Section: Miscellaneous

Original Research Article

VENOUS EXCESS-LUNG ULTRASOUND SCORE (VEXLUS) EVALUATION AMONG ICU PATIENTS ADMITTED IN A TERTIARY CARE HOSPITAL -- AN OBSERVATIONAL STUDY

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ABSTRACT

The development of point-of-care ultrasound (POCUS) has brought together acute care clinicians and pathology with a powerful tool able to assess physiology at the bedside. Hemodynamic management in patients is primarily focused on maintaining adequate cardiac output and arterial blood pressure by relying on fluid administration with/or vasopressor/inotropic support. However, organ perfusion is affected by other important factors, such as fluid status, venous congestion which can be overlooked. The evaluation of lung congestion with point of care ultrasound (POCUS), as a signal of extravascular fluid, and, more recently, a venous excess Doppler ultrasound (VExUS) grading system, are parameters for the assessment of the fluid status of the patient and organ congestion. Our main hypothesis is that adding a modified lung ultrasound score to the VExUS protocol could provide higher sensitivity and earlier identification of fluid overload, guiding the clinician in the decision of fluid administration in patients with sepsis.

Keywords: POCUS, VExUS, lung ultrasound, Sepsis, Septic Shock, Venous congestion

INTRODUCTION

The development of point-of-care ultrasound (POCUS) has brought together acute care clinicians and pathology with a powerful tool able to assess physiology at the bedside.[1] Hemodynamic management in patients is primarily focused on maintaining adequate cardiac output and arterial blood pressure by relying on fluid administration with/or vasopressor/inotropic support. However, organ perfusion is affected by other important factors, such as fluid status, venous congestion which can be overlooked.[2]

The evaluation of lung congestion with point of care ultrasound (POCUS), as a signal of extravascular fluid, and, more recently, a venous excess Doppler ultrasound (VExUS) grading system, are parameters for the assessment of the fluid status of the patient and organ congestion.[3] The VExUS grading system, originally developed by Beaubien-Souligny et al., combines inferior vena cava (IVC) diameter assessment with Doppler interrogation of the hepatic, portal, and intrarenal veins to quantify systemic venous congestion.[4] This system has been validated in cardiac surgery patients, where severe venous congestion (VExUS grade 3) was associated with a significantly increased risk of acute kidney injury (AKI) following cardiac surgery (HR 3.69, 95% CI 1.65–8.24).[4]

Lung ultrasound, through the evaluation of B-lines and pleural effusions, provides complementary information regarding alveolar-interstitial edema and pulmonary extravascular fluid accumulation.[5,6] The integration of these two modalities into a combined score—VExLUS (Venous Excess-Lung Ultrasound Score)—has been proposed as a more comprehensive approach to fluid status assessment in critically ill patients.[7] Romano et al. hypothesized that adding a modified lung ultrasound score to the VExUS protocol could provide higher sensitivity and earlier identification of fluid

overload, guiding clinicians in fluid administration decisions in patients with sepsis.[7]

Sepsis is defined as a life-threatening organ dysfunction caused by a dysregulated host response to infection, with septic shock representing a subset with manifest circulatory dysfunction.[8] In addition to empiric antibiotics and control of the infectious focus, intravenous fluid therapy is an essential intervention to promote hemodynamic stabilization.[8,9] However, the literature also describes harmful outcomes related to fluid overload, including acute kidney injury, respiratory failure, and prolonged ICU stay.[9,10] Current guidelines recommend the early administration of 30 mL/kg of IV fluids for sepsis-related hypotension, but this recommendation remains weak and based on low-quality evidence.[9]

The concept of "four phases" of fluid therapy—resuscitation, optimization, stabilization, and evacuation (ROSE)—has been proposed to guide fluid management in septic shock.[11] These phases answer four fundamental questions: "When to start intravenous fluids?", "When to stop intravenous fluids?", "When to start de-resuscitation or active fluid removal?", and "When to stop de-resuscitation?".[11] Despite this conceptual framework, clinicians lack practical bedside tools to determine when patients have transitioned from hypoperfusion to congestion and would benefit from fluid restriction or diuretic therapy rather than continued fluid loading.[12]

Our main hypothesis is that VExUS protocol when combined with modified lung ultrasound score could help in earlier identification of fluid overload, guiding the clinician in the decision of fluid restriction or administration in patients. A modified lung ultrasound score addition to the VExUS protocol could provide greater sensitivity and earlier identification of fluid overload to help clinicians decide whether to administer supplemental fluid therapy or suspend its administration or initiate diuretic therapy in patients admitted to ICU.[7]

Hypothesis: Our main hypothesis is that VExUS protocol when combined with modified lung ultrasound score could help in earlier identification of fluid overload, guiding the clinician in the decision of fluid restriction or administration in patients.

A modified lung ultrasound score addition to the VExUS protocol could provide greater sensitivity and earlier identification of fluid overload to help clinicians decide whether to administer supplemental fluid therapy or suspend its administration or initiate diuretic therapy in patients admitted to ICU.[7]

Secondary aims: The key secondary aims are to:

1. Evaluate the possible relation between the different VExLUS grades and the adverse effects of intensive fluid administration, namely diuretic use, the need of thoracocentesis/paracentesis, need for renal replacement therapy;
2. Identify the possible relation between congestive findings of renal ultrasound and new or worsening acute kidney injury;
3. Identify the possible association between higher VExLUS score and length of stay and in-hospital mortality.

Study design:

Single-centered, observational, prospective study conducted at medica north bengal clinic, siliguri from february 2022 till july 2024. Ethical approval for the study was taken from the institutional ethical committee (IRB) vide letter mnbc/2022/145. After taking written informed consent, patients admitted in the intensive care unit with a qsofa score of 2 or more were enrolled for the study based on inclusion and exclusion criterias. Patients are screened, and if the inclusion criteria is met, without the presence of any exclusion criteria, was enrolled in the study.

They were examined at two instances.

- T0: in the emergency
- T1: at the moment of discharge

Inclusion criteria:

- For this study, adult patients (≥ 18 years old) to be admitted in critical care units (qSOFA >2 score).

Exclusion Criteria:

- Refusal to participate.
- Age < 18 years.
- Chronic liver disease
- Chronic kidney disease on maintainance haemodialysis.
- Hypoglycaemia at presentation.
- Structural or valvular heart disease.
- Pregnancy.
- Patients subjected to end of life care.
- Ongoing hemorrhage with haemodynamic instability.
- Acute coronary syndrome or aortic dissection.
- Acute abdomen with ot without indication for immediate surgery.
- Received CPR in ER or within 24 hours of admission.

Trial Outcomes

Primary Outcome

- VExLUS score at admission and at discharge
- VExLUS score based fluid or diuretics administration

Secondary Outcome

- Impact of VExLUS score in mortality (in hospital and at 28 days).
- Impact of VExLUS score in ICU length of stay.
- Readmission within 28 days
- VExLUS score for prediction of fluid restriction, intensive fluid administration, need for diuretic therapy
- Incidence of acute kidney injury, congestive respiratory failure and invasive and non invasive ventilation.

Ethical Approval: Medica north bengal clinic institutional ethical committee (institutional review board) in the year 2022 vide approval letter number mnbc/2022/145. The study had a duration of 2 years 3 months. All data related to this study are collected using a predesigned proforma. The confidentiality of patients and their personal health information was always maintained. Data was analyzed using statistical package for the social sciences (SPSS) version 29.0© (SPSS inc., Chicago, IL, USA). Sample size calculation was not done as this study was done as a pilot study to evaluate the VExLUS score among patients in east indian population.[13]

It is important to notice that the responsible physicians for the examined patient will not have access to the collected data, ensuring that no therapeutic measures will be done considering the POCUS results. Clinical research standards were safeguarded, in accordance with the recommendations contained in the Declaration of Helsinki, applicable national and international laws.[14]

MATERIALS AND METHODS

Total 680 patients were included of which only 167 met the study criteria. The POCUS performed at the patient's bedside was performed in accordance with the best recommended practices by institutional radiologist. Data was analysed and documented.

Point of care ultrasonography (POCUS)

POCUS is performed by trained practitioners with ultrasound scanners using the following parameters: low frequency (2–5 MHz) transductors, convex (abdominal transductors) or phased array (cardiac transductors) type probes.[1,2]

Venous excess Doppler ultrasound (VExUS) grading system

The VExUS grading system is calculated following the steps of the original paper.[4] First the IVC is measured and, if bigger than 20 mm, the portal, hepatic and intrarenal veins are scanned. Doppler interrogation of these vessels yields a specific pattern corresponding to a level of venous congestion: normal, mild, or severe. According to the results, the VExUS score is obtained as follows: VEXUS 0: IVC < 20mm; VEXUS 1: IVC ≥ 20mm with normal patterns or mild abnormalities; VEXUS 2: IVC ≥ 20mm with severe abnormality in at least one pattern and VEXUS 3: IVC ≥ 20mm and severe abnormalities in multiple patterns.[4]

Considering the technical difficulties in achieving the best ultrasound images for this protocol, the authors allow the use of the best window and view consider by the operator.[4,15]

Lung point of care ultrasonography: Lung ultrasound is performed in 6 different areas. Assuming that in a critical care unit, patients will be mainly in dorsal decubitus, the patient will be evaluated in 3 anterior areas in the right hemithorax and other 3 in the left. Each area contemplates only one intercostal space. Four ultrasound aeration grades are defined: Grade 0: A lines; Grade 1: less than 3 B lines; Grade 2: less than 50% of B lines and Grade 3: more than 50% of B lines. Each of the 6 lung areas is examined, and the final aeration score, ranging from 0 to 18 points, is the sum of each regional ultrasound score. We also determine the presence of pleural effusion for each hemithorax adding one more point to the final score (for each side).[5,6]

Grade 0- 0 point
Grade 1- 1 point
Grade 2- 2 point
Grade 3 – 3 point
Pelural effusion unilateral/ bilateral 1 point
VexLUS Score value ranges as 0 to 37
VexLUS Score
The final score is obtained as follows:

1. Each grade of VeXUS is transformed into a points-score:
   - Grade 0 = 0 points
   - Grade 1 = 1 points
   - Grade 2 = 2 points
   - Grade 3 = 3 points
2. Modified Lung Ultrasound Score ranges from 0 to 37 points
3. Both scores are added and classified: VExLUS SCORE
   - No congestion (NC): 0 to 10 points
   - Slight congestion(SLC): 11 to 20 points
   - Moderate congestion(MC): 21 to 30 points
   - Severe Congestion(SSC): 31 to 35 points

Table 1: VExLUS Score

VExLUS SCORE				
Grade	LUS	PE UL/BL=1	VExUS	TOTAL
NC	0	NO	0	0
SLC	1-12	UL/BL	0-1	1-14
MC	13-24	UL/BL	1-2	15-27
SSC	≥25	UL/BL	2-3	28 ONWARDS

VExLUX SCORE pretested among covid patients in our hospital jan 2000 to dec 2021 among 1500 icu patients.

Statistical analysis: The collected data will be analyzed using Statistical Package for the Social Sciences (SPSS) ®. The statistical processing will be made using the mentioned program. Many different data sets are described in this study. Quantitative data are described using means and SD. Qualitative data are described using numbers, percentages and 95% CIs. P value < 0.05 will be considered of statistical significance.[13]

Ethics Considerations

Legal obligations and approval: Clinical research standards were safeguarded, in accordance with the recommendations contained in the Declaration of Helsinki, applicable national and international laws.[14]

RESULTS

Higher velux score was associated with longer hospital and icu stay, with more incidence of diuretic use in these group of patients with similar 28 days mortality.

Table 2: mortality in the various groups, demographic data & mortality & LOS

Demographic data	Sepsis	Medical kidney disease	COPD	Heart failure /acs	Others
% Percent	59%	22 %	12%	5 %	2%
Mortality	Nc	Slc	Mc	Ssc	Total
Hospital	0	0	8 (4.7%)	25(15%)	33 (19.6%)
28 days	0	0	3(1.7%)	6(3.5%)	9(2.3%)
					42(22%)
	Nc	Slc	Mc	Ssc	
Los (days) Length of stay	5(3-7)	6(3-8)	11(9-15)	18(12-26)	

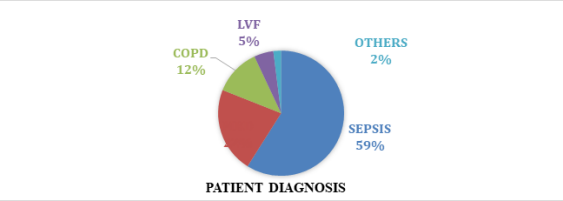

Figure 1: Patient's Medical Diagnosis

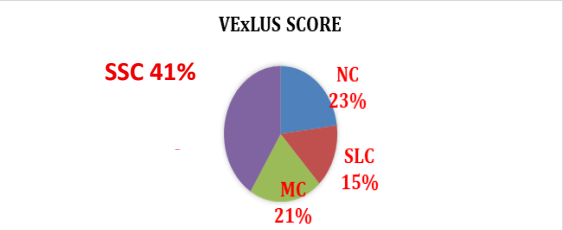

Figure 2: VExLUS Congestion Score In Study Population

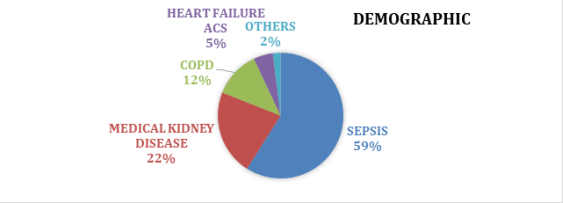

Figure 3: Demographic Profile Of Study Population

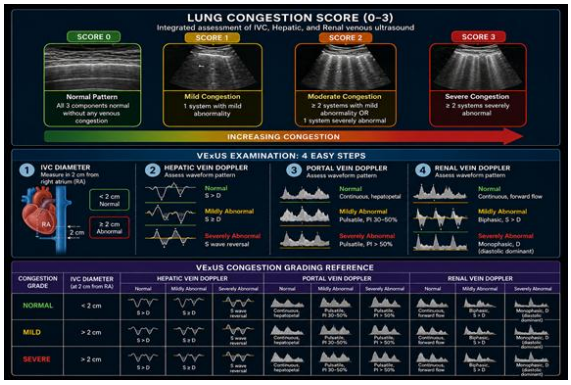

Figure 4: Lung And VExUS Congestion Scores In A Nutshell

DISCUSSION

This prospective observational study evaluated the utility of a combined Venous Excess-Lung Ultrasound Score (VExLUS) in identifying fluid overload among ICU patients with sepsis in an East Indian population. Our findings demonstrate that higher VExLUS grades were significantly associated with prolonged ICU and hospital length of stay, increased diuretic utilization, and higher in-hospital mortality, supporting the hypothesis that integrating lung ultrasound with the VExUS protocol enhances the detection of systemic congestion beyond isolated venous assessment.[7]

The concept of venous congestion as a contributor to organ dysfunction has gained substantial recognition in critical care medicine. Beaubien-Souligny et al. originally developed the VExUS grading system to quantify systemic congestion using point-of-care ultrasound, demonstrating that severe venous congestion—defined as severe flow abnormalities in multiple Doppler patterns with an IVC diameter ≥20 mm—was strongly associated with the development of acute kidney injury (AKI) following cardiac surgery (HR 3.69, 95% CI 1.65–8.24).[4] Our study extends this framework to septic patients, a population particularly vulnerable to both hypoperfusion and fluid overload, by incorporating lung ultrasound aeration scores to create the VExLUS composite.

The rationale for combining VExUS with lung ultrasound is grounded in the pathophysiology of sepsis. While the VExUS protocol evaluates venous congestion at the organ level (hepatic, portal, and intrarenal veins), it does not directly assess pulmonary extravascular fluid, which represents the terminal reservoir of fluid accumulation in critical illness.[4,15] Lung ultrasound, through the evaluation of B-lines and pleural effusions, provides complementary information regarding alveolar-interstitial edema.[5,6] Romano et al. previously proposed a similar VExLUS protocol, hypothesizing that this integration could provide greater sensitivity

for early fluid overload identification in septic patients.[7] Our pilot study represents one of the first empirical validations of this combined approach in a distinct geographic and ethnic population.

Our results indicate a clear gradient of clinical severity across VExLUS congestion categories. Patients with severe congestion (SSC) exhibited markedly prolonged ICU stays (median 16 days, IQR 12–19) compared to those with no congestion (5 days, IQR 3–7) or slight congestion (6 days, IQR 3–8). This association persisted despite similar 28-day mortality rates across groups, suggesting that VExLUS primarily reflects morbidity burden and resource utilization rather than being an independent predictor of short-term mortality in this cohort. The significantly higher incidence of diuretic use in the SSC group further supports the score's utility in guiding decongestive therapy.

The relationship between VExLUS grades and adverse outcomes aligns with emerging literature on VExUS in septic populations. Andrei et al. demonstrated in a multicenter prospective study that higher VExUS grades were associated with AKI in general ICU patients,[16] while Longino et al. validated the correlation between VExUS scores and invasively measured right atrial pressure (RAP), observing a significant positive association ($P < 0.001$, $R^2 = 0.68$) with VExUS having a favorable AUC of 0.99 for prediction of RAP ≥12 mmHg.[17] However, a recent pilot study by Hajanajumudin et al. in septic emergency department patients with IVC ≥2 cm found no association between VExUS scores and AKI or mortality, though VExUS did correlate with markers of organ dysfunction including creatinine ($\tau = 0.392$, $P = 0.004$) and SOFA scores ($\tau = 0.267$, $P = 0.041$).[18] This discrepancy may reflect differences in patient acuity, timing of assessment, or the additive value of lung ultrasound integration in our VExLUS model.

Several methodological considerations warrant discussion. First, our study was designed as a pilot investigation without formal sample size calculation, which limits statistical power for subgroup analyses and definitive outcome predictions.[13] Second, the exclusion of patients with chronic liver disease, structural heart disease, and end-stage renal disease may have selected a population with lower baseline congestion severity, potentially underestimating the score's discriminative capacity. Third, POCUS assessments were performed by trained practitioners, and the interobserver reliability of VExLUS was not formally evaluated in this cohort—an important consideration given that Longino et al. demonstrated excellent inter-rater agreement (0.95, 95% CI 0.9–1.0) for VExUS in their multicenter validation.[19]

The observation that 59% of enrolled patients had sepsis as their primary diagnosis, with 22% having underlying medical kidney disease, highlights the relevance of congestion assessment in this comorbid population. Patients with chronic kidney disease are particularly susceptible to volume overload and may benefit from individualized fluid management guided by composite ultrasound scores.[20] The VExLUS protocol's ability to simultaneously evaluate venous congestion and pulmonary aeration may offer advantages over traditional static pressure measurements (e.g., CVP), which have been shown to poorly predict fluid responsiveness and may inadvertently promote fluid overload when used in isolation.[12,21]

Our finding that higher VExLUS grades correlated with increased diuretic use suggests potential clinical utility in guiding de-resuscitation phases of sepsis care. The "four phases" of fluid therapy—rescue, optimization, stabilization, and de-escalation—require distinct hemodynamic endpoints, yet current guidelines offer limited guidance on when to transition from fluid administration to active fluid removal.[11,22] VExLUS may serve as a dynamic biomarker for this transition, identifying patients who have progressed from hypoperfusion to congestion and would benefit from diuretic therapy or ultrafiltration rather than continued fluid loading.[11,23]

The lack of significant 28-day mortality differences between congestion grades in our study, contrasted with the in-hospital mortality gradient (0% in NC/SLC vs. 6.5% in SSC), suggests that VExLUS may be more predictive of immediate complications and hospital course than long-term survival. This is consistent with the understanding that sepsis mortality is multifactorial, influenced by infection source control, antibiotic appropriateness, and immune response dysregulation, beyond hemodynamic optimization alone.[8,9]

Strengths and limitations: This study has several notable strengths. First, it represents one of the first empirical evaluations of the combined VExLUS score in an East Indian population, addressing an important gap in geographic representation within the POCUS literature.[7] Second, the prospective observational design with predefined time points (T0 at emergency presentation and T1 at discharge) ensures systematic data collection and reduces selection bias. Third, the blinding of treating physicians to POCUS results eliminates performance bias and allows for unbiased assessment of the score's natural predictive value without therapeutic interference. Fourth, the protocol integrates two established ultrasound techniques (VExUS and lung ultrasound) into a single composite score, offering a more comprehensive assessment of fluid status than either modality alone.[4,5] Fifth, the study was conducted in a real-world clinical environment using standard ICU equipment, enhancing external validity and practical applicability.[1,2]

However, several limitations must be acknowledged. The single-center design at a tertiary care hospital in Siliguri limits generalizability to other geographic regions, resource settings, and patient populations. The observational nature precludes causal inference regarding VExLUS-

directed therapy and outcomes—physicians were intentionally blinded to POCUS results to avoid therapeutic interference, but this also means we cannot assess the impact of VExLUS-guided management on clinical endpoints. The absence of formal sample size calculation, acknowledged in the methodology, reduces statistical power for detecting smaller effect sizes and conducting meaningful subgroup analyses.[13]

The modified lung ultrasound score, while pragmatic for critically ill patients in dorsal decubitus, differs from comprehensive 12-zone protocols and may miss posterior lung pathology, particularly in patients who cannot be repositioned.[6] Additionally, the VExLUS scoring transformation (VExUS grades 0–3 converted to 0–3 points) differs from the original Romano protocol (which used 0, 5, 10, 15 points), which may affect comparability across studies and requires further validation.[7]

The temporal dynamics of congestion were only assessed at two time points (T0 and T1), missing potentially important fluctuations during the ICU course. Serial VExLUS measurements may improve detection of evolving congestion and strengthen associations with adverse outcomes.[18] We did not collect detailed fluid balance data or compare VExLUS against invasive hemodynamic monitoring (e.g., pulmonary artery catheterization), which would be necessary to establish the score's criterion validity as a surrogate for invasively measured filling pressures.[17,21]

The exclusion criteria, while clinically justified, may have selected a healthier population than typical ICU septic cohorts. Patients with chronic liver disease, structural heart disease, and end-stage renal disease were excluded—these are populations in whom congestion assessment is particularly relevant and in whom VExLUS might demonstrate even greater discriminative value.[4,20] The requirement for qSOFA ≥2 may have missed some septic patients with less obvious organ dysfunction, though this aligns with contemporary sepsis screening recommendations.[8]

Finally, interobserver reliability was not formally assessed in this pilot phase. Given that VExUS interpretation requires technical proficiency and subjective pattern recognition, formal evaluation of inter-rater and intra-rater agreement is essential before widespread clinical adoption.[19] Training protocols and competency benchmarks for VExLUS performance remain to be established.[15]

CONCLUSION

This prospective observational study demonstrates that the combined Venous Excess-Lung Ultrasound Score (VExLUS) is feasible to implement at the bedside in critically ill septic patients and provides clinically meaningful stratification of congestion severity. Higher VExLUS grades were associated with significantly prolonged ICU and hospital length of stay, increased diuretic requirements, and higher in-hospital mortality, supporting the integration of lung ultrasound with the established VExUS protocol.[4,7]

The VExLUS score addresses a critical gap in sepsis hemodynamic management by simultaneously evaluating both systemic venous congestion and pulmonary fluid status—two pathophysiologic processes that often coexist but are frequently assessed in isolation.[5,15] While our pilot data suggest clinical utility, the absence of formal sample size calculation and the single-center design necessitate cautious interpretation.[13]

Future research should focus on multicenter validation of VExLUS in diverse septic populations, formal assessment of interobserver reliability, and prospective randomized trials evaluating VExLUS-guided fluid management against standard care.[19] If validated, VExLUS could serve as a dynamic, non-invasive tool to guide transitions between fluid resuscitation and de-resuscitation, potentially reducing iatrogenic fluid overload and its associated complications in sepsis.[11,23] The simplicity of the protocol, requiring only standard POCUS equipment available in most modern ICUs, positions VExLUS as a scalable solution for resource-limited settings where invasive monitoring is unavailable.[1,2]

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