

A particular strength of the present analysis is that competency was evaluated during 1,200 real clinical observations rather than solely in a simulation laboratory, so the observed improvements are likely to reflect genuine clinical competency under routine emergency department conditions rather than isolated simulation performance.

These findings also carry practical implications for emergency nursing. Emergency departments worldwide continue to experience increasing patient volumes and prolonged waiting times. Incorporating focused IVC ultrasonography into the role of appropriately trained emergency nurses may facilitate earlier recognition of haemodynamic instability while complementing physician assessment. Rather than replacing physician-performed ultrasound, NISt has the potential to enhance multidisciplinary trauma care by providing rapid bedside information that supports timely clinical decision-making and prioritisation of patient management.

Overall, the present study demonstrates that emergency nurses can successfully acquire competency in focused IVC ultrasonography through the NISt programme. The significant improvement in competency scores, together with attainment of the predefined competency threshold by the large majority of nurses, supports the integration of competency-based ultrasound education into emergency nursing curricula and continuing professional development, and contributes to the expanding evidence base for nurse-performed point-of-care ultrasound as a feasible and clinically relevant component of emergency care.

Clinical Implications

The significant improvement in emergency nurses' competency in IVC assessment demonstrates that focused haemodynamic ultrasonography can be successfully incorporated into the NISt programme through a structured competency-based educational approach. As emergency departments continue to experience increasing patient

volumes and resource constraints, empowering nurses with focused ultrasound competency may facilitate earlier recognition of haemodynamic instability and support timely clinical decision-making.

Competency in IVC ultrasonography has the potential to complement conventional trauma assessment by providing objective bedside information regarding intravascular volume status. Although nurse-performed IVC assessment is not intended to replace physician-performed comprehensive ultrasonography, it may serve as an adjunctive assessment tool that enhances interdisciplinary collaboration and promotes more efficient patient prioritisation during emergency care. The findings also support the inclusion of focused ultrasound competency within postgraduate emergency nursing curricula and continuing professional development programmes.

Strengths of the Study

This study has several notable strengths. First, competency was evaluated during 1,200 real-world clinical observations, providing evidence of performance under routine emergency department conditions rather than simulated environments. Second, the study employed a validated observational checklist with excellent inter-rater reliability ($\kappa = 0.90$) and high expert agreement (0.86–0.96), ensuring consistency in competency assessment. Third, the competency-based educational programme integrated theoretical instruction, demonstration, return demonstration, and supervised bedside practice, reflecting contemporary principles of competency-based clinical education. Finally, the study addresses an important gap in emergency nursing literature by evaluating nurse competency in focused IVC ultrasonography as part of the broader NISt programme.

Limitations

The study should be interpreted in light of several limitations. It was conducted in a single tertiary care emergency department, which may limit the generalisability of the findings to other healthcare settings. The quasi-experimental one-group pre-test–post-test design did not include a control group, limiting causal inference. Although competency was assessed across a large number of clinical encounters, only 30 nurses participated in the study, and four of these nurses (13.3%) did not reach the predefined competency threshold within the standard programme timeframe; this study was not designed to identify the individual or patient-related factors underlying this variation, and the reasons warrant dedicated investigation. Furthermore, competency was evaluated immediately following supervised clinical practice, and long-term retention of IVC ultrasonography skills was not examined. Future multicentre studies involving larger samples and extended follow-up are recommended to evaluate sustained competency, the factors associated with slower skill acquisition, translation into independent clinical practice, and the influence of nurse-performed IVC assessment on patient-centred outcomes.

Conclusion

Emergency nurses achieved substantial improvement in clinical competency in IVC assessment following implementation of the NISt programme. Competency scores improved significantly after competency-based education and supervised clinical practice, with the large majority of participating nurses (86.7%, 26/30) attaining the predefined competency threshold, indicating that most emergency nurses can successfully acquire the technical and interpretative skills required to perform focused IVC ultrasonography within the emergency department, although a minority may require additional training time or support.

The integration of focused IVC assessment into NISt represents a promising strategy to strengthen emergency nursing practice by complementing conventional clinical assessment with objective bedside ultrasonography. While further multicentre research is required to establish long-term competency retention and evaluate impact on patient outcomes, the present findings support the feasibility of incorporating competency-based ultrasound education into emergency nursing practice.

Future Research

Future research should investigate long-term retention of IVC ultrasonography competency among emergency nurses, evaluate competency across diverse healthcare settings, and examine the effect of NISt on clinical decision-making, patient flow, and patient-centred outcomes. Comparative studies involving different competency-based educational models and multicentre implementation strategies would further strengthen the evidence supporting nurse-performed point-of-care ultrasound.

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Conflict of Interest

The authors declare that there are no conflicts of interest related to this study.

Data Availability

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

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