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NARRATIVE REVIEW

# Focused cardiac ultrasound in anesthetic practice: technique and indications

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**KEYWORDS**
Point of care ultrasound;
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**Abstract** The use of ultrasonography is well established in several anesthesia sub-specialties. Recently, there has been a major expansion of the POC (Point-Of-Care) ultrasound technique in intensive care, surgery, and emergency medicine, corroborating that USPOC in perioperative medicine has a much more comprehensive capability for both providing improved hemodynamic monitoring and early diagnosis of complications. The objective of the present article was to describe the use of a USPOC modality (focused cardiac US) that can be used for bedside assessment of unstable patients. Within a specific list of diagnoses, clinical treatment for a given situation can be tailored according to ultrasound findings, and by using binary and simple questions. Perioperative focused cardiac US use by the anesthesiologist has been related to lower rates of complications and mortality in high-risk patients.
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**PALAVRAS-CHAVE**
Ultrassonografia *point of care*;
Ultrassom cardíaco;
Instabilidade hemodinâmica

## Ultrassom cardíaco focado na prática anestésica: técnica e indicações

**Resumo** O uso da ultrassonografia na prática anestésica já é bem estabelecido com a sua utilização em diversas sub-especialidades. Recentemente houve uma grande disseminação da técnica de ultrassonografia POC (*point-of-care*) nas áreas de medicina intensiva, cirurgia e medicina de urgência confirmando que o seu uso em medicina perioperatória tem um potencial muito mais abrangente tanto para melhor monitorização hemodinâmica, como também para diagnóstico precoce de complicações. O objetivo desse artigo é descrever a utilização de uma modalidade de USPOC (US cardíaco focado) que pode ser utilizado à beira do leito com o objetivo de avaliar o paciente instável e dentro de uma lista específica de diagnósticos individualizar o tratamento clínico para determinada situação baseado nos achados ultrassonográficos

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utilizando-se de questões de caráter binário e simples sendo o seu uso pelo anestesiologista no período perioperatório relacionado a menores taxas de complicações e mortalidade em pacientes de alto risco.
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## Introduction

Ultrasonography use in anesthetic practice has been well established and the technique is currently used to perform regional blocks[1] to obtain venous access,[2] and to perform transesophageal echocardiography in perioperative care during cardiac surgery.[3–5]

Recently, there has been an upsurge in interest and expansion of the Point-Of-Care Ultrasound technique (USPOC) in intensive care, surgery and emergency medicine, confirming that ultrasound in perioperative medicine has a comprehensive capability, for both improving hemodynamic monitoring and performing early diagnosis of complications.

Its perioperative use has been specifically well established in the following areas: (1) Cardiac, (2) Pulmonary, (3) Hemodynamic assessment, (4) Abdominal, (5) Vascular access, (6) Airways and (7) Intracranial pressure assessment.[6]

Focused cardiac US, a USPOC modality, is defined as the bedside use of US with the goal of assessing the unstable patient and, within a specific list of diagnoses, of tailoring clinical treatment for a given situation according to US findings, and by using binary and qualitative questions (yes/no – a lot/a little). Additionally, focused cardiac US is a fast-execution aide to physical examination with defined goals. Perioperative focused cardiac US use by the anesthesiologist has been related to lower rates of complications and mortality in high-risk patients.[7–9]

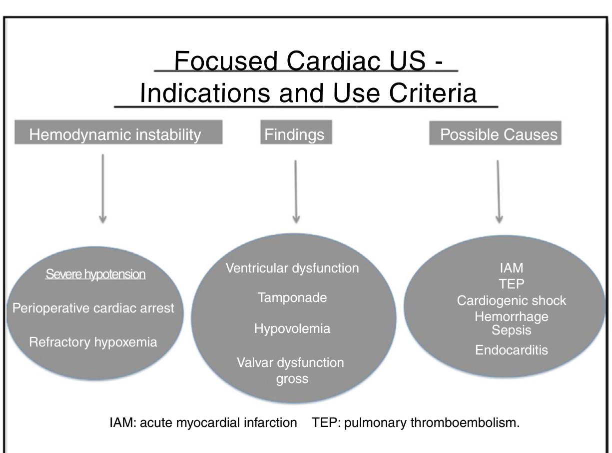


**Figure 1** Usage criteria and indications for performing cardiac US focused on the perioperative period.

## Indications

The indications of focused cardiac US are based on finding the etiology of perioperative hemodynamic instability and on decision making, thus providing new data that can change hemodynamic management and improve outcome of the procedure (Fig. 1).

The core of focused US examination is based on qualitative analysis using a simple and binary interpretation (full/empty heart, satisfactory or unsatisfactory ventricular function), essential for decision making. It represents the modus operandi of the focused examination, and presents a satisfactory correlation when its findings are compared to formal comprehensive quantitative examination.[10,11]

## Technique

### Equipment

Focused cardiac US can be performed with any ultrasound device, ranging from the simplest models found in surgical areas, which are used for venous access and peripheral blocks, to the more sophisticated devices used for comprehensive echocardiographic examination. The minimum equipment requirements are: sector probe, simple commands for image optimization (depth and gain control), ability to store patient data and examination date. The availability of other features, such as color Doppler, M – Mode and spectral Doppler, as well as the presence of ECG are not necessary for the examination.

### Optimization of the Image (Knobology)

To perform the examination, some basic commands for image optimization are required, and are present in basically all devices used routinely, the main ones being:

Gain: By increasing gain, the signal received is uniformly amplified, making the image brighter; it is analogous to the brightness function in a domestic TV set. Excessive gain impairs resolution, and prevents identification of fine details of the image. Little gain makes the image very dark, making it difficult to identify certain structures. Optimum gain must be obtained with the lowest required intensity, but maintaining image quality (Fig. 2).

Depth: Upon adjusting depth, the penetration distance changes, and only the structures of interest should be included. Excessive depth makes the structures appear smaller, in addition to worsening time resolution and image quality (Fig. 3).

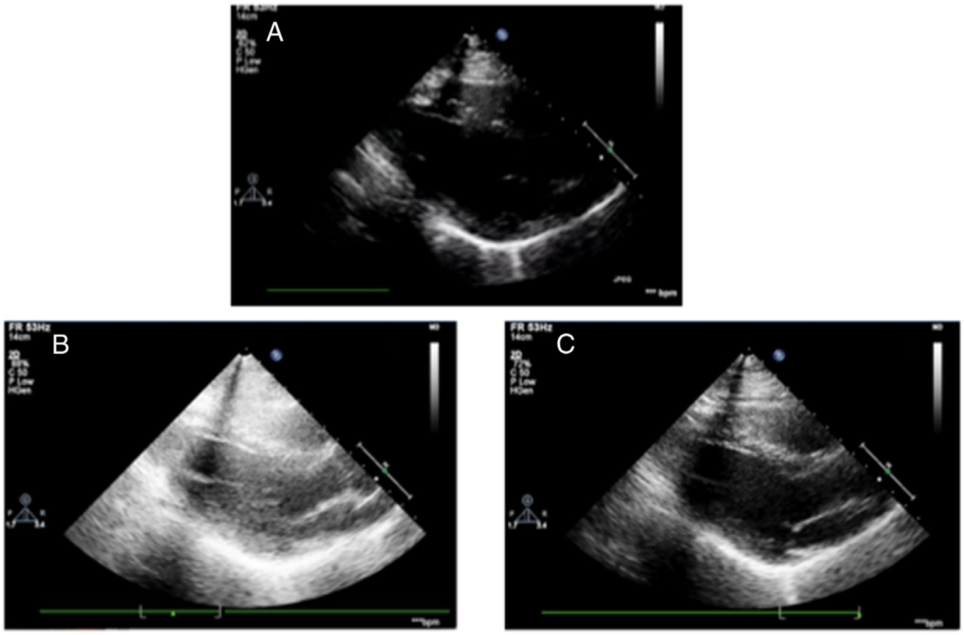


**Figure 2** Examples of images with little gain (A), excessive gain (B) and adequate gain (C). Note that increasing gain dramatically worsens image resolution.

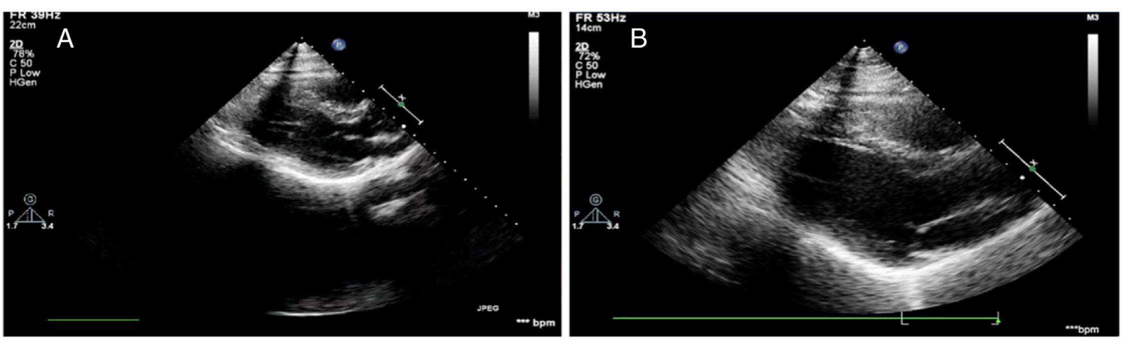


**Figure 3** Examples of views with too much depth (A) and adequate depth (B). Note the difference in resolution between them.

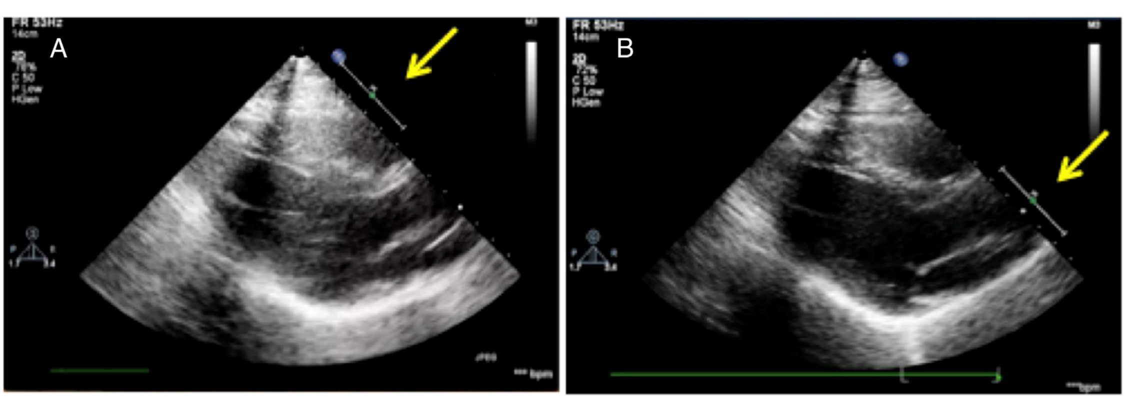


**Figure 4** Focus – Note in example A that the focus (arrow) is correctly positioned on the structure of interest (mitral valve), enabling better resolution when compared to image B.

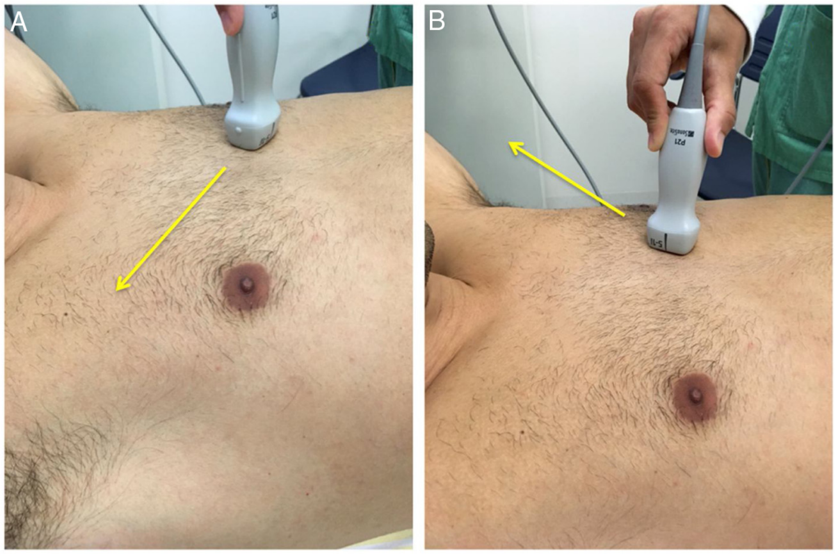


**Figure 5** Parasternal long and short axis views. To obtain the long axis, the probe marker should be oriented toward the right shoulder (A); the short axis (B) is obtained rotating the probe 90° clockwise.

Focus: Adjusting the focus allows better image resolution in the area of interest (Fig. 4)

## Focused cardiac US: windows and views[12]

There are three windows for performing focused examination, and toward that end we must position ourselves on the patient's left side, handling the probe with our left hand and the US device with our right hand.

### Parasternal window (long and short axis)

The parasternal view, on its long axis, is obtained by positioning the probe between the fourth or fifth intercostal space to the left of the sternum, with the probe marker oriented towards the patient's right shoulder (Fig. 5A). The structures observed in this cross section are (Fig. 6):

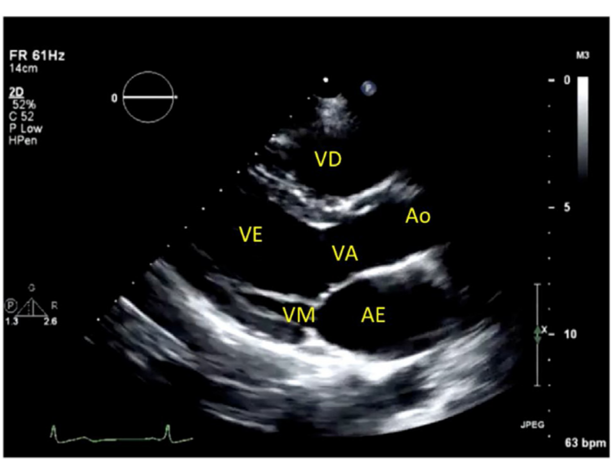


**Figure 6** Parasternal long axis view with the structures shown (VE, Left Ventricle; VD, Right Ventricle; VM, Mitral Valve; VA, Aortic Valve; Ao: Aorta; AE, Left Atrium).

Left Atrium (LA): The size of the left atrium can be judged by comparing its diameter with the Ascending Aorta (Ao) diameter. Very different values may indicate increased left atrial pressure due to diastolic dysfunction.

Mitral Valve (MV): The anterior and posterior leaflets can be identified. The first is larger and contiguous with the aortic valve. Additionally, one is able to appreciate the mitral sub valvular apparatus (papillary muscles and tendon cords). The window is ideal for qualitative diagnosis of stenosis, regurgitation and the presence of calcifications.

Left Ventricle (LV): It is possible to identify the anteroseptal and inferolateral walls and obtain reliable assessment of global and regional contractile function.

Aortic Valve (VA): The presence or absence of leaflet calcification, presence of valvar stenosis and regurgitation; and aortic root dilation can be identified.

Right Ventricle (RV): The right ventricular outflow tract is observed.

Descending Aorta: The thoracic descending aorta is identified, and is a reference for the differentiation between pleural (presence of fluid below) and pericardial (presence of fluid above) fluid.

The parasternal short axis view is obtained from the long axis by rotating the probe 90° clockwise (Fig. 5B). Fig. 7 depicts the structures observed in the view:

Left Ventricle (LV): The LV is observed at the level of the Papillary Muscles (PM), and the different territories irrigated by the main coronary arteries can be identified (Fig. 8). It is a useful view for assessing global and regional ventricular function, as well as assessing the volumetric status of the LV.

RV: In this cross section, it is possible to assess the size of the RV and the behavior of the interventricular septum throughout the cardiac cycle, giving an idea of the pressure and volume in the RV. Normally, the interventricular septum keeps its concavity facing the LV.

In cases of increased pressure or volume of the RV, this concavity is lost and the LV changes to a D-shape (D-shape

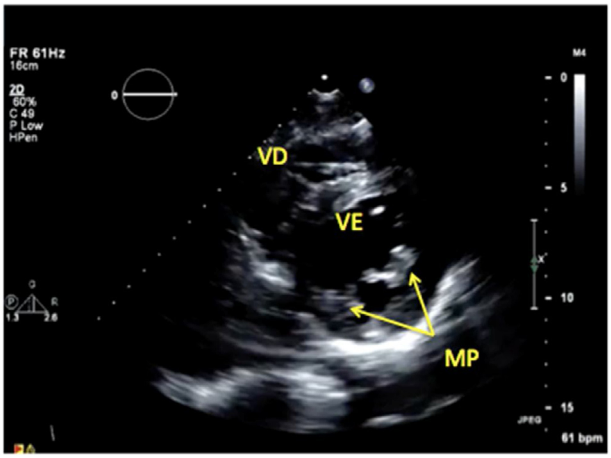


**Figure 7** Parasternal short axis view with structures visualized (VE, Left Ventricle; VD, Right Ventricle; MP, Papillary Muscles).

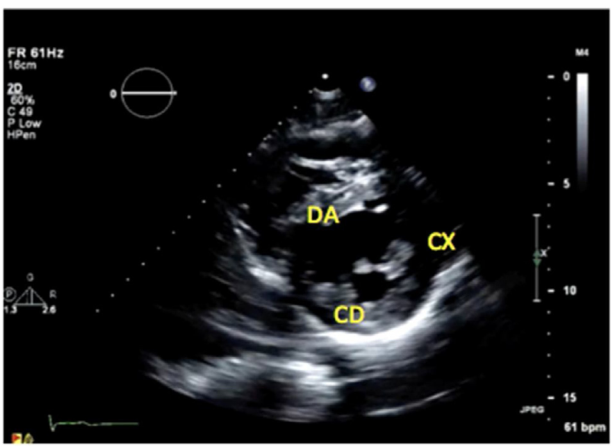


**Figure 8** Parasternal short axis showing territories irrigated by the three main coronary arteries: Anterior Descending (DA), Circumflex (CX) and Right Coronary (CD).

septum). If the septum remains rectified throughout the cycle, this suggests RV increased pressure; conversely, if it remains rectified only during diastole, the diagnosis of RV increased volume is the most likely.

## Apical window

Of the three windows used to perform focused cardiac US, the apical window is usually a little more difficult to obtain. First, the point of maximal impulse should be identified, which normally corresponds to the LV apex (if possible, a decubitus shift to the left side facilitates identification), where the probe should be positioned with the marker facing the left side of the patient (Fig. 9).

It is an ideal view for the global and regional assessment of LV wall motion (anterolateral and inferoseptal wall) and RV, which are seen in all its extensions; moreover, the incidence of the US beam, parallel to blood flow, enables the use of Doppler modules (PWD and CWD) for calculations of Systolic Volume (SV) and Cardiac Output (CO) (beyond the scope of this article). The structures displayed are (Fig. 10):

**Figure 9** Apical window: probe should be positioned over the point of maximal impulse with the marker facing the patient's left side.

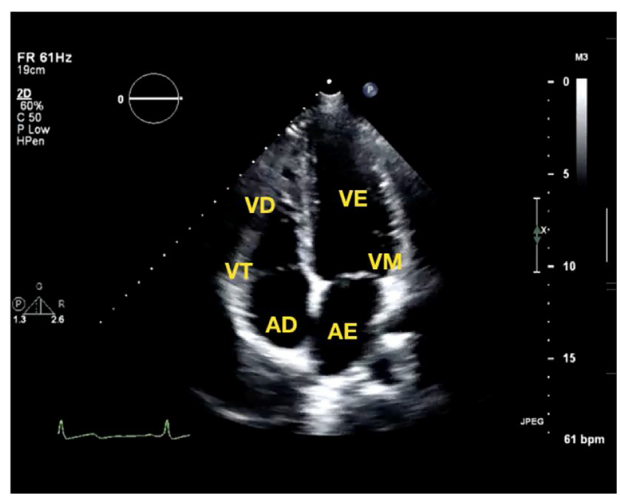


**Figure 10** Apical view with the four chambers and structures identified (VD, Right Ventricle; VT, Tricuspid valve; AD, Right Atrium; VE, Left Ventricle; VM, Mitral Valve; AE, Left Atrium).

LV: As mentioned, LV anterolateral and inferoseptal walls are identified. LV global, segment and regional motion, and LV volume can be assessed.

RV: As all the extension of the RV (lateral and septal wall) can be appreciated, one can assess RV size (the maximum RV extension must be around 2/3 of LV extension), its contractile function and volume.

LA and RA: The atria are identified and one can assess sizes of both; if they are enlarged, they may indicate, for example, some degree of diastolic dysfunction.

MV: The mitral valve can be identified between the LA and LV with its major anterior and minor posterior leaflets.

Figure 11 Subcostal window. Probe marker facing left.

A qualitative analysis of valve function can be performed in an attempt to identify gross valve lesions (e.g. vegetation).

Tricuspid Valve (TV): The tricuspid valve has more apical implantation when compared to the MV. Qualitative assessment of TV function and identification of gross lesions of the TV are also possible.

### Subcostal window

The subcostal window (subxiphoid) is obtained by placing the probe approximately 2 cm below the xiphoid process with the marker facing the patient's left side (Fig. 11). The image of the liver must be obtained first and used as an acoustic window for the visualization of the heart. So, the examination begins with the probe around 2–3 cm to the left of the xiphoid process. After visualizing the liver, the probe is slowly moved towards the structure of interest. It is a window that normally complements information obtained in other views, but that in patients with a chest drain, or COPD, becomes very useful due to easier image acquisition.

The cross section enables seeing the following structures (Fig. 12):

LV: The LV is also seen in all its extension, and can be assessed in terms of global and regional ventricular contractile function and patient volemia.

RV: RV is seen slightly more posteriorly than in other views on its diaphragmatic face. It is possible to make an assessment of ventricular function and volume, and it also very helpful for identifying pericardial effusion and diagnosing cardiac tamponade.

MV and TV: The two valves can be assessed in terms of gross pathologies and they are in an ideal incidence to use Doppler modes (PW/CW/CWD) to assess gradients and search for regurgitation and stenoses.

By keeping the probe in the same position in which the cross section was obtained and only changing marker orientation (it should be oriented towards the patient's head), it is possible to identify the cavo-atrial junction and visualize the Inferior Vena Cava (IVC) (Fig. 13). This new cross section is very useful for the assessment of patient volemia and volume responsiveness in unstable patients (beyond the scope of this study).

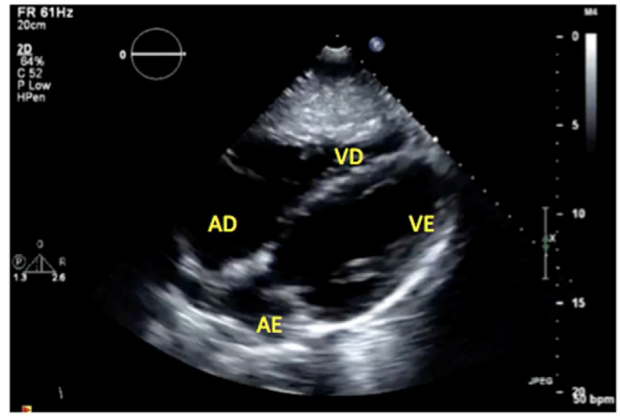


Figure 12 Subcostal window and structures visualized (AD, Right Atrium; VD, Right Ventricle; AE, Left Atrium; VE, Left Ventricle).

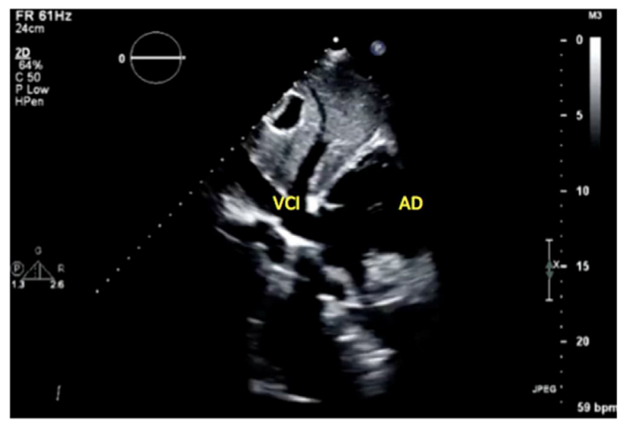


Figure 13 Subcostal cross section showing cavo-atrial junction, very useful for assessing blood volume (VCI, Inferior Vena Cava; AD, Right Atrium).

## Training

With regard to Focused Cardiac US learning and training, despite the lack of uniformity in how a training curriculum should be implemented, there is a current trend towards earlier introduction, even during medical school.[13,14] Training and qualification of professionals consist of a program comprised by theory and practice (image acquisition, identification and interpretation of findings and documentation) that provide skills and capabilities for comprehensive assessment of symptomatic patients, and for effectiveness of treatment based on examination findings. It is important to emphasize the great difference between focused cardiac US and formal echocardiographic examination performed by an expert echocardiographer. The latter depends on a trained, qualified and certified professional in the acquisition, analysis and interpretation of the images obtained. The formal echocardiographic examination is often used in different clinical scenarios beyond the perioperative period, has a quantitative characteristic, and is much more complex and comprehensive than POC modality examination.[7]

## Conclusion

Focused cardiac US with the objective of POC (Point-Of-Care) has become a useful and relatively simple tool to assist in the perioperative diagnosis and management of causes of hemodynamic instability. This examination can be rapidly performed and guides the treatment according to the etiology found.

We should bear in mind that the examination is qualitative in its essence, and, should not dispense the formal echocardiographic examination performed by an echocardiographer when indicated.

## Conflicts of interest

The author declares no conflicts of interest.

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