EDITORIAL

VeXUS: Do Not Drown in the ExCESS

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The venous excess in ultrasound score (VeXUS) is a point of care ultrasound-based non-invasive assessment of venous congestion of the liver, gut, and kidney. The score came into existence on the premise that venous congestion of organs leads to organ hypoperfusion and subsequent organ dysfunction culminating in an increase in morbidity and mortality. The current literature on VeXUS reports that an objective assessment of venous congestion performs better than the traditional parameters of edema, body weight, and cumulative fluid balance. The measurement of central venous pressure (CVP) is an invasive procedure and has its limitations. The score looks simple at first glance—measurement of inferior vena cava (IVC) size and evaluation of the Doppler patterns of hepatic vein (HV), portal vein (PV), and renal interlobar vein (ILRV). However, between the apparent ease of these measures and abnormal patterns lies an uneasy and mostly unexplored terrain. Let us delve into these domains one by one.

The score was constructed from a single-center retrospective data derived from adult cardiac surgical patients post-cardiopulmonary bypass. The score was designed to predict postoperative acute kidney injury (AKI) due to venous congestion. The data included baseline demographic variables with hemodynamic parameters including measures of CVP, natriuretic peptide (NT pro-BNP), EuroSCORE II, AKI predictive score, and used the KDIGO definition to diagnose AKI. The data, however, lacked many more variables including intraoperative parameters which were required to be protocolized for better prediction of AKI. The data excluded critically ill patients, those with preoperative AKI, preoperative delirium, cirrhosis of the liver, portal hypertension, end-stage renal disease with eGFR <15 mL/min/1.73 m^2, and those on dialysis.[1]

Postoperative AKI has a multifactorial etiology with venous congestion contributing to only a small percentage of patients. This explains the paradox of patients with a positive VeXUS score and no organ failure and is the reason why the application of this score in isolation to guide a therapeutic intervention fails to improve outcomes despite fluid removal in all patients. This score must be applied in conjunction with other therapeutic targets like stroke volume and mean arterial pressure to contribute meaningfully to improving organ perfusion as well as providing decongestion.[2,3]

The score assesses venous hypertension which has a multifactorial etiology. The common causes include fluid overload, pulmonary hypertension, and right heart failure. The measurement of venous pressure is therefore incomplete without diagnosing the etiology as there is no point in treating the effect without understanding the cause. The original database of VeXUS had only one preoperative transesophageal echocardiogram with no echocardiogram being done during the postoperative period. About 12.4% of these patients had right ventricular dysfunction while 25.5% had left ventricular dysfunction in the preoperative assessment. Right ventricular dysfunction is a common complication in the postoperative cardiac surgery patient, especially in patients with prolonged cardiopulmonary bypass times.[1] Assessing the VeXUS without assessing the right heart function by serial echocardiograms is analogous to sailing the high seas without any idea of the seashore. The proponents of VeXUS without accompanying echocardiography state that the latter requires more training and is often hindered by poor image quality while VeXUS can be repeated frequently and easily. There have been several studies published before VeXUS was described which looked at the individual components of this score and described a significant correlation between an individual component (PV pulsatility fraction, intrarenal Doppler abnormality) and right ventricular dysfunction. Portal vein pulsatility fraction is also documented as a surrogate for right ventricular dysfunction.[4] Even in the dataset from which the VeXUS was derived the PV pulsatility had a better predictive value for AKI as compared to grade III of VeXUS score. The addition of IVC measurement to these individual components reduced the false positive results.[1]

The ultrasonographic aspect of the score also has several limitations. The IVC is dilated in athletes and falsely narrowed in patients with raised intra-abdominal pressure. The measurement of both the long and short axis diameters of the IVC has a better correlation with right atrial pressures rather than only a long axis measurement.[5,6] The HV waveform shows a false-positive S wave reversal in the presence of tricuspid regurgitation and right ventricular dysfunction without tricuspid regurgitation. Similar changes are seen in cases of atrial fibrillation when a wave is absent. The hepatic vein changes are also blunted in cases of cirrhosis of the liver, fatty liver, abdominal compartment syndrome, and IVC stenosis.[7] The PV pulsatility is exaggerated in athletes along with false positive results in slim patients. The PV changes are blunted in patients with cirrhosis of the liver and fatty liver. The RV imaging

is difficult and there are studies that have done the VeXUS scoring without including the ILRV. It is important to correctly image the inter lobar vein as the hilar veins overestimate and the arcuate veins underestimate the Doppler waveform. Besides, VeXUS measures and abnormal patterns are identical in right ventricular volume overload and right ventricular pressure overload conditions and cannot differentiate between them.

In the cardiac surgical patients, VeXUS at ICU admission which is suggestive of severe congestion (VeXUS grade III) predicts the development of AKI with a low sensitivity, high specificity, moderate positive likelihood ratio, and a poor negative likelihood ratio after adjustment for preoperative AKI, vasopressor-inotrope score (VIS), cardiac output, and cardiopulmonary bypass time. The score shows a good correlation with CVP, cumulative fluid balance, and NT pro-BNP.[1]

Reviewing the above preface will help in understanding the work of Natraj R et al.[8] published in this issue of the journal. The authors studied VeXUS in the pediatric cardiac surgical patients with congenital heart disease who developed postoperative right ventricular dysfunction after a complete surgical repair. About 19% of their patients had right ventricular dysfunction during initial assessment at ICU admission. Their results show a significant association between severe venous congestion (VeXUS grade III) and the development of postoperative AKI. There is also a significant association between severe congestion (VeXUS grade III) and prolonged cardiopulmonary bypass time, the presence of moderate to severe right ventricular dysfunction, and increased pulmonary artery systolic pressures. Venous excess in ultrasound score improved in these patients with fluid removal; however, these changes in VeXUS did not translate into an improvement in right ventricular function.[8] Their study has several unique points– use of IVC/aorta ratio for IVC size in pediatrics; cutoff of tricuspid annular plane systolic excursion (TAPSE) as <1 SD, <2 SD, <3 SD, for quantifying mild, moderate, and severe right ventricular dysfunction respectively; and use of pRIFLE for diagnosing AKI.[9–11] None of these three parameters have so far been validated in VeXUS. Their work reveals a cautious and balanced use of this score in an unexplored setting with new surrogate variables and will pave the way for larger studies in pediatric subjects.

I cannot conclude before mentioning the small but very elegant and pragmatic prospective observational study of Adrain Wong who studied VeXUS in the hemodynamically stable patients of chronic kidney disease before and after a planned dialysis. In this small subset, he showed that VeXUS improved with fluid removal but despite this, there was no improvement in cardiac performance. All patients with a raised VeXUS score had evidence of right ventricular dysfunction. He also showed that individual components like abnormal HV and PV waveforms improved with fluid removal even when the VeXUS score was zero since the IVC was not dilated. He also documented abnormal lung ultrasound in two patients with VexUS score >1 and a regression to normal lung ultrasound after fluid removal.[12]

Putting it all together the VeXUS components need to be reviewed to assess the feasibility of including right ventricular dysfunction, IVC collapsibility (vs IVC size), lung ultrasound with extravascular lung water measurement, followed by multiple logistic regression analysis, and a prediction equation assigning appropriate weightage to all the variables rather than just scoring the grades as I, II, and III. The score also needs to be validated in different critically ill subjects.

Venous excess in ultrasound score also needs to integrate into an ultrasound-based hemodynamic monitoring algorithm which includes sequential assessment and optimization of left ventricular systolic function (stroke volume), followed by left ventricular diastolic function (E/A of mitral inflow and E/e'), right ventricular systolic (TAPSE and S') and diastolic function (E/A of tricuspid inflow), assessment of regional perfusion (renal and splenic Doppler resistive index), and followed in the end by evaluation of this score.

In conclusion VeXUS is an isolated upstream measurement of venous hypertension the components of which need to be reviewed, modified, and integrated with all other hemodynamic monitoring variables for improving the organ perfusion. It is better to be cautious in the interpretation of the score rather than drown in the euphoria of an attractive but false measure.[13]

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