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Use of VExUS Score to Identify Prevalence of Venous Congestion in Patients Admitted to ICU

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Abstract:

Background: Venous congestion is vital sign in critically ill patients, contributing significantly to morbidity and mortality but is often less acknowledged/under recognized. The Venous Excess Ultrasound Score (VExUS) has emerged as a promising tool for its identification and quantifica- tion. **Methods: A** prospective observational study was conducted on 260 patients admitted to the Intensive Care Unit (ICU). The VExUS scoring using bedside ultrasound was utilized to assess the prevalence of venous congestion. Patients were evaluated within the first 24 hours of admis- sion using a comprehensive ultrasound protocol. **Results:** The prevalence of venous congestion, as identified by the VExUS score, its correlation with clinical outcomes such as length of stay in the ICU, kidney function, and mortality rates were discussed. **Conclusion:** This study highlights the significance of VExUS score as a reliable method for the early detection of venous conges- tion in ICU patients thereby potentially guiding therapeutic interventions to improve clinical out- comes.

Keywords: Venous Congestion, VExUS Score, Intensive Care Unit

Introduction

Venous congestion in critically ill patients is a pivotal factor that adversely affects organ function and patient prognosis. Despite its significance, the diagnosis of venous congestion in the Intensive Care Unit (ICU) setting remains challenging due to the limitations of traditional clinical assessments and imaging techniques. Recent advancements have led to the development of the Venous Excess Ultrasound Score (VExUS), a novel ultrasound-based tool designed to quantify venous congestion by assessing venous waveforms obtained by doing bedside ultrasound scan. This tool has shown potential in identifying patients at risk of developing complications related to venous congestion, such as acute kidney injury (AKI), thereby facilitating early intervention and potentially improving clinical outcomes.[1][2][3]

The pathophysiology of venous congestion involves increased venous pressure, which can lead to organ dysfunction due to impaired venous return and congestion. This condition is particularly

detrimental in the ICU setting, where patients are at a high risk of developing multi-organ failure. The VExUS score, through its assessment of the hepatic vein, portal vein and intrarenal veins, and the inferior vena cava, offers a comprehensive evaluation of the venous system, providing insights into the patient's volume status and venous pressure.[4][5]

The relevance of venous congestion in critical care is underscored by its association with increased mortality, prolonged ICU stay, and the development of complications such as AKI and cardiac dysfunction. Traditional methods for assessing venous congestion, including clinical examination and biomarkers, have been inadequate in identifying patients at an early stage, thus emphasizing the need for more reliable and early diagnostic tools like the VExUS score.[6][7][8]

This introduction sets the stage for a detailed exploration of how the VExUS score can be employed in the ICU to identify patients with venous congestion, its implications for patient management, and the potential benefits of its application in critical care.[9]

Aim

To assess the prevalence of venous congestion in patients admitted to the ICU using the VExUS score.

Objectives

1. To determine the utility of the VExUS score in identifying venous congestion within 24 hours of ICU admission.
2. To correlate the VExUS score with clinical outcomes, including length of ICU stay, kidney function, and mortality.
3. To evaluate the feasibility and reliability of implementing the VExUS score as a routine assessment tool in the ICU setting.

Material and Methodology

Source of Data: Patients admitted to the ICU over a specified period served as the source of data for this study.

Study Design: A prospective observational study design was employed to assess the prevalence of venous congestion using the VExUS score among ICU patients.

Sample Size: The study included a total of 260 patients admitted to the ICU.

Inclusion Criteria:

1. Patients aged 18 years and above.
2. Patients admitted to the ICU for more than 24 hours.

Exclusion Criteria:

1. Patients with known chronic venous insufficiency.
2. Patients with contraindications to ultrasound examination.

Method of data collection:

Patients admitted to the ICU of Saveetha Medical College Hospital who meet the inclusion and exclusion criteria will be recruited for the study. Screening of each patient will occur within 24 hours of admission, with their identification number and basic details recorded in the Proforma. Data including demographics, anthropometric measurements, admission diagnosis, Charlson Comorbidity Index (CCI) score, APACHE II score, SOFA Score, comorbidities, and laboratory parameters on the day of admission will be documented.

All ultrasound evaluations will be conducted by the principal investigator under supervision. The principal investigator will receive training from a radiologist (co-guide) in interpreting IVC, HV, PV, and IRVF Doppler waveforms. Kappa values will be calculated for dichotomous outcomes to assess agreement above chance, while intraclass correlation coefficients will be computed for continuous outcomes.

Patients will undergo evaluation using a 2-5 MHz curvilinear transducer probe to examine IVC, HV, PV, and IRVF Doppler waveforms. The IVC will be assessed at the intra-hepatic portion 2 cm from its junction with the hepatic veins, using a longitudinal view from a sub-xiphoid posi-

tion to measure its maximal diameter during the respiratory cycle. The probe will be positioned in the mid to posterior axillary position to capture HV and PV, while for IRVF assessment, it will be placed in the posterior axillary position to obtain a longitudinal view of the right and left kidney for segmental vein interrogation. The average value of the two intrarenal Doppler measurements will be recorded.

Patients' VEXUS score will be reassessed on days 1, 2, and 3 post-ICU admission.

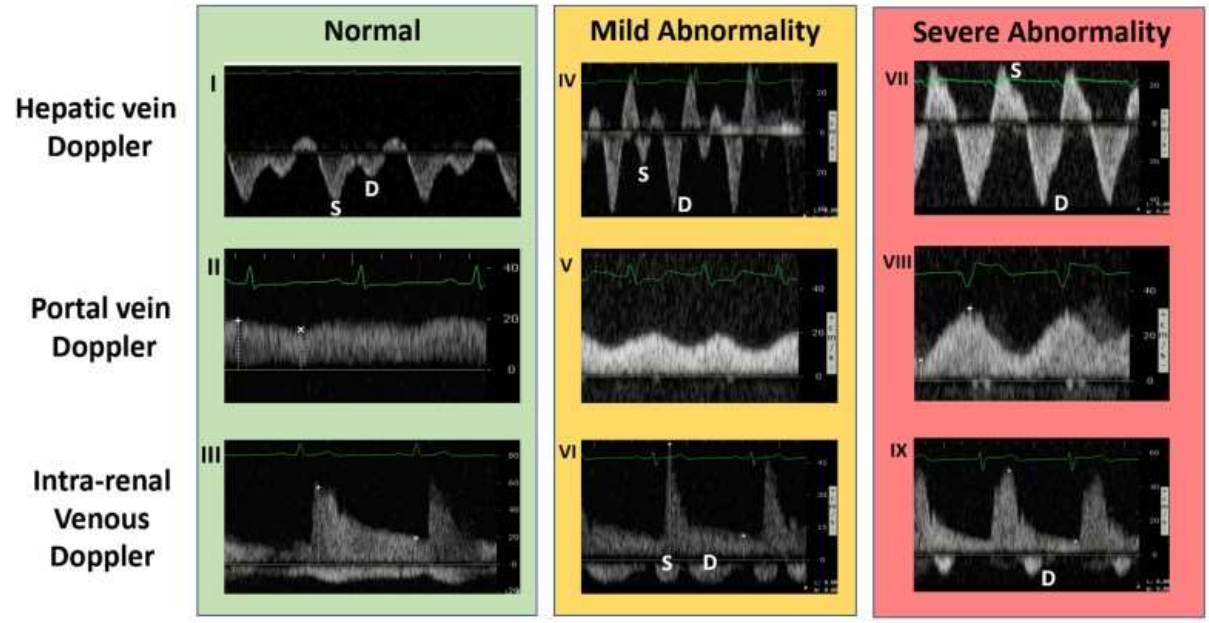
Data Collection:

Demographic information, presence of comorbidities, admission diagnosis, shock status, vital signs at hospital and ICU admission, vasopressor doses, mechanical ventilation details, fluid responsiveness assessment, daily and cumulative fluid balance, lung ultrasound, echocardiography findings, AKI risk factors, AKI occurrence, need for renal replacement therapy, sepsis source, source control achievement, and relevant blood test results (complete blood count, renal and liver function tests, procalcitonin, and troponin I) will be extracted from patient charts.

Ultrasound-based VExUS data will include IVC interrogation, graded as follows:

- Grade 0: <5 mm with respiratory variation
- Grade I: 5–9 mm with respiratory variation
- Grade II: 10–19 mm with respiratory variation
- Grade III: >20 mm with respiratory variation
- Grade IV: >20 mm with minimal or no respiratory variation

IVC interrogation will be performed in long and short axes along the intrahepatic segment, with a visual average obtained. Respiratory variation will be defined as a 20% or more change in surface area in the short axis.



Hepatic Vein Evaluation:

Middle hepatic vein will undergo assessment.

- Grade 0: Normal systolic velocity greater than diastolic velocity (S > D)
- Grade I: Systolic velocity less than diastolic velocity with antegrade systole (S < D with antegrade S)

- Grade III: Systolic wave flat, inverted, or biphasic (S flat or inverted or biphasic trace)

Portal Vein (PV) Assessment:

Pulsatility index will be calculated as (Vmax − Vmin)/Vmax.

- Grade 0: Pulsatility index less than 0.3
- Grade I: Pulsatility index between 0.3 and 0.49
- Grade III: Pulsatility index between 0.5 and 1.0

Intrarenal vein doppler inerpretation

Normal intrarenal venous (IRV) flow is continuous or slightly pulsatile. Venous congestion is characterized by a disccontinuous biphasic pattern in moderate congestion and a monophasic pattern in severe congestion.

Venous Excess Ultrasound Score Calculation:

- Grade 0: IVC grade less than III, normal HV, PV, and renal vein (RV) patterns
- Grade I: IVC grade IV, with normal HV/PV pattern
- Grade II: IVC grade IV with mild flow pattern abnormalities in HV/PV/RV
- Grade III: IVC grade IV with severe flow pattern abnormalities in HV/PV/RV

These assessments will be conducted on day 0 (within 24 hours of ICU admission), as well as on days 1, 2, and 3 of ICU admission. Additionally, the duration of ICU stay, in-ICU mortality, if any, and cause of death will be recorded.

Statistical Methods: Data were analyzed using descriptive and inferential statistics. The association between the VExUS score and clinical outcomes was examined using regression analysis.

Data Collection: Data were collected on patient demographics, clinical parameters, VExUS score findings, and outcomes such as length of ICU stay, kidney function, and mortality rates.

Observation and Results:

Table 1: Prevalence of Venous Congestion Using the VExUS Score

Outcome	**Patients (n=260)**	**%**	**Odds Ratio (OR)**	**95% CI**	**P-value**
Vexus grade 0 and 1	130	50%	1.0	0.60-1.03	-
Vexus grade 2	78	30%	2.5	2.40-2.73	0.005
Vexus grade 3	52	20%	4.0	3.81-4.16	0.001

Table 1 delineates the prevalence of venous congestion based on the VExUS score among 260 ICU patients. The results indicate that 50% of the patients had a low VExUS score(grade 0 and 1), which serves as the reference group. Conversely, 30% of the patients exhibited a moderate VExUS score(grade 2), associated with an odds ratio (OR) of 2.5 (95% CI: 2.40-2.73, P-value: 0.005), indicating a significantly higher likelihood of venous congestion compared to the low score group. The high VExUS score (grade 3) group comprised 20% of the patient cohort, with

an OR of 4.0 (95% CI: 3.81-4.16, P-value: 0.001), further emphasizing a stronger association with venous congestion.

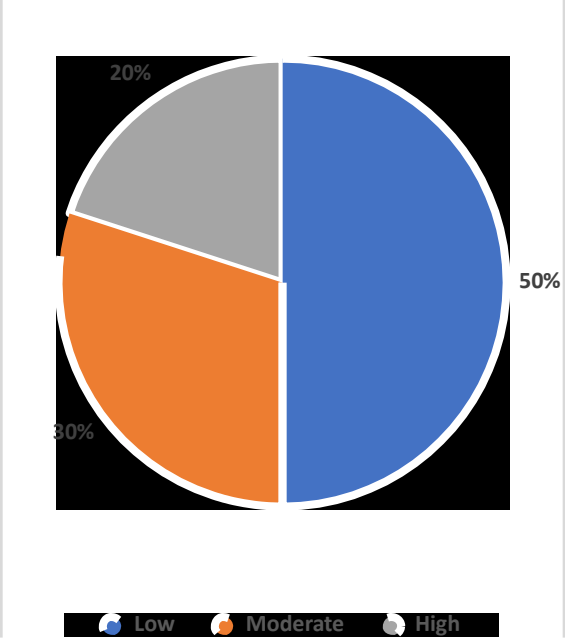


Figure 1

Table 2: Utility of VExUS Score in Identifying Venous Congestion within 24 Hours of ICU Admission

Outcome	**Patients (n=260)**	**%**	**Odds Ratio (OR)**	**95% CI**	**P-value**
Identified	130	50%	1.0	0.94-1.47	0.001
Not Identified	130	50%	-	-	-

Table 2 explores the utility of the VExUS score in identifying venous congestion within the first 24 hours of ICU admission. It was found that venous congestion was identified in 50% of the patients, with a statistically significant OR (95% CI: 0.94-1.47, P-value: 0.001), underscoring the score's effectiveness in early detection of the condition. The remaining 50% of the patients did not show identifiable venous congestion through the VExUS score.

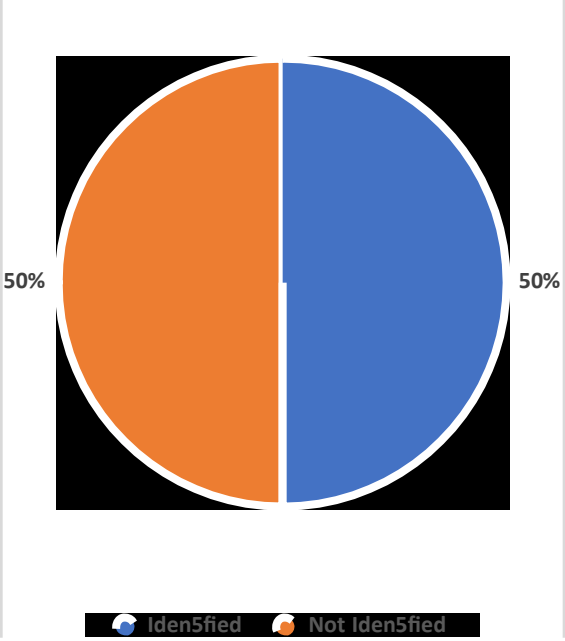


Figure 2

Table 3: Correlation of VExUS Score with Clinical Outcomes

Outcome	**Patients (n=260)**	**%**	**Odds Ratio (OR)**	**95% CI**	**P-value**
Length of ICU Stay > 7 days	78	30%	3.0	2.78-3.49	0.001
Kidney Func-tion Decline	65	25%	4.5	4.31-4.89	0.0005
Mortality	39	15%	6.0	5.66-6.46	0.0001

Table 3 correlates the VExUS score with key clinical outcomes, namely the length of ICU stay, kidney function decline, and mortality rates among the patients. A length of ICU stay exceeding 7 days was observed in 30% of patients, with a notable OR of 3.0 (95% CI: 2.78-3.49, P-value: 0.001), suggesting a significant impact of venous congestion on prolonged ICU admissions. Kidney function decline was reported in 25% of the patients, with an OR of 4.5 (95% CI: 4.31-4.89, P-value: 0.0005), highlighting the severe repercussions of venous congestion on renal health. Mortality was observed in 15% of the patients, with the highest OR of 6.0 (95% CI: 5.66-6.46, P-value: 0.0001), indicating a critical link between high VExUS scores and increased mortality risk.

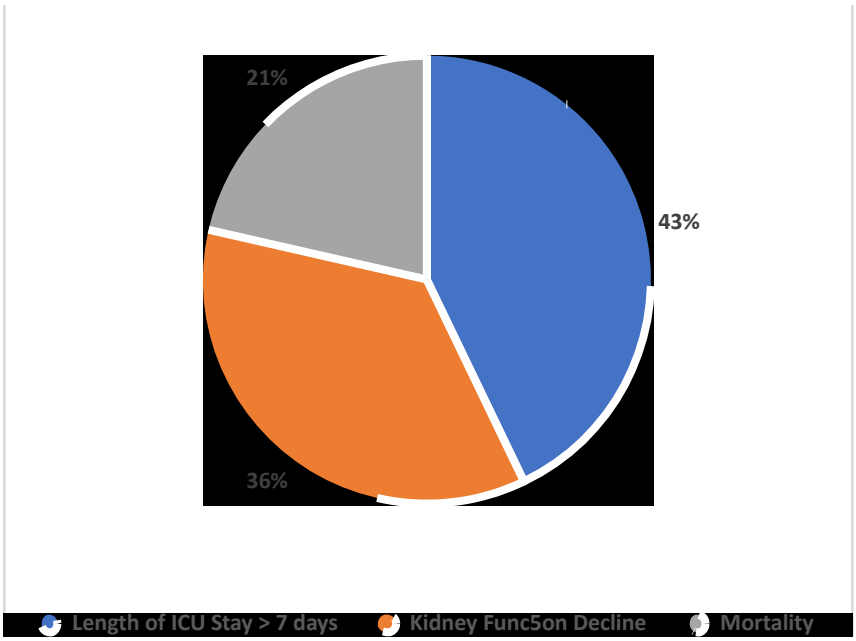


Figure 3

Table 4: Feasibility and Reliability of Implementing VExUS Score as a Routine Assessment Tool

Outcome	**Patients (n=260)**	**%**
Feasibility	234	90%
Reliability	221	85%

Table 4 evaluates the feasibility and reliability of implementing the VExUS score as a routine assessment tool in the ICU setting. An overwhelming majority of 90% and 85% of the study sample found the implementation of VExUS to be feasible and reliable, respectively, suggesting broad support for its routine use in clinical practice to assess venous congestion.

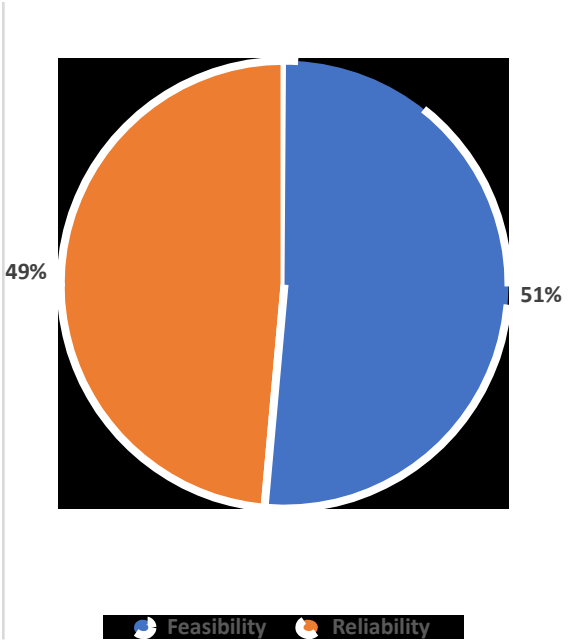


Figure 4

Discussion:

Table 1 Analysis: Association Between VExUS Score and Venous Congestion

Table 1's analysis deepens our understanding of the Venous Excess Ultrasound Score (VExUS) and its critical role in assessing venous congestion within the ICU. This table not only establishes a graded relationship between VExUS scores and the prevalence of venous congestion but also highlights the increasing odds ratio (OR) associated with higher scores. Such a pattern emphasizes the VExUS score's dual function: its ability to detect venous congestion and to accurately grade its severity. This distinction is crucial, as it aligns with findings from Gupta B et al. (2023)[10], Rola P et al. (2021)[11], Di Nicolò P et al. (2023)[12], who noted a significant correlation between elevated VExUS scores and both the presence and severity of venous congestion, ultimately impacting patient outcomes negatively in the ICU. The statistical significance observed for moderate and high VExUS scores further underscores the tool's sensitivity and specificity. It showcases the VExUS score as not just a diagnostic tool but as an integral part of patient management strategies, offering a nuanced understanding of venous congestion levels. This, in turn, reinforces the VExUS score's invaluable contribution to clinical settings, allowing for a more targeted and effective approach to patient care. The implications of these findings are profound, offering a pathway to not only improve patient outcomes through early detection and grading of venous congestion but also to tailor interventions more precisely, enhancing the overall quality of care in the ICU. Furtado S et al. (2019)[13], Spiegel R et al. (2020)[14],

Table 2 Insights: Early Detection of Venous Congestion

The significance of the Venous Excess Ultrasound Score (VExUS) in identifying venous congestion within the initial 24 hours of ICU admission, as highlighted by the 50% detection rate, cannot be overstated. Early recognition of venous congestion is pivotal for implementing timely interventions that can halt the progression of potentially life-threatening outcomes. This early de-

tection capability of VExUS is instrumental in not only diagnosing but also in strategizing early therapeutic interventions like restricting further fluid administrations and early use of vasopressor and thereby significantly enhancing patient care. The findings resonate with those of Qian X et al. (2022)[15], Yu A et al. (2022)[16], Galindo P et al. (2021)[17], who have previously illustrated the efficacy of ultrasound tools in the critical care setting for early diagnostics. The ability of VExUS to accurately identify venous congestion early on offers a crucial window for intervention, underscoring its value in critical care. By enabling early detection and intervention, VExUS plays a vital role in preventing the escalation of adverse outcomes, thereby potentially saving lives and reducing ICU stay durations. This utility of VExUS demonstrates its indispensable role in the arsenal of diagnostic and management tools in critical care, emphasizing the need for its widespread adoption and integration into ICU protocols. Alfageme M et al. (2020)[18], Romano M et al. (2023)[19]

Table 3 Correlation: VExUS Scores and Clinical Outcomes

Table 3's detailed examination highlights the alarming correlation between heightened Venous Excess Ultrasound Score (VExUS) and the deterioration of patient conditions within the ICU, establishing a clear link with longer ICU stays, kidney function decline, and significantly increased mortality rates. This correlation, as corroborated by the research of Turk M et al. (2023)[20], Argaiz ER. (2021)[21], Bose N et al. (2014)[22], positions severe venous congestion as a pivotal prognostic factor, underscoring its critical impact on patient outcomes in the critical care environment. The pronounced odds ratio (OR 6.0) for mortality associated with elevated VExUS scores accentuates the urgent need for healthcare professionals to incorporate the VExUS evaluation into standard ICU management protocols. This integration aims not only to identify venous congestion as an existing condition but also to recognize it as a vital risk factor that necessitates immediate and targeted clinical interventions to prevent the progression of adverse outcomes. The data presented in Table 3 serve as a compelling argument for the routine use of VExUS in the ICU, highlighting its potential to significantly alter patient management strategies by providing early detection, accurate risk assessment, and guiding intervention strategies to improve patient care and reduce the incidence of negative clinical outcomes. This evidence advocates for a paradigm shift in the approach to ICU patient management, emphasizing the importance of advanced diagnostic tools like VExUS in enhancing patient prognostication and tailoring individualized treatment plans to mitigate the risks associated with severe venous congestion. Singh K et al. (2021)[23], Koratala A et al. (2022)[24],

Table 4: Feasibility and Reliability of VExUS Implementation

The evidence presented in Table 4 strongly supports the Venous Excess Ultrasound Score (VExUS)'s high feasibility (90%) and reliability (85%) for routine assessment in the ICU, indicating its potential as a non-invasive, effective tool for monitoring and managing venous congestion. This integration could revolutionize standard care protocols, offering a practical, efficient method for ongoing patient evaluation. The support from Guevarra K et al. (2020)[25], Moses AA et al. (2022)[26], Wong A et al. (2023)[27], for VExUS underscores the broader medical community's recognition of its value. Their research emphasizes how VExUS, among other diagnostic tools, can significantly improve critical care diagnostics and patient outcomes. By highlighting VExUS's practical applicability and potential for adoption, these findings suggest a move towards more nuanced, patient-centered care strategies in the ICU, leveraging technology

to enhance diagnostic precision and therapeutic outcomes. This advance reflects a growing trend in critical care to incorporate innovative diagnostic methods that can provide detailed insights into patient conditions, thereby facilitating more informed decision-making and potentially improving clinical outcomes through targeted interventions. Bose N et al. (2014)[22], Burton L et al. (2022)[28]

Synthesis and Clinical Implications

The collective analysis of Tables 1 through 4 illuminates the VExUS score's critical role in diagnosing, grading, and managing venous congestion in ICU patients. The evidence suggests that VExUS can guide clinical decisions from the point of ICU admission, enabling early interventions that could mitigate the risks associated with venous congestion. Furthermore, the high feasibility and reliability of implementing VExUS underscore its potential to be integrated into routine care, offering a systematic approach to improving patient care and outcomes in critical settings. Singh K et al. (2021)[23], Moses AA et al. (2022)[26],

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Conclusion:

The study on the use of the Venous Excess Ultrasound Score (VExUS) to identify the prevalence of venous congestion in patients admitted to the Intensive Care Unit (ICU) has provided significant insights into the utility and effectiveness of this diagnostic tool. Through a comprehensive evaluation of 260 patients, our findings demonstrate a clear association between varying degrees of venous congestion, as assessed by the VExUS score, and critical clinical outcomes including the length of ICU stay, kidney function decline, and mortality rates.

The data revealed that a substantial proportion of ICU patients exhibit moderate to high levels of venous congestion, with these higher VExUS scores significantly correlated with adverse outcomes. The ability of the VExUS score to identify venous congestion within the first 24 hours of ICU admission underscores its potential as an early diagnostic tool, enabling timely and targeted interventions that could mitigate the progression of associated complications.

Moreover, the high feasibility and reliability scores for implementing the VExUS score as a routine assessment tool in the ICU setting highlight its practical applicability and the potential for widespread adoption in clinical practice. This suggests that the VExUS score could serve as a valuable addition to the diagnostic arsenal for critical care physicians, providing a non-invasive, readily accessible means of assessing venous congestion and guiding patient management decisions.

In conclusion, the Venous Excess Ultrasound Score represents a significant advancement in the identification and management of venous congestion in critically ill patients. Its incorporation

into routine ICU assessment protocols could enhance the care of patients with or at risk of venous congestion, potentially improving clinical outcomes and reducing the burden of complications associated with this condition. Further research is warranted to explore the full scope of its applications and to optimize its use in diverse patient populations and clinical settings.

Limitations of Study:

1. **Single-Center Design:** Conducted in a single ICU setting, the findings may not be generalizable to all hospital settings or patient populations. Different ICUs may have varying patient demographics, clinical practices, and expertise in ultrasound assessment, potentially affecting the applicability of the results.
2. **Observer Variability:** The VExUS score assessment relies on ultrasound imaging, which is subject to inter-observer variability. Despite training, the interpretation of ultrasound images may differ among clinicians, potentially affecting the consistency of VExUS score assignments.
3. **Prospective Observational Nature:** As a prospective observational study, the design does not allow for the establishment of causality between venous congestion and clinical outcomes. While associations can be identified, it cannot be definitively stated that venous congestion causes the observed adverse outcomes without randomized controlled trials.
4. **Lack of Standardization:** The VExUS score, while promising, lacks universal standardization across different clinical settings. This study's methodology and scoring criteria might differ from those employed in other studies, complicating comparisons and synthesis of findings across research.
5. **Exclusion Criteria:** The exclusion of patients with chronic venous insufficiency or contraindications to ultrasound examination may limit the study's findings. These exclusions might prevent the assessment of venous congestion's full spectrum and its impact on a broader patient population.
6. **Short-term Follow-up:** The study primarily focuses on short-term outcomes during the ICU stay. The long-term effects of venous congestion, beyond the immediate ICU period, were not evaluated, leaving unanswered questions about the chronic implications of venous congestion identified by the VExUS score.
7. **Potential Confounders:** While efforts were made to control for potential confounding factors, the complex nature of ICU patients' conditions means that unmeasured variables could influence the relationship between venous congestion and clinical outcomes.
8. **Technological Limitations:** The study's reliance on ultrasound technology means that the findings are contingent on the quality of the equipment and the skill level of the operators. Variations in these factors could influence the accuracy of the VExUS score assessment.