Review Article

Point-of-Care Ultrasound in Acute Heart Failure: Basic Concepts for Clinical Practice

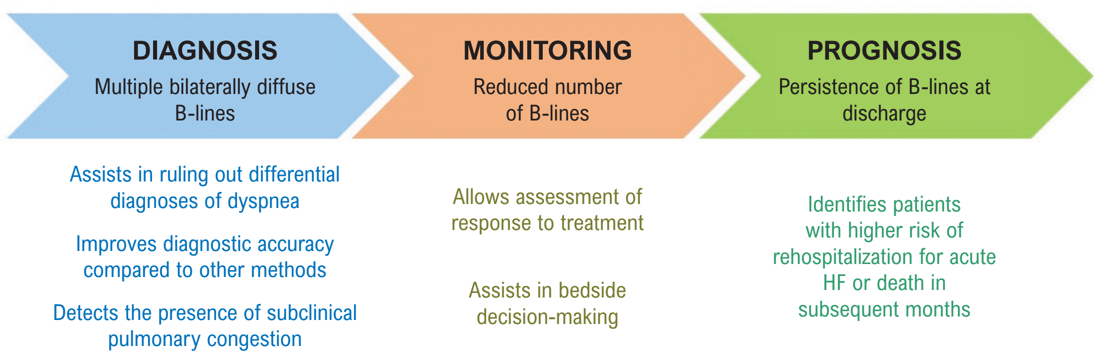
Leticia Kunst,[1] Luiz Claudio Danzmann,[1,2] Keslly Krauspenhar Cuchinski,[1] João Ricardo Cambruzzi Zimmer[1]

Universidade Luterana do Brasil (ULBRA),[1] Canoas, RS – Brazil

Santa Casa de Misericórdia de Porto Alegre – Centro de Insuficiência Cardíaca,[2] Porto Alegre, RS – Brazil

Central Illustration: Point-of-Care Ultrasound in Acute Heart Failure: Basic Concepts for Clinical Practice

ABC Heart Failure & Cardiomyopathy



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Introduction

Heart failure (HF) is a complex clinical syndrome that promotes a system of poor tissue perfusion in conditions of low cardiac output and elevated filling pressures, resulting in circulatory congestion and hypoperfusion.[1] The exacerbation of this condition is responsible for 40% of consultations due to dyspnea in emergency rooms,[2] and the main cause is worsening congestion due to poor medication adherence.[1] In in-hospital clinical assessment, the most prevalent HF profiles are B (warm and wet) and C (cold and wet), both of which are characterized by circulatory congestion.[1]

Although it causes great demand in the emergency room, it is sometimes difficult to identify signs of hypervolemia in acute decompensated HF in the context of differential diagnosis with other determining syndromes of dyspnea and hypoperfusion.[3] Clinical findings are fundamental for the initial investigation, but objective and rapid confirmation of diagnosis reduces door-to-furosemide time, which is directly related to in-hospital mortality.[4] Natriuretic peptides are tools with high negative predictive value for congestion; however, moderately elevated serum levels represent a diagnostic gray area, as the increase in this marker is related to several diseases that are independent of HF.[1] The use of bedside point-of-care ultrasound (POCUS) has emerged as an excellent tool for comprehensive assessment of this condition, with analysis of cardiac structure and function, the pulmonary interstitium, and some venous vessels. It also offers a rapid, non-invasive, and low-cost opportunity, with greater accuracy than conventional assessment methods for detecting circulatory congestion.[2]

Keywords

Heart Failure; Ultrasonography; Practice Guideline.

Mailing Address: Leticia Kunst •
Universidade Luterana do Brasil (ULBRA) – Avenida Farroupilha, 8001. Postal Code 92425-900, Canoas, RS – Brazil
E-mail: leticiakunst3@gmail.com
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POCUS

POCUS is a diagnostic tool that makes it possible to view ultrasound images immediately and dynamically. Used at the bedside, it provides additional clinical information during physical examination for a specific procedure or disease.[3] The practicality and speed of obtaining images have made it widely used in the hospital environment for patients with severe illness.[5] POCUS is being used in several medical specialties, especially in pulmonary and cardiac ultrasound.[5]

Lung ultrasound

Lung ultrasound is a widely used tool in the examination of patients with dyspnea in the emergency room, making it possible to access lung tissue and interstitial free water, which is the main sign associated with pulmonary congestion.[3] Medical societies have progressively adhered to the technique. The European Society of Cardiology recommends performing bedside lung ultrasound in patients with dyspnea within the first hours of admission.[6] This strategy allows for highly accurate assessment to detect pulmonary edema and rule out differential diagnoses. (Figure 1).[6]

Lung ultrasound findings are relatively easy to apply in clinical practice, seeing that training is relatively quick, and high levels of agreement have been found from training. In a pioneering manner, the Bedside Lung Ultrasound in Emergency (BLUE) protocol, using 3 lung zones in each hemithorax, was designed as a means of systematizing the use of lung POCUS in patients with acute respiratory failure.[7] This systematization has made it possible to assess the main causes of dyspnea in emergency practice dynamically and in a few minutes. Other protocols are currently used. The most common in practice is performed in 4 lung zones in each hemithorax, with the patient in the supine position (Figure 2). Based on the image generated, the presence of pulmonary artifacts, pleural sliding, the presence of pleural effusion, and inferior vena cava caliber and compressibility are investigated.[8]

Artifacts occur due to the interaction between air and higher density structures, such as liquid. The A-lines, which are also present in healthy individuals, are reverberation artifacts, as they are a repetition of the pleural line, and they appear as equidistant parallel horizontal lines (Figure 3).[7] On the other hand, the B-lines, which indicate the presence of echogenic borders between the alveolar spaces, appear vertically, and they accompany lung movements (Figure 4). The presence of up to 2 B-lines per zone can be considered normal, whereas 3 or more B-lines between the ribs indicate a pathological process.[8]

It is possible to quantify B-lines based on their sum in an intercostal space per zone or a scoring system (Table 1). These methods can be useful in the assessment of pulmonary edema in emergency practice, where a score ≥ 2, that is, the presence of at least 2 zones per hemithorax with 3 or more B-lines defines the diagnosis.[9]

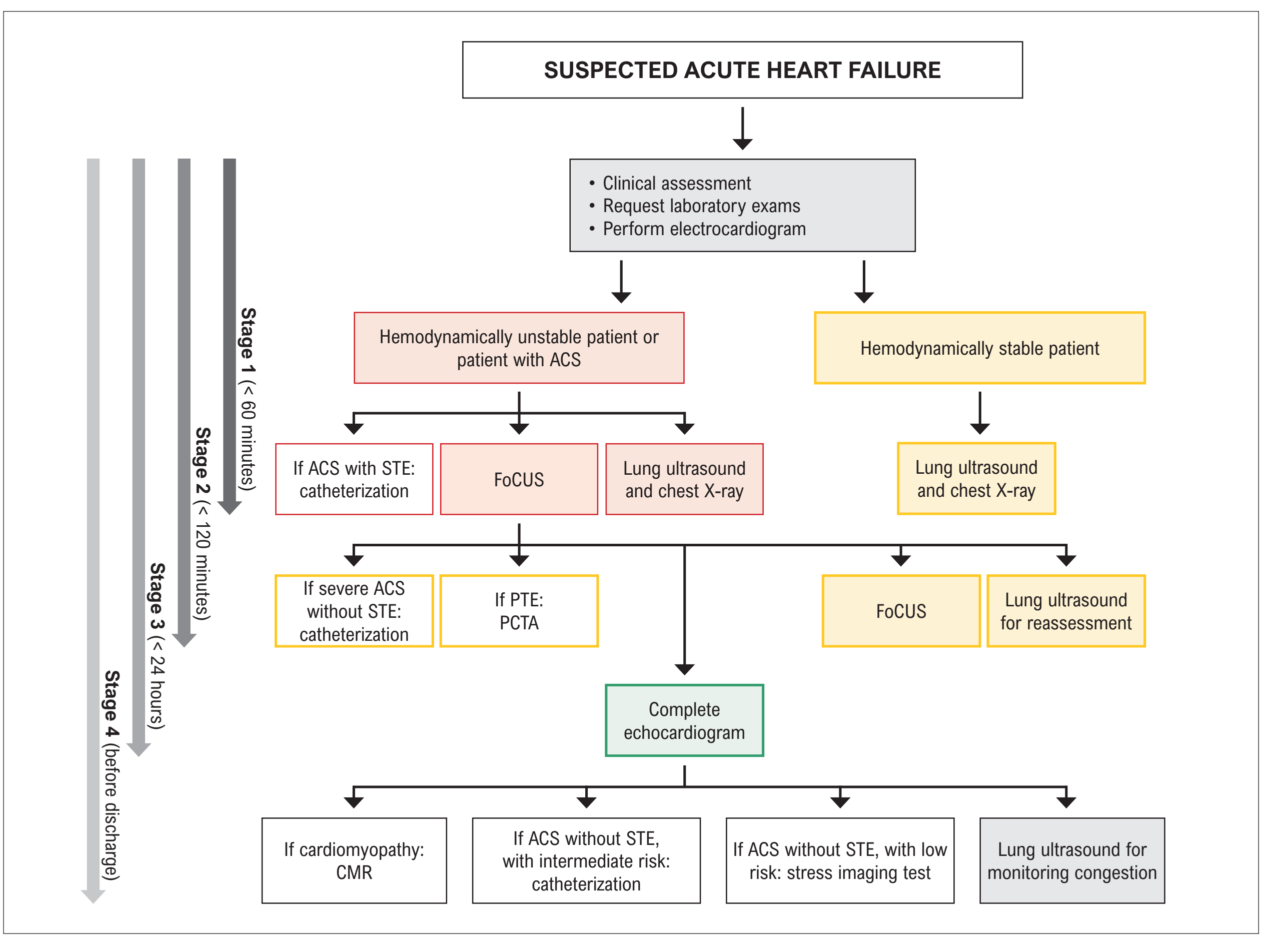

Figure 1 – *Flowchart for diagnosis of acute heart failure in the context of time. ACS: acute coronary syndrome; CMR: cardiac magnetic resonance; FoCUS: focused cardiac ultrasound; PCTA: pulmonary computed tomography angiography; PTE: pulmonary thromboembolism; STE: ST-segment elevation.*

Some current follow-up protocols for acute HF recommend daily assessment of signs and symptoms of systemic congestion.[8,10] The use of lung ultrasound has shown to be effective in directly assessing the presence of pulmonary congestion, guiding the treatment of patients hospitalized for HF, with a reduction in outcomes during the vulnerable phase.[8,11]

The Brazilian Heart Failure Guidelines recommend bedside transthoracic ultrasound as an objective and complementary assessment to be performed early in order to confirm the clinical history and guide therapy (Central Illustration).[1] Direct assessment of pulmonary congestion by means of pulmonary B-lines has shown superior diagnostic accuracy compared to other methods of observing interstitial extravasation, such as chest radiography. Furthermore, it adds agility to the diagnostic process to guide acute HF treatment, even in places without available resources.

Hemodynamic parameters can be continuously monitored based on diuretic treatment optimization, in order to directly and individually assess the patient's response to therapy.[11] Targeted therapy has greater diagnostic accuracy and can facilitate faster reduction of congestion, guiding therapy according to B-line variation. The BLUSHED-AHF[11] and LUS-HF[12] studies provided evidence that diuretic treatment with guided ultrasound showed a significant improvement in all parameters related to congestion, resulting in shorter hospital stays and promoting significantly better

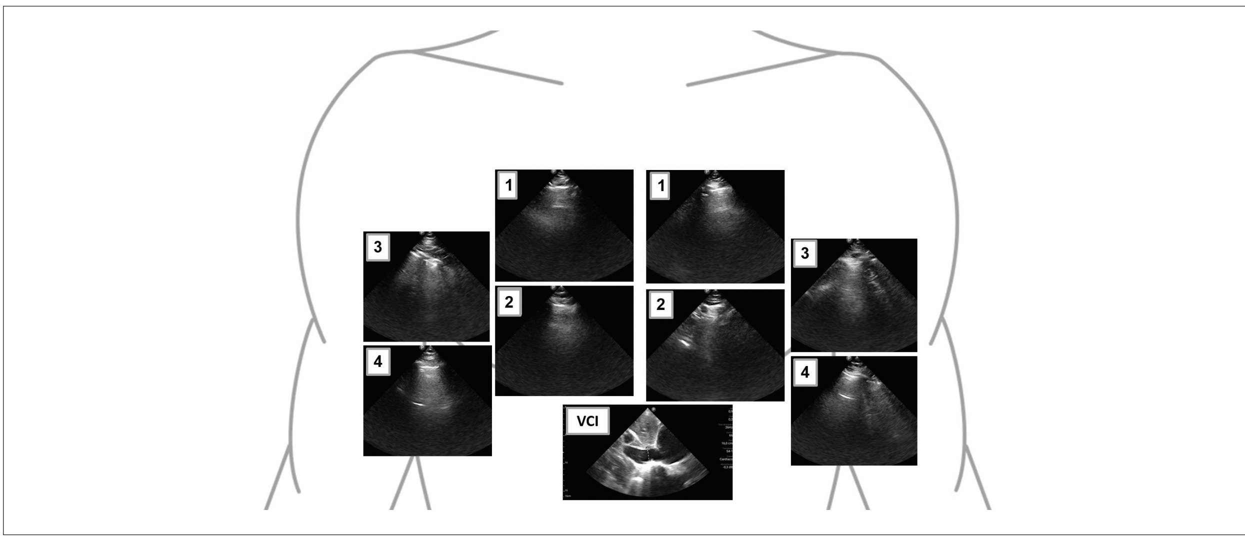

Figure 2 – *Method of obtaining chest ultrasound images. Arrangement in 4 lung zones in each hemithorax, obtained from the intercostal spaces. Zones 1 and 2 should be obtained from the anterior, upper, and lower chest between the midclavicular lines and the sternum, respectively. Zones 3 and 4 should be obtained from the upper and lower lateral thorax between the midclavicular and posterior axillary lines, respectively. Images of the inferior vena cava are complementary and are obtained from the subxiphoid region, between the chest and abdomen.*

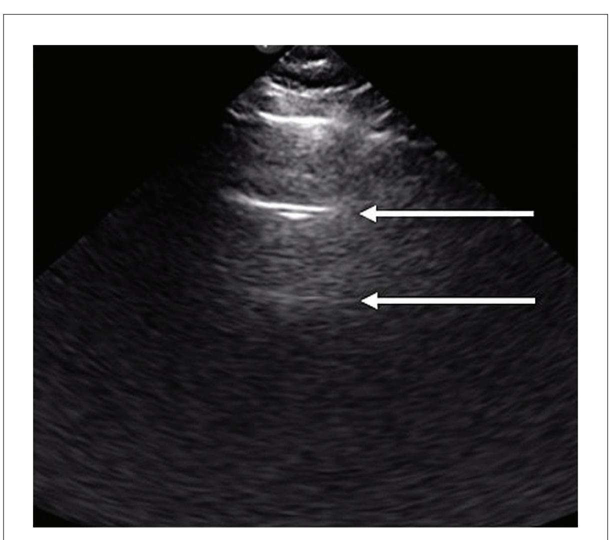

Figure 3 – *A-lines on lung ultrasound. Equidistant horizontal lines represented by white arrows correspond to reverberation of the pleural line.*

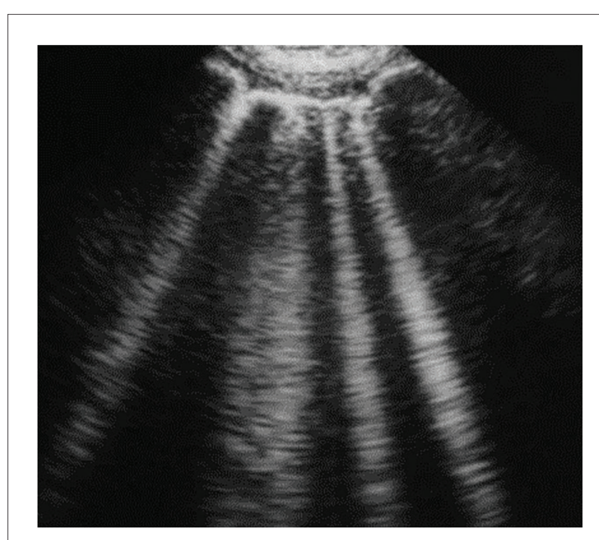

Figure 4 – *B-lines on lung ultrasound. Vertical lines indicate echogenic borders in the interalveolar spaces.*

Table 1 – Quantification of B-lines in the assessment of 8 zones of the anterior and lateral thorax

Method	Quantification of B-lines
Count	Sum of B-lines in all zones
Score	0 points: < 3 B-lines per zone 1 point: ≥ 3 B-lines per zone Score = number of points

post-discharge prognosis in relation to all-cause mortality within 6 months and hospitalization due to HF decompensation.[11,12]

Patients who present with residual pulmonary congestion after stabilization of acute HF have higher rates of readmission and mortality within 12 months. Platz et al. analyzed the association of B-lines with prognosis, based on the 4-zone lung ultrasound method. The study demonstrated that patients who had a greater number of B-lines in at least 1 zone had more readmissions or death between 90 and 100 days after discharge.[13] The use of B-line variation as a dynamic marker has shown to be superior to assessment of natriuretic peptide as a prognostic marker.[12] Rivas-Lasarte et al. showed that patients who were guided by lung ultrasound had a lower risk rate for the primary outcome of congestion and/or death after hospital discharge (0.518; 95% confidence interval: 0.268 to 0.998; $p = 0.049$). They also received more loop diuretics ($p = 0.02$) and significantly improved the distance covered on the 6-minute walk test compared to the control group (60 m [interquartile range: 29 to 125 m] versus 37 m [interquartile range: 5 to 70 m]; $p = 0.023$).[12]

Cardiac ultrasound

Bedside focused cardiac ultrasound (FoCUS) should be performed together with lung ultrasound in the initial approach to patients with acute HF.[6] The basic examination allows rapid detection of systolic or diastolic dysfunction and structural changes, assisting in determination of the type of shock and guiding initial treatment. The assessment of left ventricular dimension and function is extremely important in patients who are unstable, not only because it makes it possible to guide treatment with inotropic support and/or volume adjustment, but also because it serves as a prognostic marker, seeing that the presence of compromised contractility, whether global or regional, is a strong indication of poor prognosis in cardiogenic shock.[14] Since the publication of the SHOCK Trial,[14] it has been known that the rapid definition of ventricular dysfunction and the presence of mitral insufficiency are associated with worse 1-year mortality.[15]

Two-dimensional FoCUS is the first-line exam to assess the categories of concentric or eccentric ventricular remodeling, and adequate endocardial assessment is complementary. Based on the estimation of left ventricular outflow tract diameter and the measurement of the time–velocity integral, stroke volume and cardiac output can be estimated. Time–velocity integral < 15 cm is an indication of low flow and, consequently, reduced left ventricular stroke volume and reduced cardiac output and, thus, of patients susceptible to hypotension and heart pump failure.[6]

After patient stabilization, it is recommended that a complete “comprehensive” echocardiogram be performed before discharge, preferably within 48 hours of admission.[6] In this case, it must be performed by an echocardiographer with specific training to conduct this examination.

Venous ultrasound

In order to complement bedside ultrasound assessment, the VExUS protocol has emerged as an extension to assess peripheral organ dysfunction provoked by high filling pressures in the venous system resulting from increased right atrial pressure. The VExUS score is based on a combined assessment of ultrasound and pulsed wave Doppler of the inferior vena cava, hepatic vein, portal vein, and renal veins, in order to constitute a useful tool to overcome the limitations of assessments of these vessels individually.[16] The protocol is based on verifying the diameter of the inferior vena cava and, if it is greater than 2 cm in diameter, the hepatic, portal, and intrarenal veins are assessed with pulsed wave Doppler (Figure 5). The protocol provides a score for the findings, ranging from no congestion to severe congestion, which should be related to clinical findings. The protocol has become useful for assessing, in addition to critical patients, fluid infusion limitation in patients with venous congestion.[16]

Conclusion

The use of POCUS is currently a reality in the assessment of patients with acute HF, as it provides speed in the diagnosis and follow-up of pulmonary and systemic congestion with a good degree of evidence of diagnostic accuracy. Furthermore, we already have robust studies that support the quality of this tool in estimating prognosis in terms of robust outcomes, mainly in the period known as the “vulnerable phase” of HF. We can, therefore, conclude that it is imperative to add this method to contemporary protocols for the treatment of acute decompensated HF.

Author Contributions

Conception and design of the research and Critical revision of the manuscript for important intellectual content: Kunst L, Danzmann LC; Acquisition of data and Writing of the manuscript: Kunst L, Danzmann LC, Cuchinski KK, Zimmer JRC; Analysis and interpretation of the data: Kunst L, Cuchinski KK, Zimmer JRC.

Potential conflict of interest

No potential conflict of interest relevant to this article was reported.

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Study association

This study is not associated with any thesis or dissertation work.

Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors.

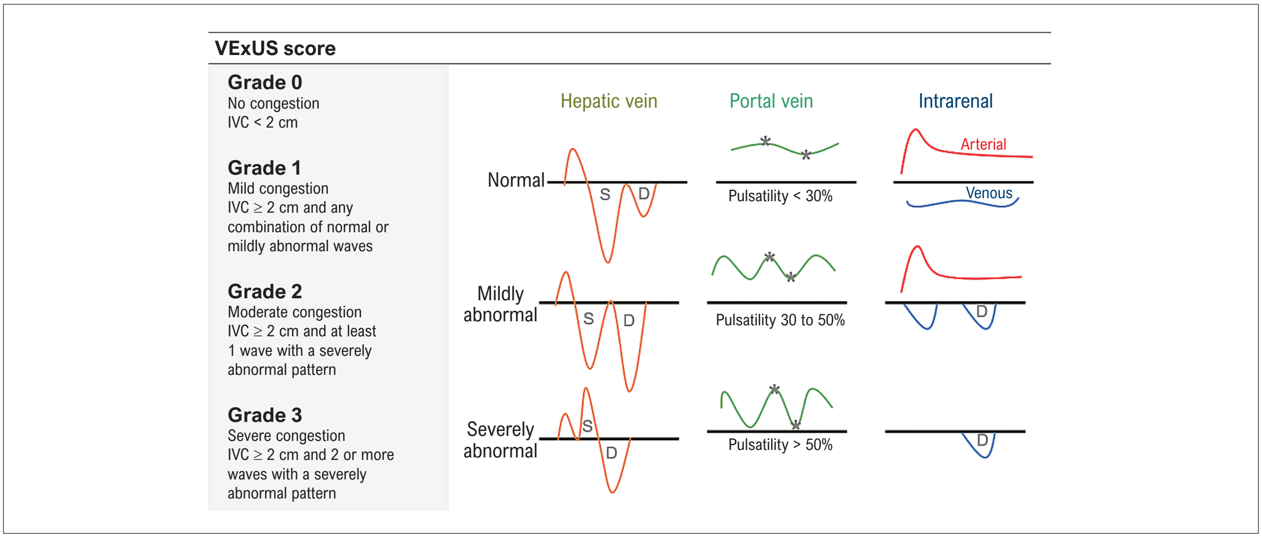

Figure 5 – *VExUS and venous congestion. The degree of venous congestion, when the diameter of the inferior vena cava is > 2 cm, can be assessed based on the severity of the changes in the venous Doppler waves. Legend: D: diastolic wave; IVC: inferior vena cava; S: systolic wave. Figure adapted from: Turk M, Robertson T, Koratala A. Point-of-care ultrasound in diagnosis and management of congestive nephropathy. World J Crit Care Med. 2023 Mar 9;12(2):53-62. doi: 10.5492/wjccm.v12.i2.53. PMID: 37034023; PMCID: PMC10075049.*

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