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The "Moving Black Pattern": Cardio-Thoracic Non-Traumatic Assessment in Four Steps

Letizia Consoli[1,*], Luciano Restivo[2], Michele Domenico Spampinato[3], Beatrice Bellini[4], Paolo Terragnoli[1], Rosita Comune[5], FrancescoTiralongo[6], Chiara Zani[7], Andrea Boccatonda[8], Vittorio Bendotti[1], Giuseppe Sarti[9], Giacomo Sica[10] and Stefania Tamburrini[5]

[1]*Department of Emergency, Fondazione Poliambulanza Istituto Ospedaliero, Brescia, Italy*
[2]*Department of Emergency, San Giovanni Di Dio Hospital, Melfi, Italy*
[3]*Department of Traslational Medicine, university Hospital of Ferrara, Italy*
[4]*Department of Medicine, ASST Settelaghi Tradate Hospital, Italy*
[5]*Department of Radiology, Ospedale del Mare, Naples, Italy*
[6]*Department of medical Surgical Science and Advanced Technologies, Radiology Unit. University Policlinico G Rodolico San Marco, Catania, Italy*
[7]*Research and Clinical Trials Unit, Fondazione Poliambulanza Istituto Ospedaliero, Brescia, Italy*
[8]*Department of Medical and Surgical Sciences, University of Bologna, Italy*
[9]*Department of Advanced Biomedical Sciences, University of Naples "Federico II", Naples, Italy*
[10]*Department of Radiology, Azienda dei Colli, Monaldi Hospital, Naples, Italy*

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*Corresponding Author

Letizia Con-soli, Department of Emergency, Fon-dazione Poliam-bulanzaIstitutoOspedaliero,Brescia, Italy,E-mail:letizia.consoli@i-cloud.com

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Abstract

Background: Point-of-care ultrasound (POCUS) has emerged as a powerful tool for the rapid diagnosis of non-traumatic emergencies. In previous study, the "Black Pattern" approach was developed for abdominal assessment by categorizing pathological findings based on the sonographic presence of fluid ("black") through three steps analysis: 1) looking for black where it shouldn't be, 2) looking for black where is too much and 3) looking for a not clearly black.

Objective: We propose an extension of that educational method, termed the "Moving Black Pattern," to evaluate non-traumatic cardio-thoracic emergencies using a four-step sonographic approach.

Methods: The four steps consist in: (1) identifying black where it should not be (e.g., pleural or pericardial effusion), (2) detecting excessive black in normal structures (e.g., chamber or vessel dilation), (3) evaluating black that is not clearly black (e.g., masses, thrombi), and (4) assessing dynamic movement (e.g., contractility, lung sliding).

Discussion: This integrated method aims to facilitate rapid bedside assessment of the heart, lungs, and major vessels in critical settings. It builds upon existing protocols by offering a structured yet flexible framework that emphasizes pathophysiological interpretation and real-time monitoring.

Conclusion: The Moving Black Pattern has the potential to enhance clinical decision-making in emergency settings, but further prospective studies are needed to validate its diagnostic accuracy and clinical impact.

Keywords: emergency ultrasound; cardio-thoracic ultrasound, emergency, black pattern

Abbreviations: POCUS: Point of care ultrasound; TTE: Transthoracic echocardiography; PAU: Penetrating aortic ulcer; TOE: Transesophageal echocardiography; IVC: Inferior vena cava; FAST: Focused Assessment with Sonography in Trauma

Introduction

Point of care ultrasound (POCUS) has revolutionized the field of medicine by providing rapid and real-time diagnostic imaging at the patient's bedside[1]. In the context of cardio-pulmonary non traumatic emergencies, POCUS has emerged as a game-changer, enabling rapid and accurate assessment of cardiac and lung function [2, 3]. One of the key advantages of POCUS in this setting is its ability to deliver rapid and accurate diagnostic information at a first sight, in a focused and time-sensitive manner. By visualizing the heart and lung interplay in real time, POCUS allows physicians to identify life-threatening conditions such as cardiac tamponade, acute myocardial infarction, pulmonary embolism or pneumothorax [4]. The immediate availability of information aids in making timely treatment decisions and potentially expedites patients' disposition in adjunct to standard clinical examination, especially during the initial and undifferentiated phase. This approach can provide fast and crucial information in order to direct a clinical decision, at the same time of the traditional physical examination while waiting for laboratory and radiological results. Continuous monitoring of cardiac and pulmonary function is crucial in the management of critically ill patients. POCUS allows physicians to monitor cardiac output, evaluate ventricular function, assess lung sliding, parenchymal pattern and detect the presence of pleural effusions. These capabilities enable early detection of deteriorating conditions, close monitoring of treatment efficacy and prompt intervention leading to improved patient outcomes [4]. As previously proposed in our study of non-traumatic acute abdominal conditions [5], the "Black Pattern" approach offers a structured and simplified framework for ultrasound interpretation by classifying findings based on the presence, distribution, and characteristics of anechoic (i.e., fluid-filled or "black") spaces. That model consisted of three primary steps: (I) identifying black where it should not be, (II) determining whether black is present in excess where it is physiologically expected, and (III) evaluating whether the black is not purely fluid (i.e., potentially representing complex or pathological content)[6-8]. Building upon this model, we hereby introduce a fourth step now specifically tailored to the dynamic nature of cardio-thoracic assessment: the analysis of movement. This dynamic dimension includes the functional evaluation of the heart, lung, and diaphragm, which is essential for understanding pathophysiological processes in real time. The purpose of this paper is to present the "Moving Black Pattern"—a four-step ultrasound-based teaching approach for the structured assessment of non-traumatic cardio-thoracic emergencies and built on theoretical reasoning. In the following sections, we outline the method in detail and provide a practical guide for its application in clinical settings.

Four Steps Moving Black Approach

The following will provide an analysis of each step, applied to scenarios involving cardio-pulmonary and vascular emergencies. Table 1 summarizes, for each of the four steps of the Black approach, the main pathological ultrasound findings related to the heart, lungs and vessels. The systematic application of this approach in critical scenarios allows for simultaneous and comprehensive view of the possible cardiopulmonary pathological conditions, which often may coexist at the same time. In the discussion, table 4 provides an explanation of this teaching approach that requires more prospective studies to validate it.

Table 1: A pocket summary of how to apply the four steps of the protocol to cardiac, pulmonary and vascular assessment

	Heart	Lung	Vessels
Black where it should not be	pericardial effusion	pleural effusion	-
Too much black	atrial and/or ventricular chambers dilation		- VCI dilation - aortic aneurysm
Black not clearly black	- masses - thrombi - vegetation - organized effusion	- organized pleural effusion - interstitial syndromes (cardiogenic and not)	acute aortic syndrome

Movement	- impaired ventricular - valvular dysfunction	contractility	

Looking for Black Where it Should Not Be

The cornerstone of the Focused Assessment with Sonography in Trauma (FAST) exam, as we know, is represented by the recognition of free fluid in specific and standardized abdominal cavities [9]. If we consider applying this method to the cardiothoracic evaluation of non-traumatized patients, it is intuitive to think of certain pathological conditions secondary to multiple etiologies and characterized by the presence of free fluid in the pleural or in the pericardial space.

Pericardial effusion

The pericardial effusion is secondary to inflammatory processes that increase the accumulation of fluid between the pericardial layers whose clinical presentation depends on the rate of accumulation [10]. It's secondary to infection, inflammation, or direct filling of the pericardial sac by blood from a defect in the myocardium (iatrogenic or traumatic injury or cardiac wall rupture) or backfilling from an ascending aortic dissection that dissects into the pericardium [11, 12]. The ultrasound study of the heart allows to detect the presence of black in the various scan windows: subcostal, apical four chambers, parasternal short axis and long axis. The application of the M-mode method confirms the presence of anechoic space between the epicardium and parietal pericardium for the entire duration of the cardiac cycle. Ultrasound also allows us to quantify the black space by defining its size, distribution and composition (figure 1). An end-diastolic echo-free space of less than 0.5 cm is considered small, up to and equal to 1 cm moderate and greater than 1 cm large. The effusion becomes tamponade when some characteristic ultrasound signs, in addition to the presence of effusion, are manifested. The pericardium is a relatively poorly distended membrane that adapts slowly to changes in volume. Rapidly forming pericardial effusions can limit cardiac filling, resulting in cardiac tamponade. This clinically critical condition is caused by the rapid increase in intrapericardial pressure, which equals or exceeds the filling pressure of the right and left ventricles. When the reduction in cardiac chamber volume reaches the point of decreasing cardiac output, tamponade becomes clinically manifest. The earliest sign is the collapse of the right atrium resulting from compression exerted by the liquid at the level of the cardiac chambers with the impossibility of adequate filling [13]. The detection of early ultrasound signs of cardiac tamponade may direct the patient to pericardiocentesis before clinical signs appear and it becomes an emergency procedure. Sometimes, if the pericardial effusion forms slowly, it can also become very abundant without necessarily causing cardiac tamponade. This phenomenon determines the echocardiographic picture of the so-called "swinging heart".

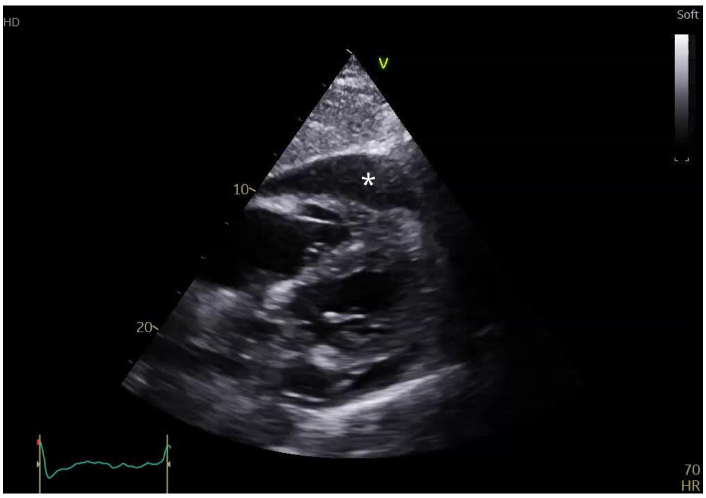

Figure 1: Subcostal view of pericardial effusion with main anterior distribution (indicated by white asterisk).

Pleural effusion

As we have seen above, the pleural effusion represents another pathological condition suggestive of an ultrasound "black" where it should not be. The use of ultrasound can rapidly help to differentiate conditions that commonly appear as non-specific, anechoic images of lower lung fields on chest radiographs, including pleural effusions, pneumonia, atelectasis, elevated hemi-diaphragm, and lung or pleural masses. Pleural effusions are best evaluated at the level of the diaphragm as most free-flowing pleural effusions accumulate within the dependent portions of the thorax [14-17]. The "curtain sign", a typical artifact that represents the normal physiological dynamics of an aerated lung, disappears in the presence of pleural effusion (figure 2). When the pleural effusion is abundant, the "jellfish sign" or "flapping lung sign" can be detected appearing like a dense echogenicity tissue, swinging in the pleural fluid [18].

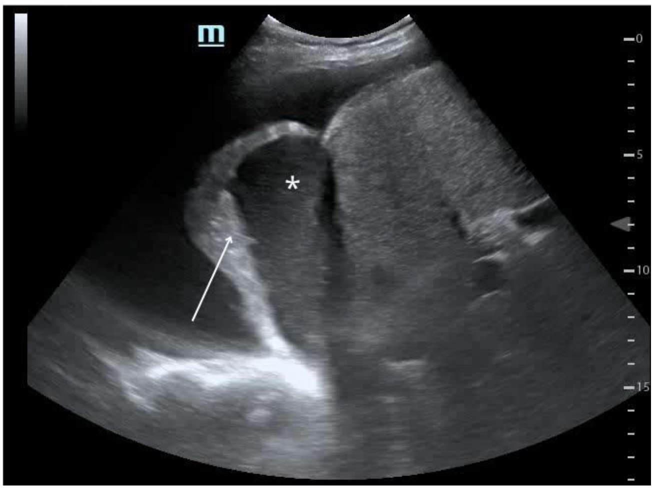

Figure 2: Right pleural effusion (white asterisk) associated with atelectasis of the adjacent pulmonary parenchyma (white arrow). Longitudinal scan obtained at the posterior costophrenic angle in the sitting position.

The ultrasound evaluation of a patient in a sitting position is better because it allows a more precise evaluation of pleural effusion whose quantification is summarized in Table 2. In some cases, ultrasound images other than those of the effusion can help assess the nature of the pleural effusion. For example, the presence of thickened pleura or of a pulmonary consolidation with dynamic air bronchogram is usually indicative of an exudate, mostly typical of infectious disease. The presence of a diffuse bilateral sign of lung congestion suggests transudative effusion during heart failure.

Table 2: Ultrasound qualification of pleural effusion. Qualitative scoring system of pleural effusion based on ultrasound delineation of the intercostal spaces occupied by the fluid.

Quantification	Ultrasound visualization	Volume estimation, mL
minimal	Costophrenic angle	< = 100
Small	Range, one probe	100-500
Moderate	Range, two probe	500-1500
large or massive	Range, three or more probes	> 1500

Looking to see if there is too much black

We now describe the recognition of those conditions in which there is too much black where physiologically present. These are mainly cardiovascular pathologies related to dilatation of the heart chambers or vascular structures, both easily recognizable with ultrasound.

Enlargement of Heart Chambers

As we know, enlargement of the ventricular and/or atrial chambers can occur in some life- threatening situations [10, 18]. Just think about the dilatation of the right sections in acute pulmonary embolism and the mechanical complications of acute myocardial infarction. It is not so uncommon, when faced with a dyspneic patient, to find a dilated cardiomyopathy (figure 3) whose causes can be multiple (ischemia, infectious disease, autoimmune or undetermined etiologies). Ventricular cavity dilation refers to coded cut-off values for both sexes. Even the increased volume of the atria, albeit with less impact in an emergency situation, falls into the category of "too black". However, it assumes importance in the context of an integrated ultrasound evaluation of other cardiac conditions such as mitral and/or tricuspid valve pathologies). As with the left sections, the right ventricle is directly involved in a variety of diseases such as left to right shunts, pulmonary hypertension tricuspid regurgitation, right ventricular infarct and cardiomyopathies. For the initial assessment, both the apical four chamber and subcostal windows offer the most optimal views of the right ventricle which should appear triangular, with a broad base and narrow apex. Qualitatively, its size is often described in comparison to the left ventricle; normally the right side should be two-thirds of the size of the left one in basal diameter measurement.

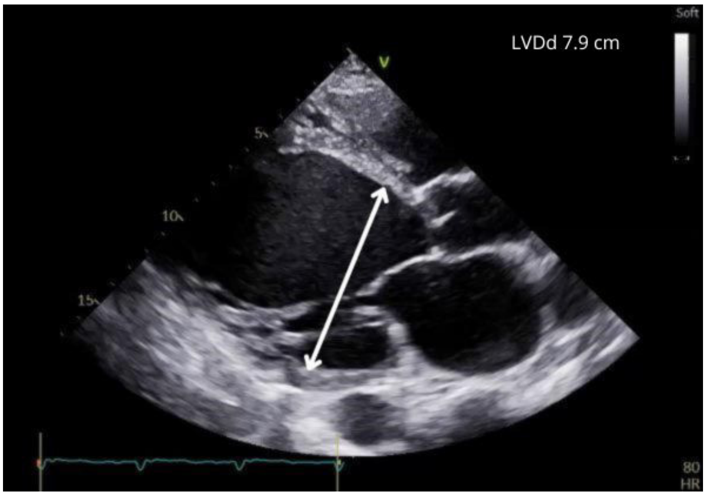

Figure 3: Parasternal long axis view showing features of dilated cardiomyopathy. This window allows linear measurement of ventricular wall thickness and atrioventricular chamber diameters. The double white arrow shows increased left ventricular diastolic diameter (LVDd).

Aortic Dilatation

Transthoracic echocardiography (TTE) permits adequate assessment of several aortic segments, particularly the aortic root and proximal ascending aorta. All scanning planes should be used to obtain information on most aortic segments. All scanning planes should be used to visualize the thoracic aorta, starting from the aortic root, arch, and parts of the descending thoracic aorta behind the heart. TTE is an excellent modality to detect aortic root dilatation which is important for patients with annulo-aortic ectasia, Marfan syndrome, or bicuspid aortic valve (figure 4). Since the predominant sites of dilatation are in the proximal aorta, TTE is suitable for a first screening [12] In ascending aorta dilatation, some echocardiographic features play an important role in the assessment of the mechanisms of functional aortic regurgitation. Tethering of the leaflets is the feature most closely associated with functional aortic regurgitation. Transesophageal echocardiography (TOE) is clearly superior to TTE for assessing aneurysms located in the aortic arch and descending thoracic aorta [19]. Because of its anatomical location, the entire thoracic descending aorta is not well visualized by TTE.

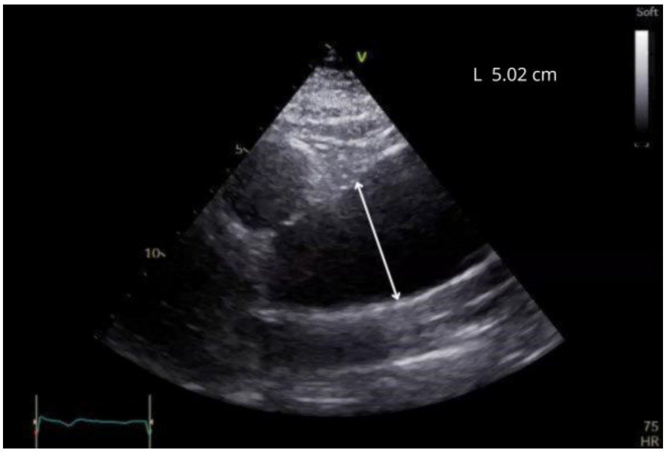

Figure 4: Parasternal long axis echocardiographic view demonstrating aneurysmal dilatation of the ascending aorta. Note the enlargement of the aortic root and proximal segment indicated by the double white arrow.

Inferior Vena Cava (IVC) Dilatation

The most useful view to identify IVC is the subcostal one. Its size is measured at end-expiration just proximal to the junction of the hepatic veins. M-mode imaging allows high frame rate measurements of size changes throughout the respiratory cycle. IVC diameter normally decreases more than 50% during inspiration in spontaneous breathing [13, 20]. A blunts or absent inspiratory variation of IVC diameter associated with dilation suggests increased central venous pressure and may accompany many pathological conditions characterized by haemodynamic overload or reduced venous return (figure 5).

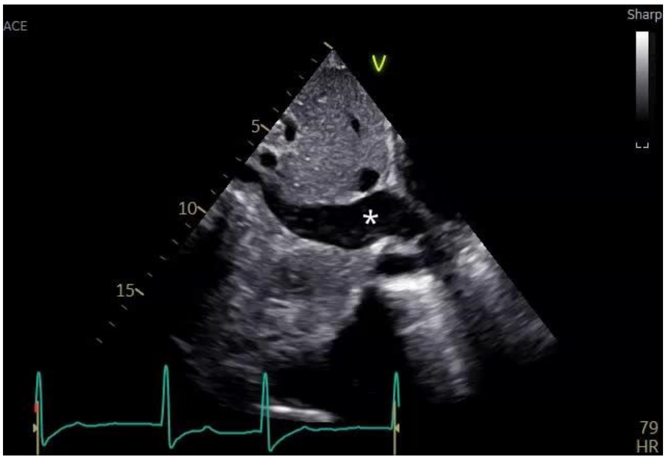

Figure 5: Subcostal longitudinal view showing marked distension of the inferior vena cava (IVC). The IVC, indicated by the asterisk, appears plethoric with reduced respiratory variation, suggestive of elevated central venous pressure.

Values for estimation of right atrial pressure using IVC collapsibility index are referenced in table 3 from the guidelines for the echocardiographic assessment of the right heart in adults [13, 14].

Table 3: Ultrasonographic indices for estimation of right atrial pressure. Scoring system of right atrial pressure as estimated by inferior vena cava variability of diameter and collapse with sniff

Variables	Normal 0-5 mmHg (3 mmHg)	Intermediate 5-10 mmHg (8 mmHg)		High 10-20 mmHg (15 mmHg)
IVC diameter (cm)	<= 2.1	<= 2.1	>2.1	>2.1
IVC collapse with sniff (%)	> 50	< 50	> 50	< 50

Looking for black that is not clearly black

This section describes pathological conditions in which the ultrasound “black” doesn’t appear as purely anechoic.

Pericardial Organized Effusion

In patients with recurrent pericarditis or longstanding disease, fibrin strands are often seen within the effusion and on the epicardial surface of the heart. Organized pericardial effusion is also observed after surgery or procedures performed percutaneously (figure 6). In this situation, the effusion is circumscribed by the presence of adhesions recognizable by ultrasound as hyperechoic material within the effusion [21, 22]. Recognition of an organized effusion is especially important when it involves areas particularly sensitive to compression, where even small amounts of fluid collection can lead to hemodynamic compromise.

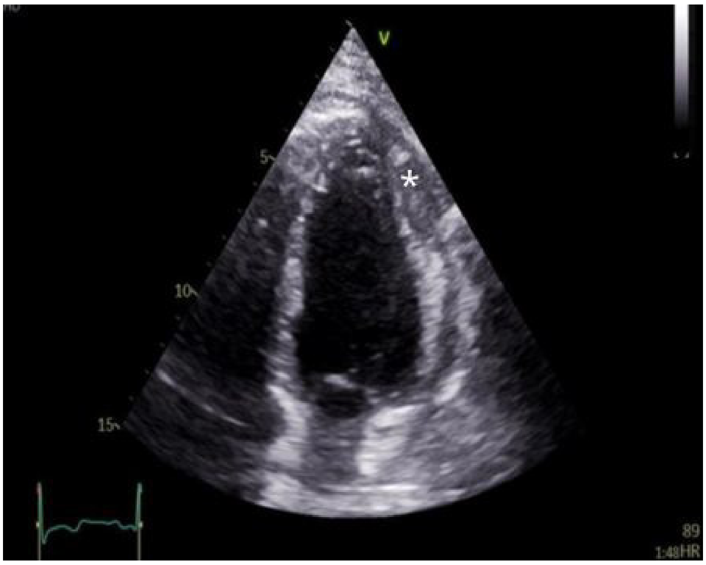

Figure 6: Apical four-chamber view demonstrating an organized pericardial effusion. Hyperechoic fibrin strands (white asterisk) are visible within the effusion, indicating chronic or post-inflammatory changes.

Intra-cardiac Masses: Tumor, Thrombus and Valve Vegetation

Trans-thoracic echocardiography is an invaluable procedure for the evaluation of intracardiac masses, and can reliably identify mass characteristics such as its location, attachment, shape, size, and mobility, while defining the presence and hemodynamic consequence. With careful attention to mass characteristics, and appropriate application of clinical information, echocardiography can usually distinguish between the three principal intracardiac mass lesions: tumor, thrombus, and vegetation [2, 3, 13, 19-35]. It is essential first of all to distinguish pseudo-mass from no pathological structures, often referred as pseudo-masses, including embryonic remnants such as the Chiari network or Eustachian valve, false tendons, moderator bands, atrial septal aneurysms, lipomatous septal hypertrophy atrial fibrillation (SIA) and finally the calcifications of the mitral annulus. In the context of intra-cardiac masses, primary tumors both benign and malignant are rare conditions. Among the benign forms the most frequent is the so called myxoma (figure 7), among the malignant ones is the angiosarcoma [13, 29]. More frequently, cardiac masses correspond to metastases or thrombi. Differential diagnosis among cardiac masses can be challenging and sometimes non conclusive; despite that, their echogenicity and ultrasound properties in combination with the use of contrast agents and the evaluation of its distribution may help to obtain diagnostically useful images. It’s not so uncommon to find intracavitary thrombus, often in asymptomatic patients unless there is a distal embolization resulting in ischemic stroke, visceral infarction or distal limb ischemia. In situ thrombosis occurs at sites of low flow, thus allowing for clot to form. In transit thrombus is typically moving from deep venous thrombosis that moves either toward the pulmonary arteries or across an interatrial shunt. The appearance of thrombi may vary greatly, ranging from fibrotic high echogenicity to soft, jelly like ones. The ultrasound can also help in the differential diagnosis with endocarditis, which cannot always be visualized with the transthoracic approach requiring the use of TEE as a diagnostic confirmation [21, 36, 37]. Typical features of valve vegetation are: echogenic mass adherent to valve, low pressure valve side mass insertion site (atrial chamber for mitral valve, ventricular chamber for aortic valve). The movement pattern is independent and chaotic from the normal valve pattern (figure 8). In high-risk patients, identifying the endocarditis focus as the septic source allows for the early start of targeted therapy, emphasizing the crucial role of echocardiographic integration in the initial assessment.

Figure 7: Apical four-chamber view showing a left atrial myxoma. The white arrow shows the mass is attached to the interatrial septum, with typical features of a benign intracardiac tumor.

Figure 8: Echocardiographic views of mitral valve endocarditis. The apical four-chamber view shows a hyperechoic vegetation on the anterior mitral leaflet, with irregular and chaotic motion (white arrow).

Acute Aortic Syndrome

Acute aortic syndrome has a high mortality rate and early medical and surgical treatment is crucial. Therefore, rapid and accurate diagnostic techniques, which can be applied in critically ill patients, are essential. The ultrasound window used to visualize the ascending aorta and part of the thoracic aorta is the parasternal long axis (figure 9) while the aortic arch is identified by the suprasternal view. A flap in the aorta or a crescent shape of the aortic wall (direct sign) and aortic regurgitation, ascending aortic dilation, or pericardial effusion (indirect signs) suggest an aortic dissection [13, 25]. In most cases, false lumen flow is detectable by color-Doppler but may be absent in totally thrombosed and retrograde dissections. Intra-mural hematoma is characterized by circular or crescentic thickening of the aortic wall and penetrating aortic ulcer (PAU) presents as an image of crater-like outpouching with jagged edges in the aortic wall, generally associated with extensive aortic atheroma [21, 31, 38]. In patients with acute chest pain, special attention should be paid during the TTE exam to aortic root dilatation, aortic regurgitation, and/or pericardial effusion, since these findings should raise the suspicion of acute aortic syndrome and showed 98 % specificity for identifying patients with suspected type A aortic dissection combining aortic dissection risk score [21, 38].

Figure 9: Parasternal long axis view shows ascendig aorta dilation (solid white arrow) with intimal flap extended to the aortic valve plane (dashed white arrow).

Organized Pleural Effusion

Based on its sonographic appearance, pleural effusions are categorized as simple or complex. As said before, simple pleural effusions are anechoic, and usually transudative. Complex pleural effusions are sub categorized as homogeneous or heterogeneously echogenic, with or without septations, and are more often exudative [37, 39]. Effusions with heterogeneous echogenicity with swirling echoes suggest high cellular content that is often associated with malignancy (figure 10). Fibrinous stranding, septations, and loculations also suggest an exudative effusion. Homogeneously echogenic effusions are most often due to hemothorax or empyema. High cell count of a hemothorax creates a layering effect in costophrenic recesses ("hematocrit sign"). Empyema develops from complex effusion that organizes into collections of pus and usually have a homogeneously echogenic, speckled appearance [37, 40]. One again we'd like to emphasize that other elements, such as blood test and clinical features, are necessary to the differential diagnosis.

Figure 10: Longitudinal scan of the right hemithorax showing a complex pleural effusion. The effusion is heterogeneously echogenic, consistent with an exudate or empyema.

Lung Interstitial Involvement

Another field of application related to this step is represented by lung parenchyma study. In 1996, Lichtenstein proposed the Bedside Lung Ultrasound in Emergency (BLUE) [41, 42]. According to this protocol, B-profile is defined by the presence of three or more B lines in longitudinal scan in more than one scanning zone in the anterolateral chest wall bilaterally (figure 11). This is typical of interstitial syndrome where the white lung profile could be considered as a "not clearly black". Many sonographic findings can also be used to distinguish pulmonary edema from other interstitial lung disease (fibrosis, infective pathologies, etc) such as homogeneous distribution, pleural alterations and consolidations.

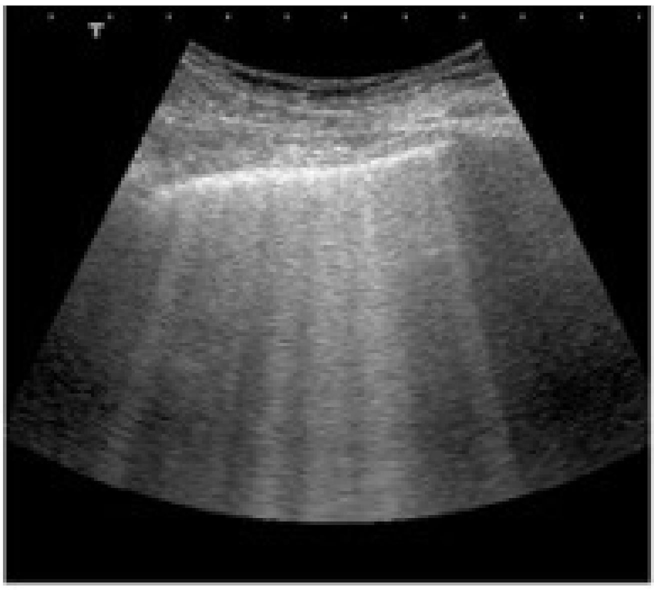

Figure 11: Interstitial lung involvement with multiple longitudinal B-lines.

While many findings can be classified using simple binary criteria, some sonographic appearances fall into ambiguous category. Table 4 summarizes the key sonographic features that help differentiate complex findings based on location, echogenicity and related clinical context. This tool aims to support bedside interpretation in diagnostically uncertain cases.

Table 4: Not clearly black findings in cardio-thoracic region, including location, sonographic appearance and associated clinical conditions

Finding	Location	US appearance	Clinical conditions
Complex pericardial effusion	PericardialSpace	Anechoic withhyperechoic strands	Chronic or constrictive pericarditis, post-procedure, infection
Complex pleural effusion	PleuralSpace	Heterogenous fluidpossible septations	empyema, hemothorax and malignancy
Thrombus	CardiacChambers	Variable echogenicityranging from soft todense	atrial fibrillation, pulmonary embolism.
Masses	CardiacChambers	Variable echogenicityand mobility mass	Benign or malignant tumors
Vegetations	Valvesleaflet	Echogenic massattached to valve	Infective endocarditis

Looking for Abnormal Movement

This step constitutes the novel addition of the Black approaches for cardiothoracic emergencies. It's a dynamic evaluation which makes use, in addition to the classic two-dimensional method, of specific techniques (such as Pulsed or Continuous Wave Doppler and M-Mode) for the movement analysis.

Impaired Systolic and/or Diastolic Cardiac Function

A visual assessment of left ventricular function is called 'eyeballing' and is based on observation of the global and regional myocardial function at a first, gross and comprehensive sight taking into account thickening and shortening or displacement of the normal geometry and motion of LV [10, 13]. The most commonly used expression of global LV systolic function is LV ejection fraction (LVEF). LVEF is preferably calculated from two-dimensional (2D) volume measurements using the following formula: LVEF (%) = (LVEDV (ml)– LVESV (ml))/ LVEDV (ml)×100 (LVEDV; left ventricular end-diastolic volume, LVESV; left ventricular end-systolic volume). The biplane Simpson method is most commonly used for measuring 2D LV volumes (LVEDV, LVESV) and LVEF [21, 23, 30]. Regional LV systolic function is assessed by dividing the LV into segments using a 16-segment model recommended by the American Society of Echocardiography [21]. A numeric scoring system is adopted based on the contractility of the individual segments. Evaluation of diastolic function is more challenging as reflected in the large number of indices which have been introduced. Some of the key measurements and findings include: a) the doppler trans-mitral flow velocity pattern with the ratio of the early filling velocity (E) to atrial contraction velocity (A); b) Tissue Doppler Imaging (TDI) for the assessment of the early diastolic mitral annular velocity (E') at the septal and lateral corners of the mitral valve annulus; c) Deceleration Time (DT) that represents the time taken for the E wave to decelerate from peak velocity to the baseline [21, 26].

Valve Dysfunction

Echocardiography might be helpful to assess the movement and functioning of the heart valves. It can detect valve regurgitation (leakage) or stenosis (narrowing). Doppler echocardiography, measures blood flow velocities across the valves and helps quantify the severity of the dysfunction [21, 27]. It is useful for monitoring the progression of the valve heart diseases over time progression and planning appropriate interventions. The valve study assumes a crucial role in some emergency conditions (figure 12). Just think, for example, of the post-infarction complications (as in the case of severe mitral insufficiency due to rupture of papillary muscles) or the multiple clinical presentations of aortic stenosis in urgency [13, 43].

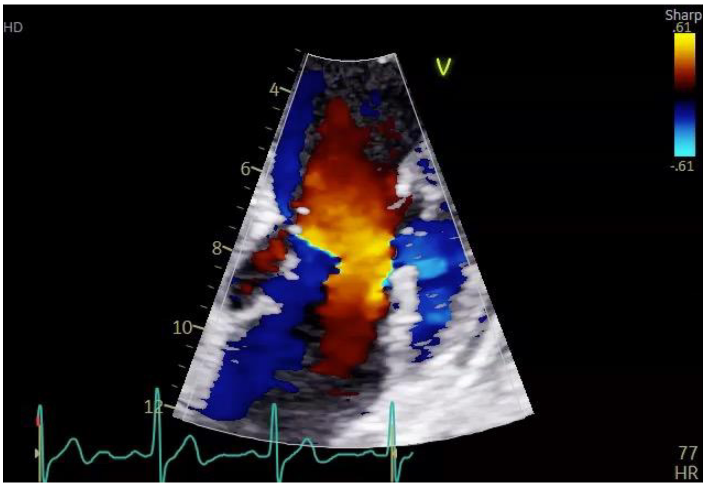

Figure 12: Apical two-chamber view demonstrating severe mitral regurgitation. Color Doppler imaging reveals an eccentric regurgitant jet directed toward the left atrial wall indicated by the blue retrograde flow.

Inferior vena cava collapsibility

As previously mentioned, the assessment of the diameter and collapsibility of the inferior vena cava can provide useful information on the patient's volume status. The normal respiratory excursion of the IVC can be further evaluated through the integration of M-mode imaging[44].

Impaired Movement in the Chest: Pleural Sliding and Curtain Sign

Lung sliding refers to the movement of the pleural layer during respiration with a dynamic pattern indicating that the lungs are properly expanding and contracting with each breath. The absence of pleural sliding may suggest the presence of pneumothorax can be confirmed by the presence of the M-mode "barcode sign" [13, 45] (figure 13). In this context, the identification of the lung point, the transition between a collapsed lung and a normally aerated lung, represents the edge of the pneumothorax. Another dynamic lung parameter is the "curtain sign", a sonographic artifact used to describe the appearance of an expanded and aerated lung, often in the context of pleural effusion diagnosis where it is usually missing. In emergency and critical care ultrasound use, the recognition of the curtain sign is very useful in the detection of early pulmonary pathological processes occurring at the lateral lung bases and costophrenic recesses [27, 28].

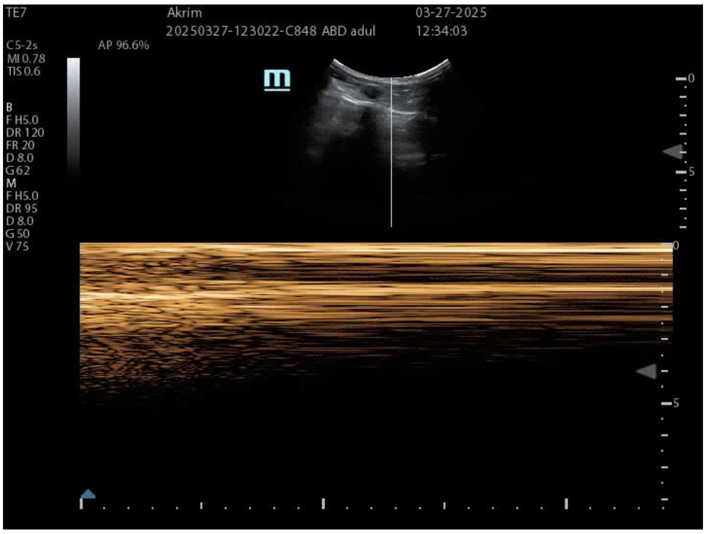

Figure 13: Longitudinal pleural scan showing signs of pneumothorax. M-mode imaging demonstrates the absence of the normal "seashore sign," replaced by a "barcode sign," consistent with absent pleural sliding.

Diaphragmatic Dysfunction

The assessment of diaphragm function through ultrasound imaging has gained significant attention in recent years [21, 41]. Ultrasonography allows for non-invasive evaluation of the diaphragm's structure and function, providing valuable insights into its performance during respiration. Diaphragmatic excursion refers to the distance the diaphragm moves during inspiration and expiration. It is a crucial parameter for assessing diaphragm function and can help clinicians to identify diaphragm weakness or paralysis. Measuring the thickness of the diaphragm using ultrasound is another important parameter in evaluating its function. The diaphragm's thickness can vary depending on the phase of respiration, with thicker muscle fibers during inspiration and thinner fibers during expiration. Ultrasound allows for real-time visualization of the diaphragm and provides accurate measurements of its thickness at different respiratory phases [23, 46]. Assessing diaphragm motility involves examining the diaphragm's ability to contract and relax effectively during respiration. Ultrasound imaging allows for dynamic visualization of the diaphragm's movement during the respiratory cycle. The diaphragmatic ultrasonographic index (DUI) is a parameter that combines both diaphragmatic excursion and thickness measurements. It provides a comprehensive assessment of diaphragm function by considering multiple ultrasound parameters [1, 32, 35]. The DUI is calculated by dividing diaphragm excursion by diaphragm thickness during a specific respiratory phase. This index allows for a quantitative evaluation of diaphragm function and can be useful in tracking changes over time or comparing different patient populations

Discussion

Over the past decade, point-of-care ultrasound (POCUS) has become an indispensable tool in the evaluation of cardiopulmonary emergencies. Several prior studies have highlighted the growing role of bedside ultrasound in the early identification of life-threatening cardiothoracic conditions. For instance, Piccioni et al. emphasized how POCUS contributes significantly to the differential diagnosis of chest pain and dyspnea in emergency settings, particularly when used as an extension of the physical exam [13]. Likewise, the BLUE and FALLS protocols developed by Lichtenstein have shown high diagnostic yield in respiratory failure and fluid management scenarios [41, 42]. However, these protocols are largely organ-specific and do not always account for the interplay between cardiac, pulmonary, and vascular findings in a unified framework.

The *Moving Black Pattern* seeks to address this gap by offering a *multisystem, stepwise approach* risulting from anatomical, fluid-related, and functional assessment across the *heart, lungs, and vascular system*. By conceptualizing ultrasound findings into four core categories— (1) presence of fluid in abnormal locations, (2) excess fluid in normal compartments, (3) complex or ambiguous "black" patterns, and (4) dynamic movement—the approach emphasizes pattern recognition that is both intuitive and clinically actionable.

Unlike other protocols, which often begin with a fixed scan order or predefined differential diagnosis, the Moving Black Pattern adapts flexibly to the clinical context. For example, in a patient with undifferentiated dyspnea, this method allows clinicians to concurrently assess for signs of heart failure (e.g., chamber dilation, B-lines, pleural effusion), pulmonary embolism (e.g., RV strain, IVC distension, wedge-shaped infarct-s), or tamponade (e.g., pericardial effusion with chamber collapse), using the same interpretative lens.

The structured classification of sonographic "black" findings—initially developed for abdominal emergencies—proves particularly effective in the thoracic domain, where fluid presence, distribution, and dynamics often determine acuity and intervention thresholds. The addition of a fourth step focused on movement introduces a *functional dimension* to the pattern, aligning with the growing trend toward *hemodynamic ultrasonography* and *dynamic monitoring* in critical care.

To illustrate the practical implications of this approach, we propose a matrix (Table 5) mapping the application of the four ultrasound steps across common non-traumatic emergencies. This "cross-system" view helps clinicians anticipate which sonographic findings are most relevant for a given diagnosis. For instance, heart failure involves all four domains (effusion, chamber dilation, B-pattern, impaired movement), while pneumothorax may lack black fluid altogether but reveal pathology through absent lung sliding and dynamic signs. This approach could be integrated into simulation-based training for emergency physicians.

Ultimately, the Moving Black Pattern is designed to enhance clinical reasoning, reduce cognitive overload in emergency settings, and bridge existing protocols into a more *holistic diagnostic tool*. Its real-world value, however, must be validated through *prospective studies*, assessing diagnostic accuracy, time to diagnosis, and impact on patient outcomes.

Table 5: Application of the Moving Black Pattern to the main cardiovascular and pulmonary conditions in emergency settings

	Heart	Lung	Vessels
Heart Failure	1;2;3;4	1;3;4	4
Pneumothorax	-	4	4
Infective diseases	1;3;4	1;3;4	2
Pulmonary embolism	2;3;4	3	3;4
Acute aortic syndrome	1;2;4	3	4
Tamponade	1;3;4	3	4

This visual and conceptual framework aims to enhance rapid bedside interpretation of cardio-thoracic findings by integrating structural and dynamic assessment into a unified mnemonic easy to teach. The effectiveness of this protocol will naturally need to be confirmed through targeted research with the ultimate goal of implementing this approach in routine clinical practice by means of specifically designed report forms. As with any ultrasound-based protocol, this approach is subject to certain limitations. One of the mail challenges is inter-operator variability which may affect the accuracy of image acquisition and interpretation, especially in less experienced users. Technical limitations such as suboptimal sonographic windows may occur in obese patients, during mechanical ventilation or subcutaneous emphysema, potentially compromising the cardiothoracic structures visualization. These aspects underscore the need for appropriate operator training and ongoing skill updates to ensure accurate interpretation and consistent diagnostic performance through the integration of this approach with clinical and laboratory data to maximize diagnostic yield.

Conclusions

According to what has been seen for abdominal settings, the black approach applied to non-traumatic cardiothoracic emergencies is intended to be a diagnostic and educational tool to support clinical decision-making in emergency settings. It is a multi-step assessment that allows the causes of the main emergency scenarios to be confirmed or excluded. The black approach, by stratifying the severity of the pathology, conditions the therapeutic choices and allows dynamic and non-invasive monitoring of the clinical picture. Ultrasound assessment of anechoic spaces and their dynamics constitutes an element of novelty as well as a strong point. It's also intuitive that, especially as regards an emergency echocardiogram, the training required to perform typically involves a combination of medical education, specialized training and clinical experience. Given its intuitive design, the "moving black pattern" may be incorporated into structured training programs or emergency decision-making algorithms to support rapid bedside assessment. Future implementation may include its use in simulation-based learning and POCUS checklists. While promising, this approach remains theoretical and requires prospective validation by building multicentric trials or educational implementation as future steps. These studies should aim to quantify its diagnostic accuracy, reproducibility, and potential impact on clinical outcomes across various emergency settings.

Author Contributions

For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, L.C,.S.T. and L.R..; methodology, L.C., S.T., L.R. and D.S.,.; software, L.C., S.T., C.Z.,; validation, L.C., S.T., L.R., B.B., G.S., R.C., and F.T..; formal analysis, L.C., S.T., C.Z., L.R.; investigation, L.C., S.T., P.T., V.B.; resources, L.C., S.T., G.S. A.B.; data curation, L.C., S.T., L.R., C.Z., G.S.; writing—original draft preparation, L.C., S.T. and L.R.; writing—review and editing, L.C., S.T., R.C..; visualization, G.S., F.T., B.B., P.T., V.B., D.S.,A.B..; supervision, L.C. and S.T.; project administration, L.C., S.T. and L.R.. All authors have read and agreed to the published version of the manuscript.

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