Unvexing the VExUS Score – An Overview

PoCUS Clinical Pearl

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Introduction:

The pursuit of a rapid and objective measure of volume status has always been a vexing problem for clinicians as proper fluid management is pivotal for patient outcomes. In recent years, there has been increased attention towards the concept of "fluid-responsive" as liberal fluid boluses can often be associated with poor outcomes as a result of systemic congestion. [1]

In the POCUS community, while Inferior Vena Cava (IVC) measurements have promise in assessing central venous pressure, the subsequent translation towards "volume responsiveness" has been met with many other limitations. For one, it did not account for venous congestion at other organ levels such as the pulmonary, renal, or hepatic systems. [2,3]

Venous excess ultrasound (VExUS) is a growing bedside ultrasound-based approach that aims to provide a more comprehensive assessment of venous congestion. This was initially described by Beaubien-Souligny et al. (2020) from a post-hoc analysis correlating ultrasound grading parameters with risk in development of AKI in cardiac surgery patients.[4] The protocol serves to assess multiple sites of venous congestion, including the IVC, hepatic veins, portal veins and intrarenal veins. By assessing congestion in these multiple sites, the VExUS score has gained attraction in providing a more comprehensive assessment of systemic congestion. [4,5]

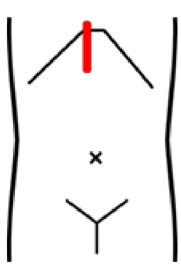
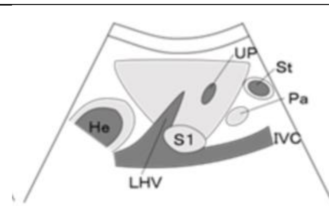
View Acquisition:

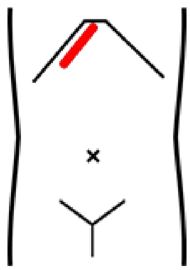
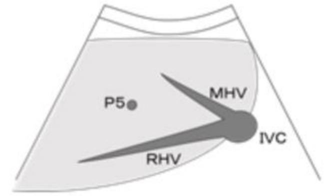
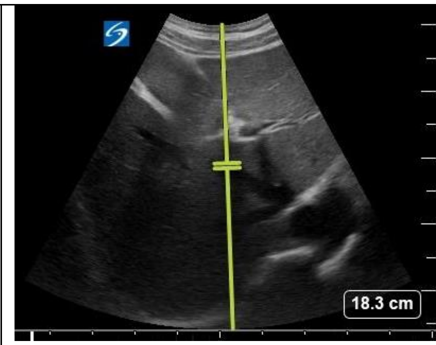
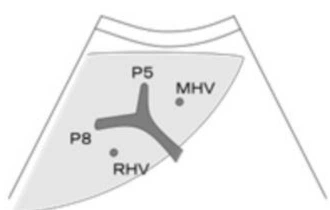
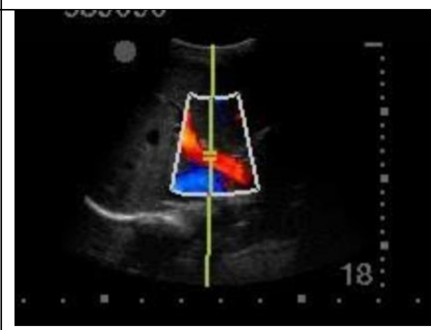
The VExUS protocol is composed of four main components outlined below:

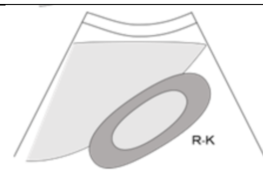
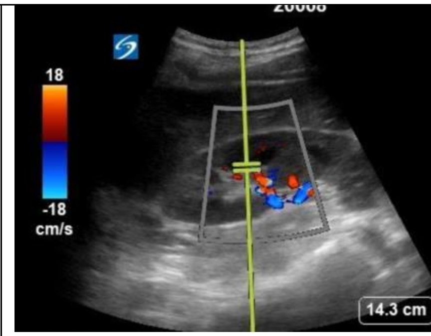
1) IVC diameter
2) Hepatic Vein Doppler Assessment
3) Hepatic Portal Vein Doppler Assessment
4) Intrarenal Vein Doppler Assessment

This can be performed using either the curvilinear probe (preferred) or the phased array probe. The patient should be positioned flat and supine on the bed to acquire the views. The table below depicts some suggested views where larger regions of the veins may be accessible for pulse wave doppler gating in reference to standardized sonography protocols. [6,7]

Note: Reviewing the basics of pulse wave doppler will be needed prior to completing VExUS scans (not covered in this article).

View	Scanning Technique/Tips	Anatomic Diagram	Sample Ultrasound Image
IVC (B-Mode)	Place the probe longitudinally slightly to the right of the subxiphoid region. The diameter of the IVC should be measured approximately 2-3 cm from the junction of the IVC and right atrium. Tip: Can begin initially with transverse subxiphoid (cardiac) view with right atrium centred before rotating 90 degrees to obtain IVC.  (Image sourced from JSS[7])	 Liver: Caudate lobe(S1), Portal vein: Umbilical portion; UP, Inferior vena cava; IVC, Pancreas; Pa, Stomach; St, Heart; He (Image sourced from JSS[7])	 (Own image)

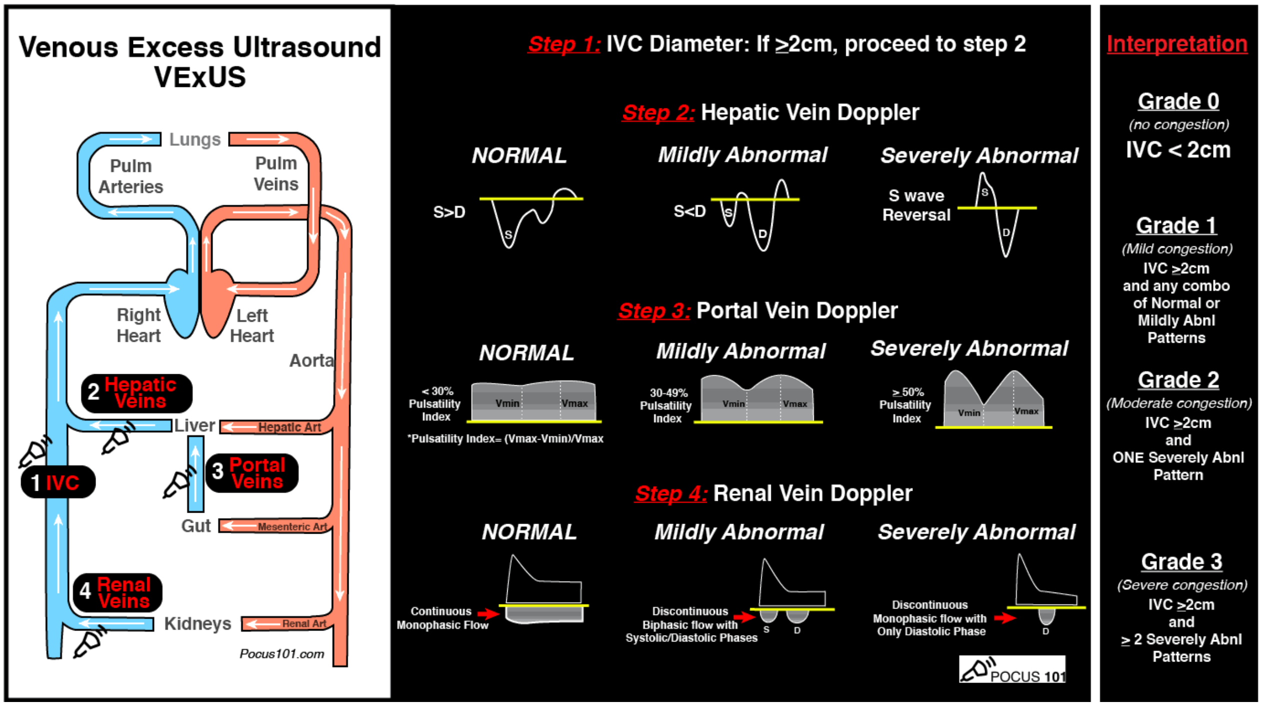
Hepatic Vein	Place the probe along the right sub-costal margin and continue fanning through the liver until hepatic veins visible. Any hepatic vein can be used for doppler gating. Proceed with colour flow doppler to ensure that flow direction is BLUE before proceeding with pulse wave doppler. Tip: The right hepatic vein may often not demonstrate doppler flow since it can be perpendicular to probe, which will require adjustments with probe positioning  (Image sourced from JSS[7])	 Liver: Right portal vein: (P5), Right hepatic vein; RHV, Middle hepatic vein; MHV, Inferior vena cava; IVC (Image sourced from JSS[7])	 (S. Chen) Note: colour had been turned off during this screen capture, the vein should be BLUE (flow away from probe)
Hepatic Portal Vein	Place the probe on the right and continue scanning within each intercostal region fanning to best visualize the portal veins. Proceed with colour flow doppler to ensure that flow direction is RED before proceeding with pulse wave doppler. TIP: The portal veins are distinguished from hepatic veins by hyperechoic (bright) tissue surrounding the vessel.  (Image sourced from JSS[7])	 Liver: Right portal vein: (P5), (P8), Right hepatic vein; RHV, Middle hepatic vein; MHV	 (S.Chen)

Intrarenal Vein	Begin at the posterior axillary line at the level of the subxiphoid. Visualize the long axis view of the right kidney in its right dorsal aspect. Proceed with colour flow doppler to ensure that there is some venous intrarenal blood flow being picked up by the transducer (you are looking for BLUE). Tip: These parenchymal vessels are SMALL and difficult to acquire. You may need to experiment with patient positioning (rolling to lateral decubitus or prone) depending on patient body habitus.  (Image sourced from JSS[7])	 Right kidney; R-K (Image sourced from JSS[7])	 (S.Chen)

Interpretation:

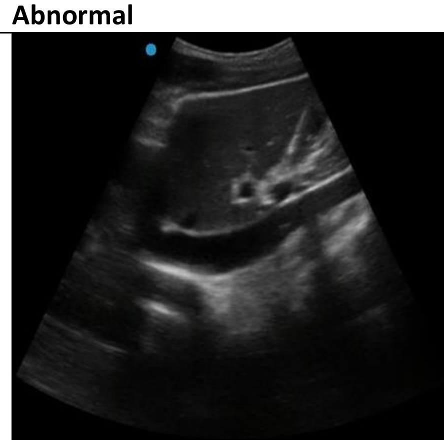
Interpretation of the VExUS grading system is well summarized in diagram below (sourced from POCUS101[8]) and takes some practice to differentiate normal from abnormal waveforms. Pulse wave doppler assessment is pursued only if the inferior vena cava is found plethoric, defined as greater or equal to 2cm. [4,5]

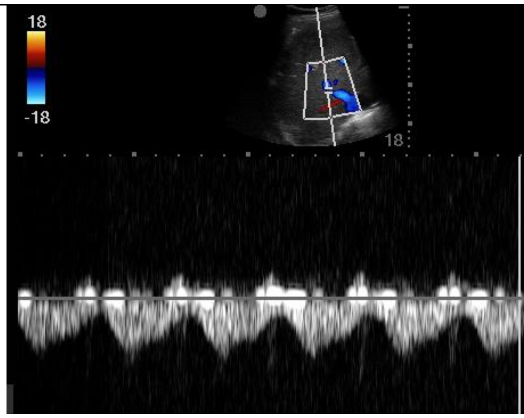
Each of the hepatic, portal and renal veins are subsequently examined and classified as normal, mildly congested, or severely congested. The VExUS system has four grades: Grade 0 represents no congestion in any organ, Grade 1 represents only mild congestive findings, Grade 2 represents severe congestive findings in only one organ, and Grade 3 represents severe congestive findings in at least two out of three organ systems. [4,5]

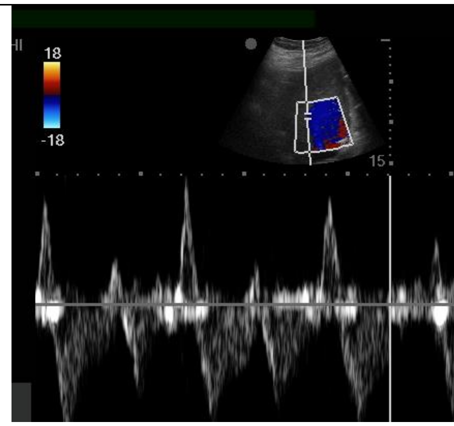


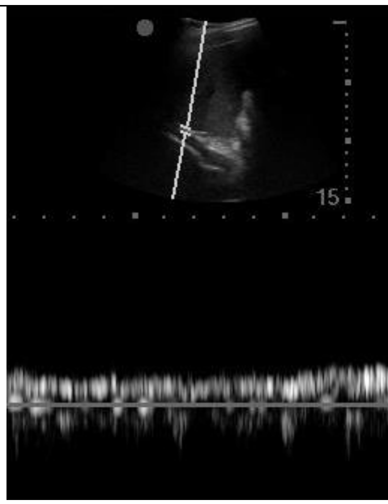
Source: POCUS101[8]

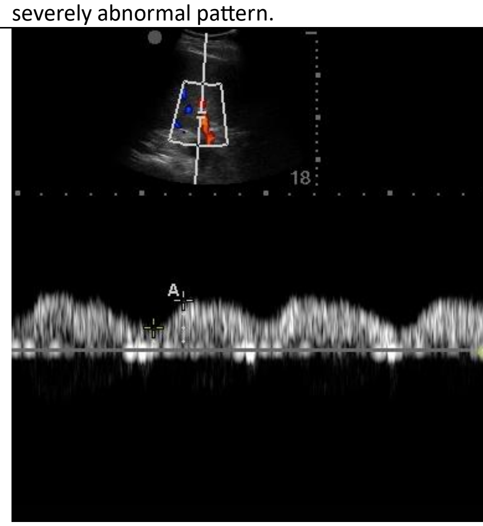
Some sample waveforms are shown below with comments to help with distinguishing normal from abnormal waveforms.

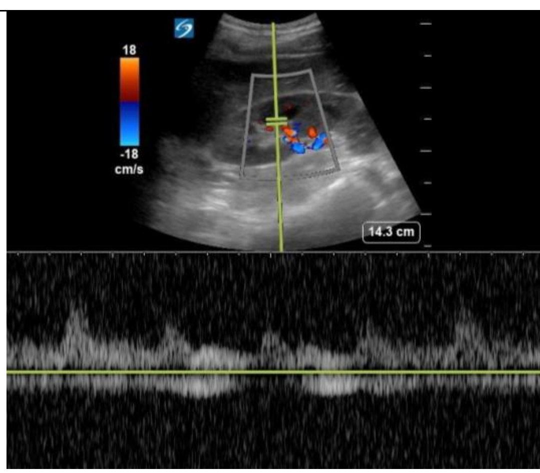
	Normal	**Abnormal**
IVC	 (S. Chen) IVC <2cm in hypovolemic "VExUS 0" patient	 (S. Chen) IVC distended (>2cm) with minimal respiratory variation

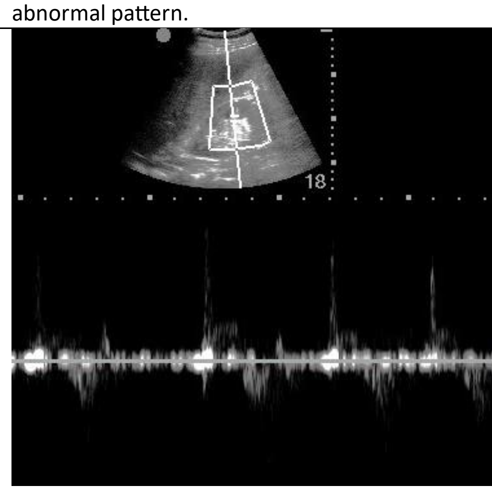
<table>
<tr>
<td>Hepatic Vein Doppler</td>
<td>

(S. Chen)
Normal waveform, with S>D albeit some fusion of the waves</td>
<td>

(S. Chen)
There is S wave reversal present here suggesting severely abnormal pattern.</td>
</tr>
<tr>
<td>Portal Vein Doppler</td>
<td>

(S. Chen)
Qualitatively, the waveform is fairly flat and would estimate <30% for pulsatility index</td>
<td>

(S. Chen)
Measurements taken formally with pulsatility index calculated at 56%. This is consistent with a severely abnormal pattern.</td>
</tr>
<tr>
<td>Intra-renal Vein Doppler</td>
<td>

(S. Chen)
Continuous monophasic venous flow with arterial doppler signal also appearing as positive waves.</td>
<td>

(S. Chen)
Discontinuous monophasic venous flow. Note that positive arterial flow can be faintly seen preceding each venous pulse, confirming diastolic flow. This is a severely abnormal pattern.</td>
</tr>
</table>

Evidence:

VExUS has also been shown to be reliable and reproducible, with good interobserver agreement in trained individuals and correlation with other measures of volume status such as central venous pressure.[4,5] As the technique is growing in the POCUS literature, below is a table summarizing several recent studies exploring its application across numerous settings.

Study	Purpose	Results
Beaubien-Souligny W, et al. (2020)[4] Post-hoc analysis of a single centre prospective study in 145 patients	Initial model of VExUS grading system looking at association in development of AKI in cardiac surgery population	Association with subsequent AKI: HR: 3.69 CI 1.65–8.24 p = 0.001; +LR: 6.37 CI 2.19–18.50 when detected at ICU admission, which outperformed central venous pressure measurements
Bhardwaj V, et al. (2020)[9] Prospective cohort study of 30 patients in ICU setting	Prospective study on application of VExUS scoring on staging of AKI in patients with cardiorenal syndrome	Resolution of AKI injury significantly correlated with improvement in VExUS grade (p 0.003). There was significant association between changes in VExUS grade and fluid balance (p value 0.006).
Varudo R, et al. (2022)[10] Case report of ICU patient with hyponatremia	Application of VExUS in case report as rapid tool to help with volume status assessment in patient with complex hyponatremia	Overall VExUS grade 2, prompting strategy for diuresis with improvement
Rolston D, et al. (2022)[11] Observational study of 150 septic patients in single centre	VExUS score performed on ED septic patients prior to receiving fluids with chart review done to determine if there is association with poorer outcomes	Composite outcome (mortality, ICU admission or rapid response activation): VExUS score of 0: 31.6% of patients VExUS score of 1: 47.6% of patients VExUS score >1: 67.7% of patients (p: 0.0015)
Guinot, PG, et al. (2022)[12] Prospective observational study of 81 ICU patients started on loop diuretic therapy	Evaluation of multiple scores to predict appropriate diuretic-induced fluid depletion (portal pulsatility index, renal venous impedance index, VExUS)	Baseline portal pulsatility index and renal venous impedance index were found to be superior predictors compared to VExUS. The baseline VExUS score (AUC of 0.66 CI95% 0.53–0.79, p = 0.012) was poorly predictive of appropriate response to diuretic-induced fluid depletion.
Menéndez-Suso JJ, et al. (2023)[13] Cross-sectional pilot study of 33 children in pediatric ICU setting	Association of VExUS score with CVP in pediatric ICU	VExUS score severity was strongly associated with CVP (p<0.001) in critically ill children.
Longino A, et al. (2023)[14] Prospective validation study in 56 critically ill patients	Validation looking at association of VExUS grade with right atrial pressure.	VExUS had a favorable AUC for prediction of a RAP ≥ 12 mmHg (0.99, 95% CI 0.96-1) compared to IVC diameter (0.79, 95% CI 0.65–0.92).

Pitfalls:

It should be kept in mind that numerous factors may affect interpretation of VExUS gradings.

For the IVC component, increased intra-abdominal pressure can affect measurements independently of the pressure in the right atrium or may be affected by chronic pulmonary hypertension. The hepatic vein may not show significant changes even in severe tricuspid regurgitation if the right atrium can still expand and contract normally. In thin healthy people and those with arteriovenous malformations, the portal vein can have a pulsatile flow without venous congestion. It is also important to note that for patients with underlying disease renal or liver parenchymal disease, venous doppler recordings may be less reliable. [3-5]

Outside of physiologic factors, another limitation is the need for adequate training and familiarity in performing and interpreting the technique. While VExUS is fairly well protocolized, it requires proficiency with pulse wave doppler to perform accurately. As with any new technique, there is a risk of variability in technique and interpretation. To avoid misinterpretation, it is important to consider repeat tracings to ensure consistency of results and to consider findings within the overall clinical context of the patient.

Bottom line:

VExUS is a non-invasive ultrasound method for assessing venous congestion across multiple organ systems. While there are several physiologic limitations and results need to be used in adjunct with the clinical picture, studies have shown promise for VExUS to be incorporated as part of a physician's toolkit to help with clinical decision making. [3-5]

References

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