



**MEDD 421 Clinical Skills
2017-2018**

**Cardiac Ultrasound
Student Guide**

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ACKNOWLEDGEMENTS

We are indebted to:
The UCSD School of Medicine
Members of the Ultrasound Working Group

ORGANIZATION

Scheduling and organization may vary slightly across sites.

- Students will be divided into groups of 4-8
- A tutor will demonstrate bedside cardiac ultrasound. Focus will be primarily on the subxiphoid (SX) view, complimented by the parasternal long (PSL) and apical 4 chamber (A4C) views
- Students will have the opportunity to perform limited bedside cardiac ultrasound. Refer to the technique section below

PREPARATION

Required Readings / Review

- MEDD 421 Cardiac Ultrasound Student Guide

Required Viewing

- *Cardiac Ultrasound*. UC Irvine. Dr. J. Christian Fox (41 min)
 - <https://itunes.apple.com/ca/itunes-u/emergency-ultrasound/id429668403?mt=10>
 - *Choose 2. Cardiac Ultrasound audio podcast View in iTunes*
 - *Note: If you do not have iTunes you will be prompted to download the free application”.*

Suggested Resources (including other texts, websites, course material, etc.)

The following online references will enhance your understanding of bedside cardiac ultrasound. You are not required to review them prior to the session, but you will find your image recognition to be much faster if you do.

- Ultrasound at U of SC School of Medicine
- https://www.youtube.com/playlist?list=PLGEKJJ3ekUkxM6M99EI4kk4XpZgUee_al
 - *Introduction to Echocardiography*
 - *Subcostal View*
 - *Parasternal Long Axis View*
 - *Apical Four Chamber View*
- Appendix A - Current Issues w/ER Cardiac US Probe and Image Conventions

OBJECTIVES

On completion of this session, students should be able to:

- Understand portable ultrasound machine use and scanning procedures
- Describe the indications for, and limitations of, portable ultrasound examination
- Describe the indications for, and limitations of, bedside cardiac ultrasound
- Recognize anatomic structures of the heart (e.g. chambers, pericardium, valves) using ultrasound
- Recognize the presence/absence of pericardial effusion and cardiac activity

EQUIPMENT

- Students must wear professional dress and wear UBC student ID.
- Portable ultrasound machines are provided.

ASSESSMENT & EVALUATION

Please refer to the Year 2 Assessment Package on Entrada to access student assessment information for Clinical Skills:

- MEDD 421 > Exam & Assessment Resources

At the end of term, student competency will be further assessed through written Multiple Choice Exams and a Summative OSCE (Objective Structured Clinical Examination) at the end of MEDD 422. Material from Clinical Skills sessions in MEDD 421 and MEDD 422 will be examinable on the Year 2 OSCE and cumulative MCQ Exams.

As part of your professional commitment, you may be required to complete an online assessment of your tutor and a course evaluation on one45.

TECHNIQUE

Indications/Limitations

View	Key Anatomic Structures/Relationships	Clinical Indications	Limitations
Subxiphoid (SX)	<ul style="list-style-type: none"> • Right atrium/ventricle • Left atrium/ventricle • Pericardium • Cardiac/hepatic juxtaposition 	<ul style="list-style-type: none"> • Cardiac arrest • Unexplained shock/hypotension • Trauma • Dsypnea • Chest pain 	<ul style="list-style-type: none"> • Epicardial fat pad may be confused for pericardial effusion • Indeterminate subxiphoid view (obesity, stomach gas) • Indeterminate PSL/A4C views (emphysema or hyperinflation)
Parasternal Long (PSL)	<ul style="list-style-type: none"> • Left atrium/ventricle • Aortic outflow tract • Mitral/aortic valves • Pericardium • Descending aorta • Right Ventricle 		
Apical 4 Chamber (A4C)	<ul style="list-style-type: none"> • Right atrium/ventricle • Left atrium/ventricle • Mitral/tricuspid valves • Intraventricular septum • Pericardium 		

PREPARATION/POSITIONING

- For the subxiphoid view the patient should be positioned supine on the stretcher and appropriately draped (figure 1)
- For the apical 4 chamber view, the patient should ideally be positioned in left lateral decubitus and appropriately draped (figure 2)
- For the parasternal long view good images can usually be obtained with the patient positioned supine; at times, this view may be improved by positioning the patient in left lateral decubitus



Figure 1 – Appropriate position and draping for Subxiphoid and Parasternal Long views.



Figure 2 – Appropriate position and draping for Apical 4 Chamber view.

- Ensure the stretcher is adjusted to an ergonomic height
- Preferably use a phased-array cardiac probe for all views (figure 3)
- A curved abdominal probe may be used if a cardiac probe is unavailable, but it may be difficult, if not impossible, to obtain determinate PSL and A4C views with this probe



Figure 3 – Phased array cardiac probe.

- Depth should be set to max initially to ensure no important structures are missed (figure 4)
- Bear in mind significantly less depth is often required for the PSL and A4C views
- Gain should initially be set mid-range; adjust as the scan proceeds (figure 5)

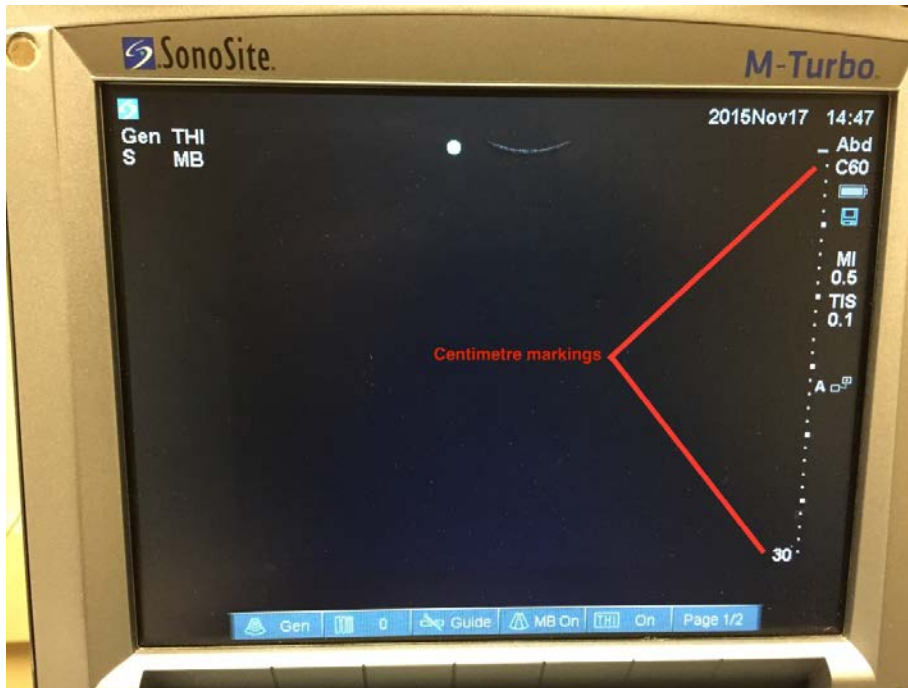


Figure 4 – Centimetre markings are located to screen right. The more cm markings, the more depth.

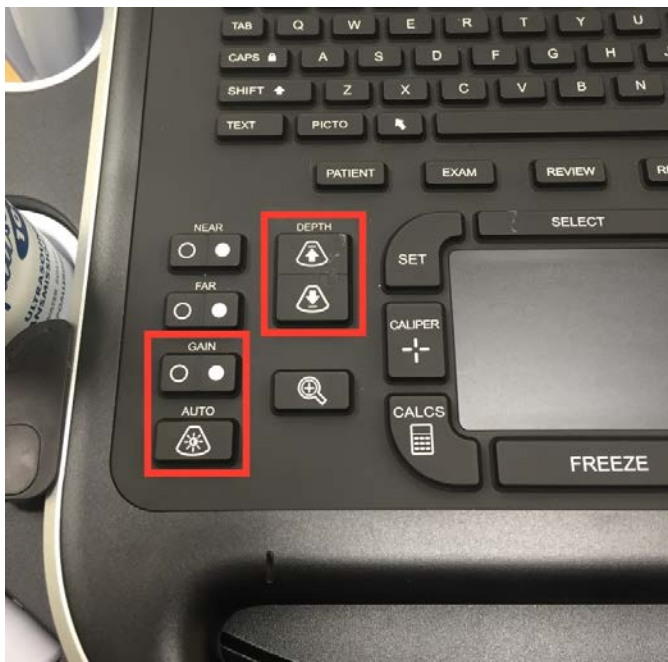


Figure 5 – Gain toggle and Autogain button (lower left box), and depth buttons (upper right).

- Apply gel directly to the probe for all cardiac scans

PROBE/IMAGE ORIENTATION – A PRECAUTIONARY TALE

If you have done some preparatory work for this session, you may already be confused about the orientation of some of the cardiac images on the screen – in particular with the PSL view. For the purpose of this session & guide, we have maintained the convention of consistently orienting the US **PROBE** marker to **PATIENT RIGHT**, and the **ONSCREEN** marker to **SCREEN LEFT**. This is consistent with the training and practice of the majority of point-of-care US practitioners, and also consistent with the probe/image orientation in your other Clinical Skills US sessions.

The echocardiography world however, does things a little differently. Echocardiographers perform these scans with the onscreen marker to **SCREEN RIGHT**, which flips the onscreen image in the horizontal plane. In addition, they perform the Subxiphoid and Apical 4 Chamber scans with the US **PROBE** marker reversed (i.e. directed to **PATIENT LEFT**), resulting in the onscreen image for these views identical to what you will see in this session.

For the Parasternal Long view, echocardiographers orient the US **PROBE** marker to **PATIENT RIGHT**, which combined with the flipping the **ONSCREEN** marker to **SCREEN RIGHT**, results in an image appearing **FLIPPED IN THE HORIZONTAL PLANE**.

Refer to Appendix 1 – *Current Issues with Emergency Cardiac Ultrasound Probe and Image Conventions* for further information on this topic.

Still confused? Don't worry – you're probably not alone. Your tutors will attempt to address any questions about probe/image orientation during the session.

SUBXIPHOID VIEW

- Grip the cardiac probe with your thumb and ring fingers on the sides, and index/middle fingers on top (figure 6)



Figure 6 – Proper probe grip for the SX view.

- Position the probe (with the indicator pointing to patient right) in the transverse plane just caudal to the xiphoid process, and angle the probe so the beam points up towards the patient’s head (figure 7)



Figure 7 – Starting point for the SX view.

- Attempt to identify the heart (figure 8)
- If you don't recognize anything initially, sweep the probe (pivot the probe on the same point of contact) anterior and posterior (figure 9)
- The heart is often quite anterior, requiring that the probe be nearly flat to obtain a good image

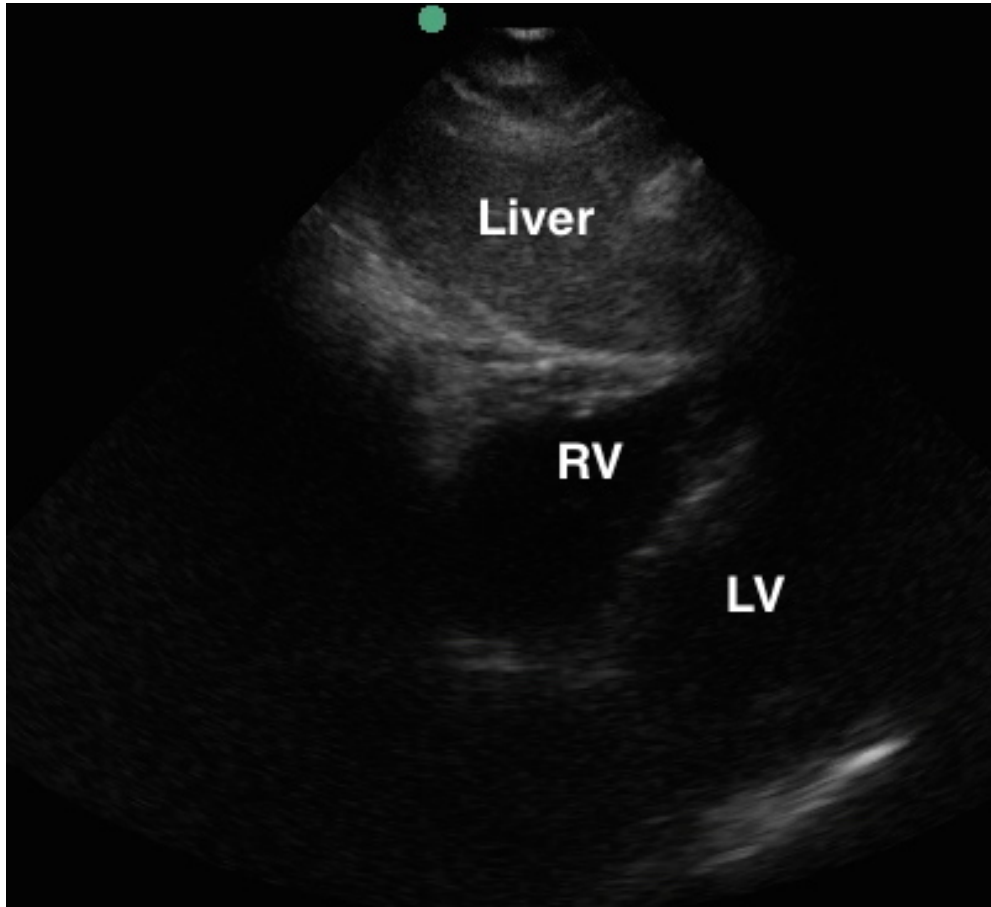


Figure 8 – Expected subxiphoid cardiac view.

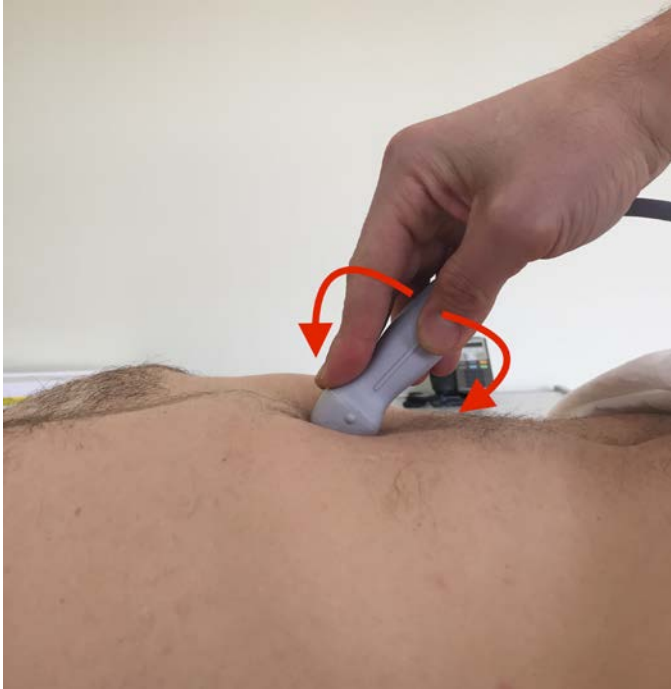


Figure 9 – Cardiac sweep for subxiphoid view.

- Figure 10 depicts the structures you should be able to see with the subxiphoid view.
- Note that because the probe is positioned below the heart, the near-field actually represents the inferior heart structures, and far-field the superior

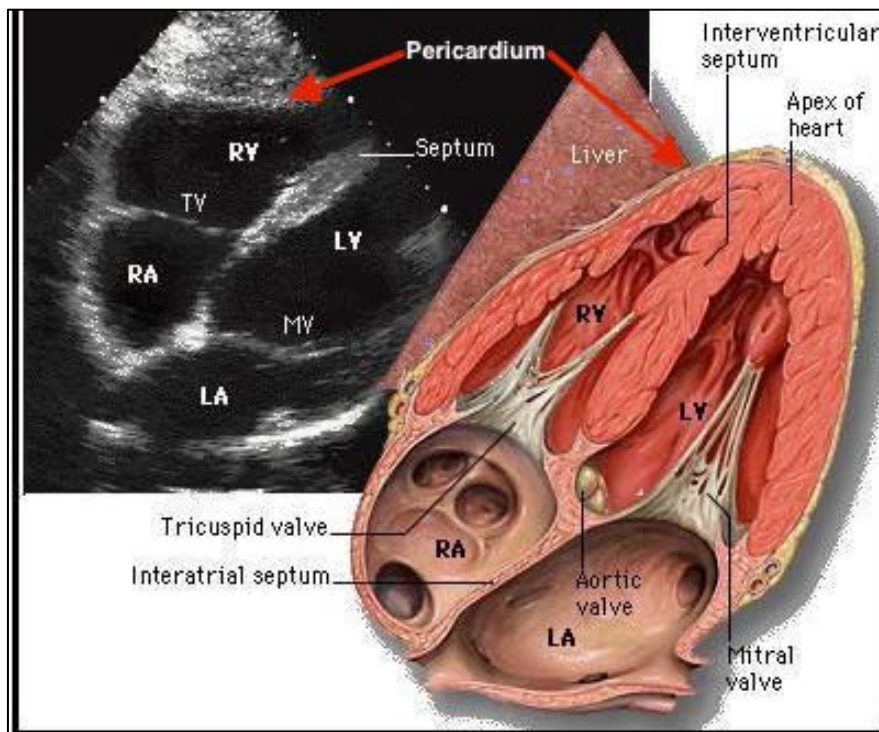


Figure 10 – Cardiac structures in the subxiphoid view.

- Once you have identified your structures of interest, it is important to sweep the heart anterior-posterior (refer again to figure 9); a small pericardial effusion (PCE) will often only be seen in the posterior (most dependent) view (figure 11)
- As you perform your sweep, focus on the pericardium (to rule out PCE) and get a general sense of cardiac activity (absent vs. abnormal vs. normal)

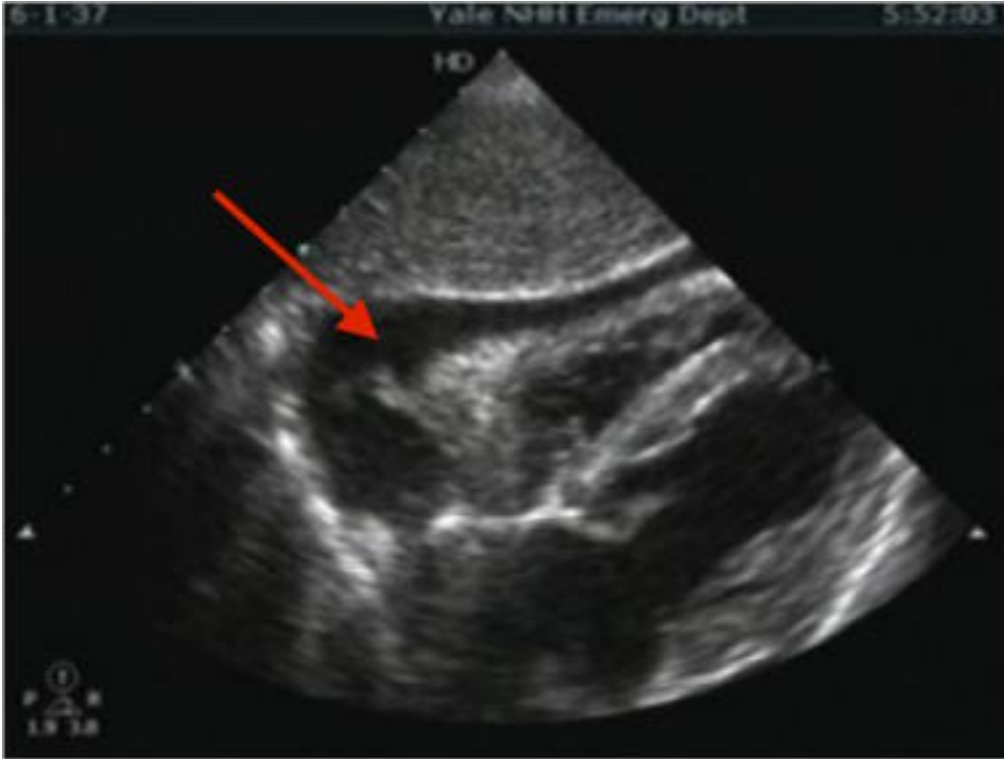


Figure 11 – Pericardial effusion on subxiphoid view.

- Tips and tricks:
 - In the subxiphoid view, the liver is your window to the cardiac structures; the probe may need to be positioned to the **right** of the xiphoid process to maximize the window and obtain a good image
 - Asking the patient to breathe in and hold their breath may improve the image by bringing the cardiac structures down and closer to the probe
- Pitfalls:
 - Epicardial fat is very common and may be confused for PCE (seen in the pericardial space and often black); it should only be seen in the anterior pericardium, whereas PCE should be seen initially in the posterior (dependent) pericardium
 - Stomach gas may make it difficult to image the cardiac apex (figure 12)

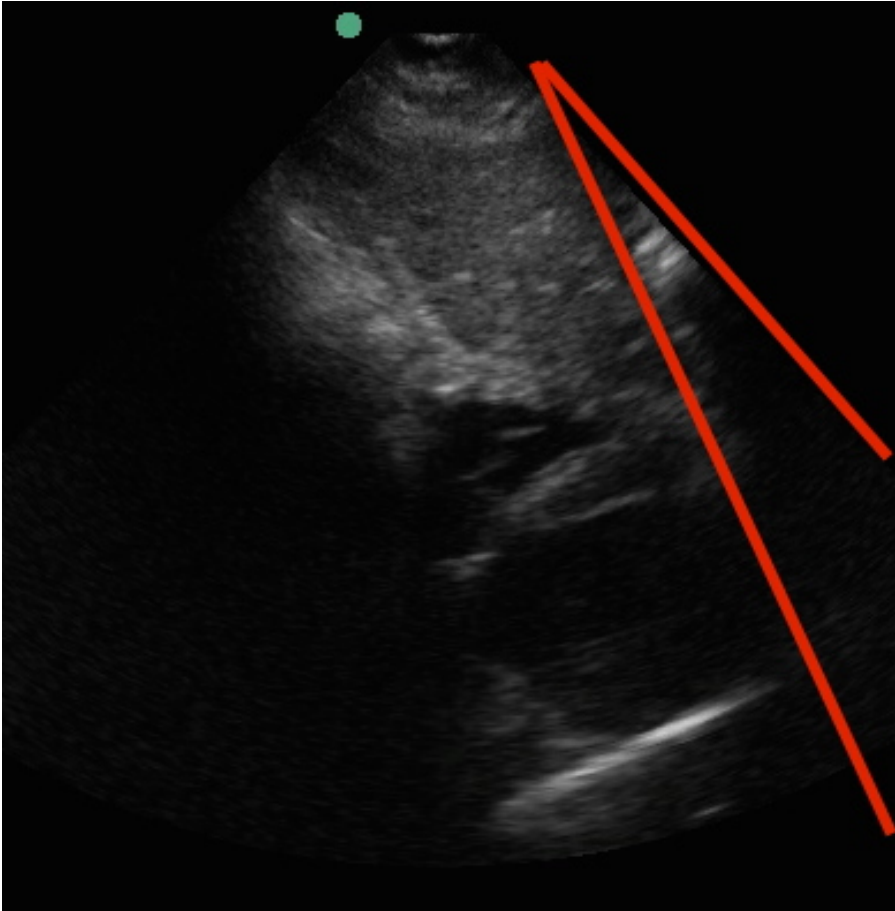


Figure 12 – Cardiac apex obscured by shadows cast from stomach material/gas.

PARASTERNAL LONG VIEW

- Grip the probe similar to how you would grasp a large pencil (figure 13)



Figure 13 – Proper probe grip for the PSL view.

- Place the probe immediately left of the sternal border at the nipple level with the probe indicator pointing to the patient's right shoulder and the beam angled straight through the patient's chest (figure 14)
- The best image may be obtained anywhere from the 3rd to 6th intercostal space



Figure 14 – Starting point for the parasternal long view.

- Attempt to identify the heart; the image you are trying to generate should resemble figure 15

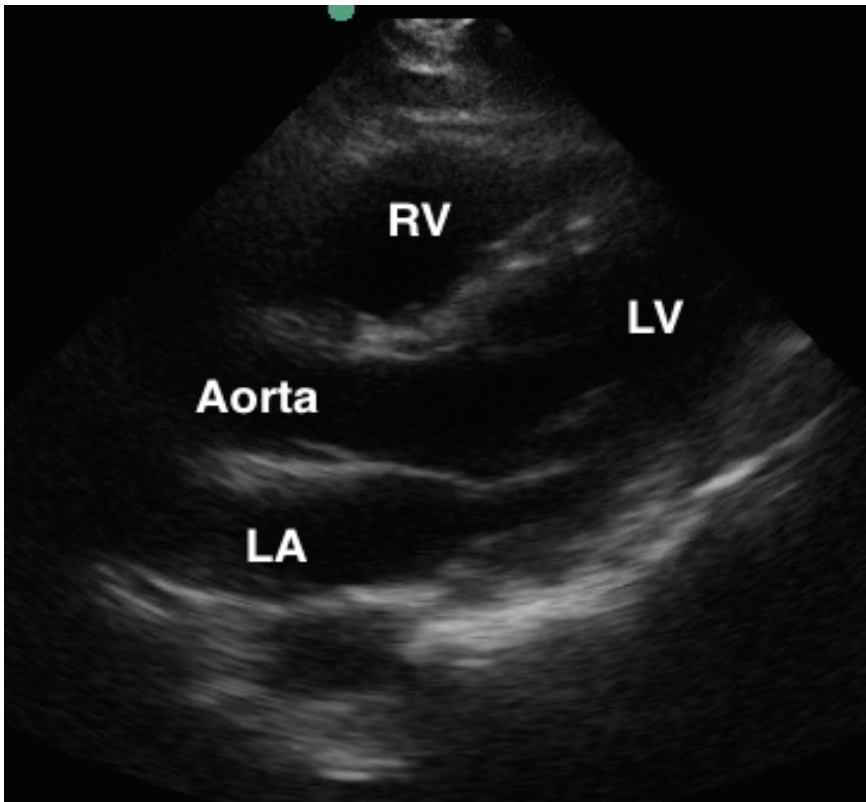


Figure 15 – Expected parasternal long cardiac view.

- You will likely need to decrease the depth setting, which will magnify the image on the screen
- A significant amount of probe manipulation may be necessary to obtain a good image; explore multiple intercostal spaces, slide the probe medial/lateral, 'toe/heel' the probe, and/or rotate the probe to find the best image
- Figure 16 depicts the structures you should be able to see with the PSL view

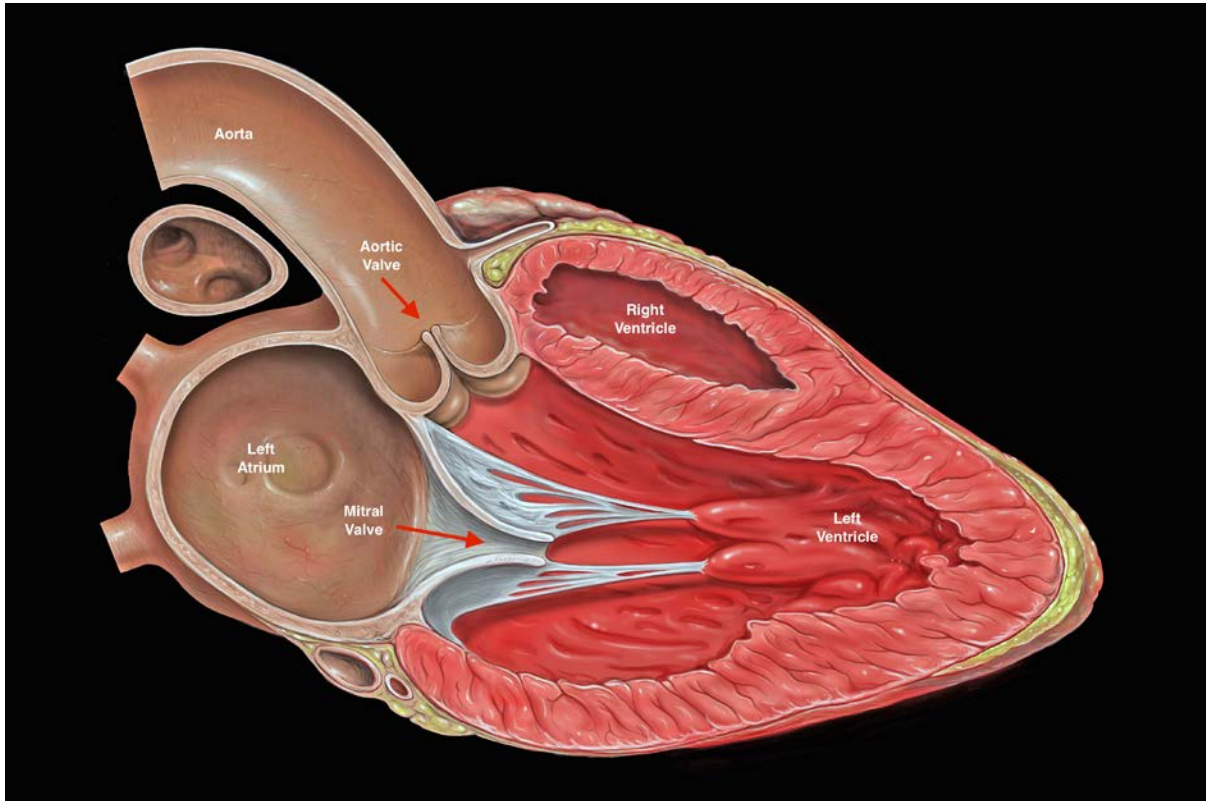


Figure 16 – Cardiac structures in the parasternal long view.

- PCE can be easily identified using the parasternal long view (figure 17)
- As always, once the image is obtained and optimized , a sweep is performed to ensure the entire heart is imaged

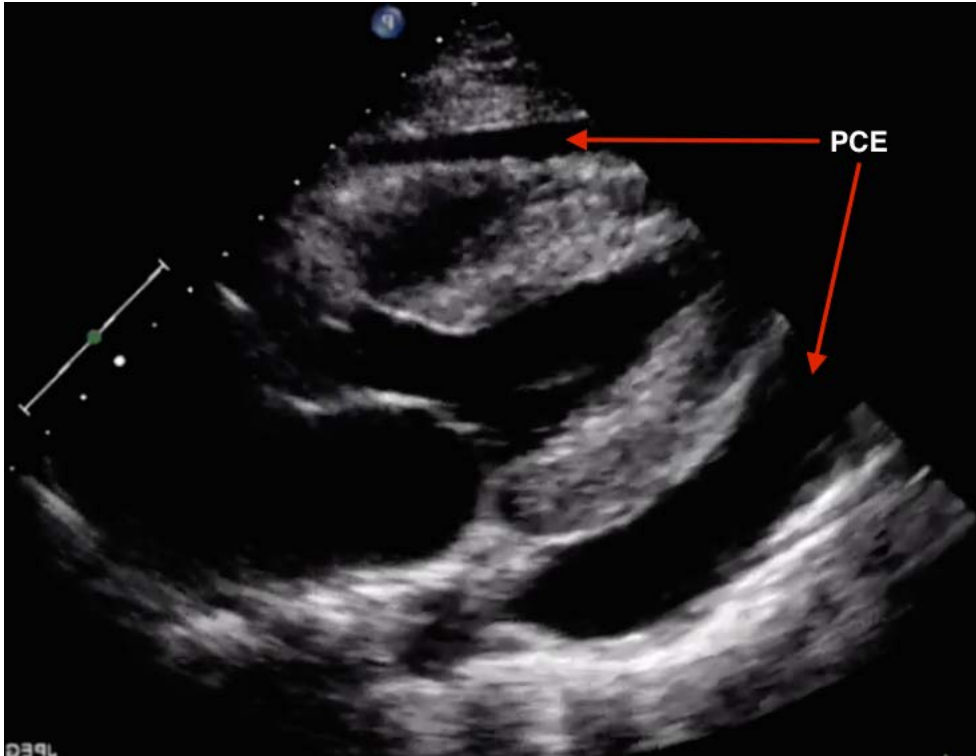


Figure 17 – Pericardial effusion on parasternal long view.

- The parasternal long view is also excellent for estimating gross LV function; there are many ways this can be accomplished, ranging from simple to very complex:
 - The simplest method is to look for '**Fractional Shortening**'
 - The diameter of the LV (measured from endocardium to endocardium at the mid LV) should shorten at least 30% in systole
 - Fractional shortening less than 30% is indicative of LV dysfunction
- Your tutor may demonstrate this and/or other methods for estimating LV function at the bedside

APICAL FOUR CHAMBER VIEW

- Probe grip is the same for this view as it was for the parasternal long view; similar to how you would grasp a large pencil (figure 13)
- Recall (figure 2) that the patient should be positioned in left lateral decubitus for this view
- Place the probe at the apex (1-2 intercostal spaces immediately inferior to the nipple) with the probe indicator pointing to the patient's right flank and the beam angled towards the patient's right shoulder (figure 18)



Figure 18 – Starting point for the apical four chamber view.

- Attempt to identify the heart; the image you are trying to generate should resemble figure 19.

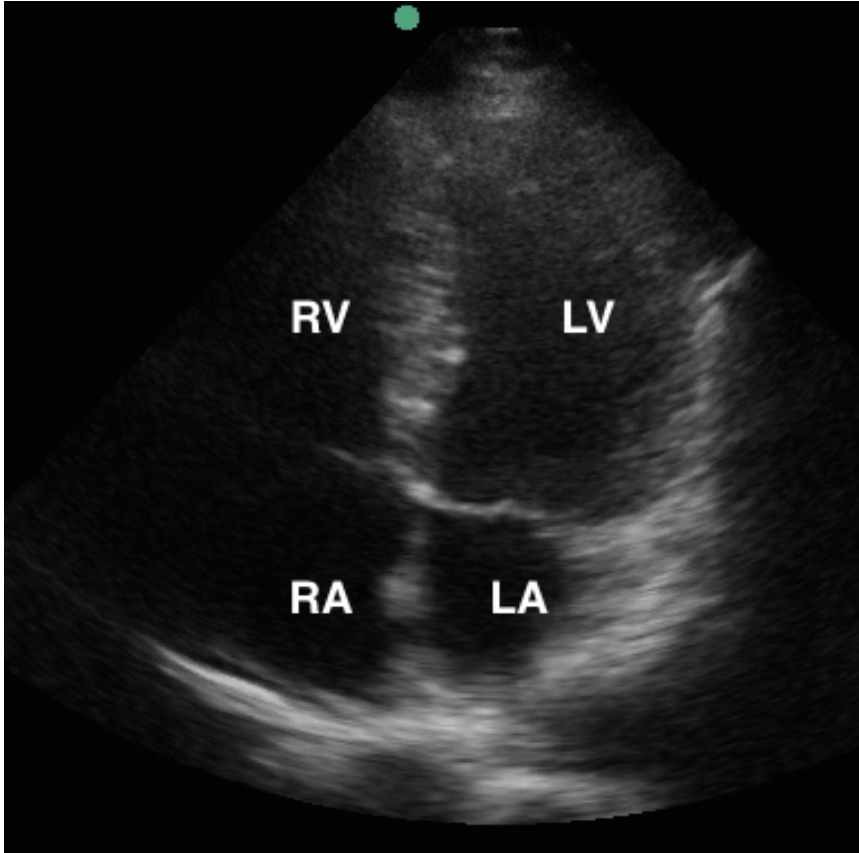


Figure 19 – Expected apical four chamber cardiac view.

- You will likely need to decrease the depth setting, which will magnify the image on the screen
- A significant amount of probe manipulation may be necessary to obtain a good image; explore multiple intercostal spaces, slide the probe medial/lateral, 'toe/heel' the probe, and/or rotate the probe to find the best image
- Figure 20 depicts the structures you should be able to see with the apical four chamber view

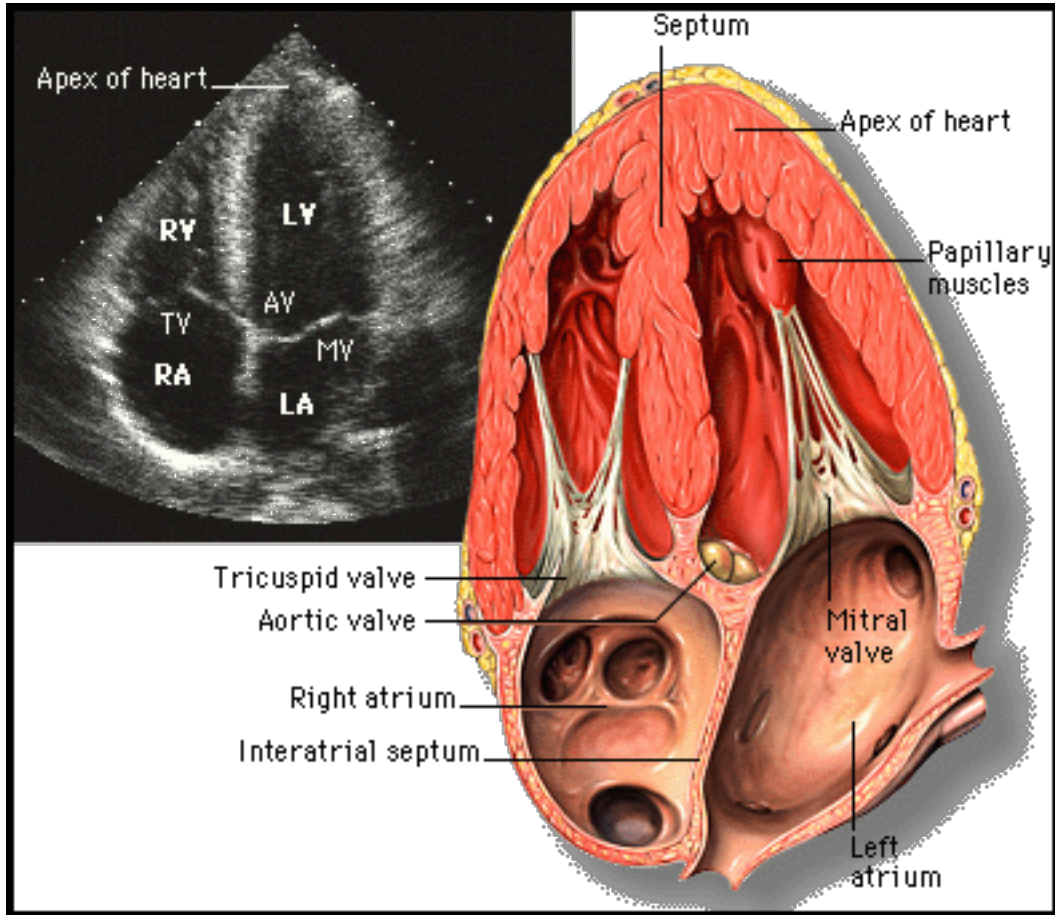


Figure 20 – Cardiac structures in the apical four chamber view.

- PCE can be identified using the apical four chamber view (figure 21)
- As always, once the image is obtained and optimized , a sweep is performed to ensure the entire heart is imaged

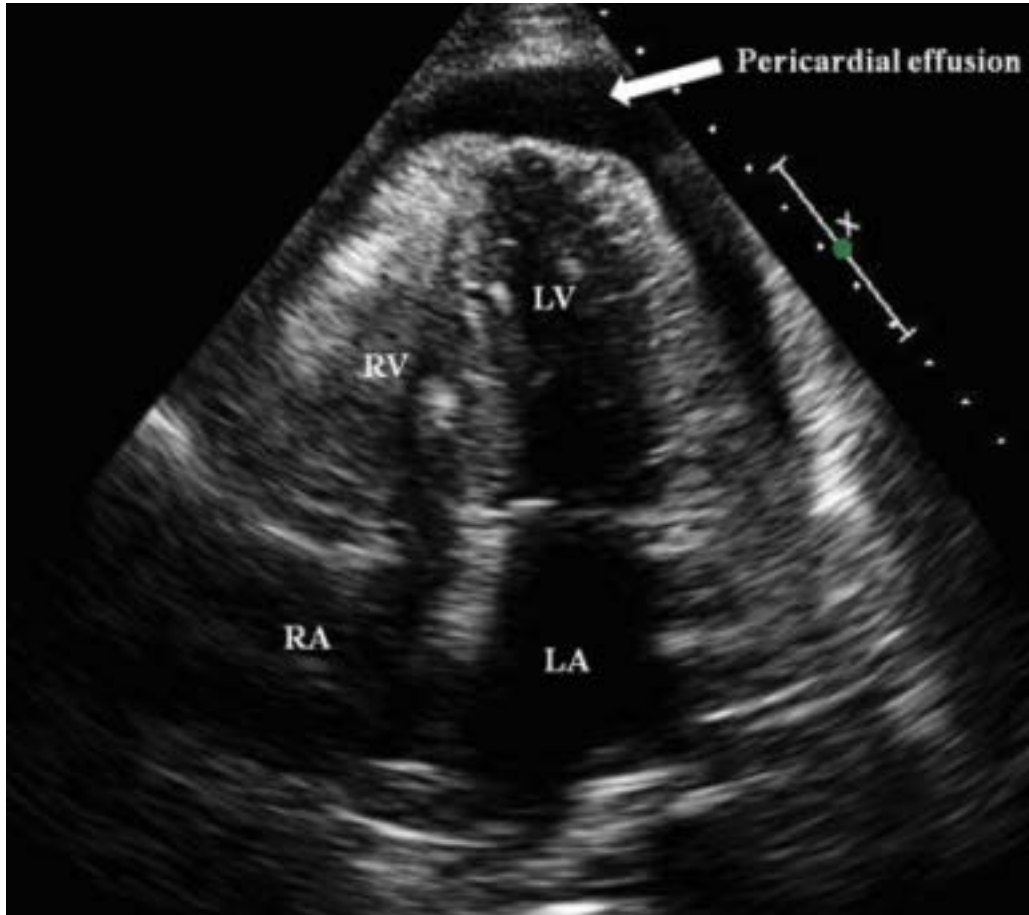


Figure 21 – Pericardial effusion on apical four chamber view.

- The apical four chamber view is the best view for observing right ventricular (RV) strain, such as would be seen with a massive pulmonary embolus
- US findings of RV strain include:
 - RV dilation (mid-RV diameter equal/greater than mid-LV diameter)
 - Bowing of the intraventricular septum into the LV (figure 22)

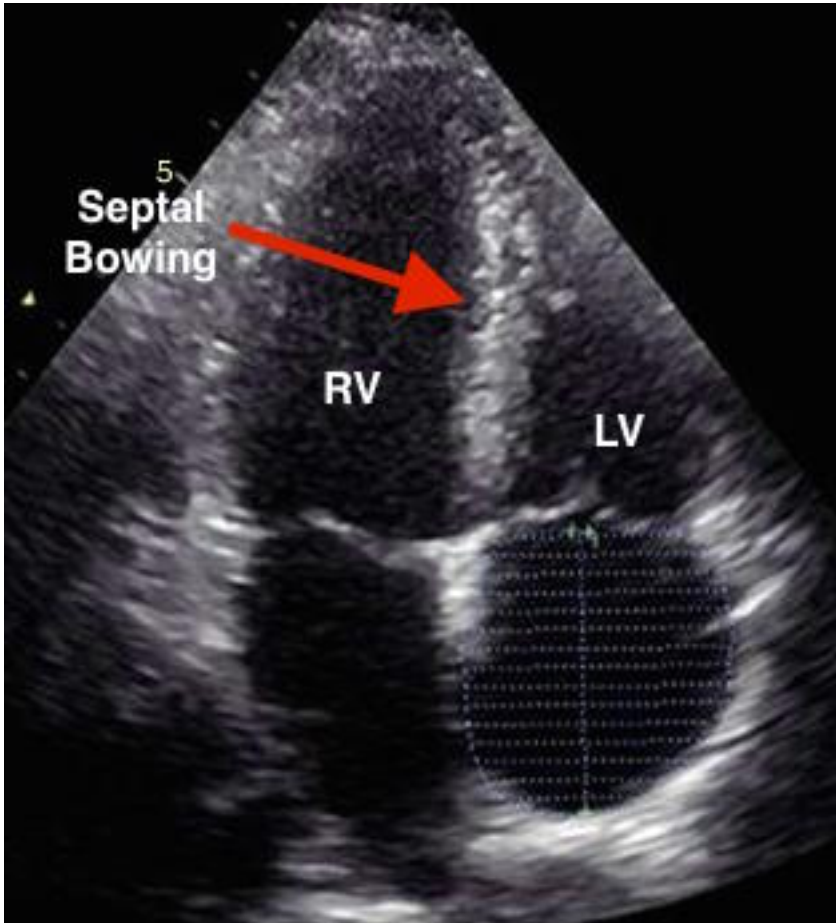


Figure 22 – Findings of right ventricular strain on apical four chamber view.

APPENDIX A – CURRENT ISSUES W/ ER CARDIAC US PROBE AND IMAGE CONVENTION

Current Issues with Emergency Cardiac Ultrasound Probe and Image Conventions

Chris Moore, MD, RDMS, RDCS

Abstract

As emergency physicians (EPs) and other noncardiologists incorporate bedside ultrasound (US) and bedside echocardiography (echo) into their practice, confusion has resulted from the differing imaging conventions used by cardiac and general imaging. The author discusses the origin of these differences, current cardiac imaging conventions, and controversies in emergency medicine (EM) regarding adoption of imaging conventions. Also discussed in detail are specific echo windows and experience with different approaches. While there is no perfect solution to merging the differing conventions, it is important that those performing and teaching bedside US and echo have a thorough understanding of the issues involved, and adopt a consistent approach.

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Keywords: emergency ultrasound, emergency echo, ultrasound, echo, echocardiography, bedside ultrasound, education

The use of bedside clinician-performed ultrasound (US) and echocardiography (echo) is increasing among noncardiologists. Emergency physicians (EPs), critical care physicians, surgeons, and anesthesiologists all represent specialties that are now using bedside US and bedside echo.^{1–5} Within emergency medicine (EM), the use of bedside echo is well established in trauma, cardiac arrest, and the diagnosis of pericardial effusion.^{6–9} Newer applications include use of echo in determining left ventricular function and to aid in the diagnosis and therapy of patients with undifferentiated dyspnea, sepsis, and shock.^{10–14}

As the prevalence of physicians who perform general and cardiac US increases, there is the potential for confusion due to differing imaging conventions in echo and general US. This article will discuss the origins of these issues, controversies in EM, specific windows, and experience with different approaches.

HISTORY

The first published work on US of the heart appears to have been in 1954, when Inge Edler, the “Father of Echocardiography,” published work about the use of a

From the Department of Surgery, Section of Emergency Medicine, Yale University School of Medicine, New Haven, CT.

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Address for correspondence and reprints: Chris Moore, MD; e-mail: chris.moore@yale.edu.

“reflectoscope” for continuous recording of cardiac motion.¹⁵ Cardiologists became more widely aware of its diagnostic potential in the 1960s, and it became a standard tool by the 1970s.^{16,17} US for gynecologic and other medical applications developed along parallel tracks, with initial publications in the 1950s progressing to more widespread adoption by the 1970s.^{18,19} In the 1980s, the first published reports of bedside US by EPs began to emerge. Bedside emergency ultrasound (EUS), both of the heart and other body areas, has spread rapidly and is now recognized as a standard EP skill.²⁰

As cardiac US and general (medical and gynecologic) US developed, each adopted its own imaging conventions. While general US is typically performed from the patient’s right, echo is usually performed from the patient’s left, closer to the heart. Additionally, cardiology adopted a different imaging convention for the US probe relative to the screen images. It is unclear why a differing probe-to-screen orientation was adopted, but was probably simply a result of two independent approaches from an early stage.

Each orientation convention is internally consistent, but problems arise when physicians use US for general and cardiac imaging in the same patient. An example might be an EP seeking to find the cause of shock in a patient with undifferentiated hypotension, where imaging of the aorta, peritoneal spaces, and heart are all performed as parts of an integrated goal-directed examination^{11,21}; or the focused assessment with sonography in trauma (FAST) examination, where physicians

are looking for fluid in both the peritoneal and the pericardial spaces.²²

CURRENT CARDIAC CONVENTIONS

There are two key issues regarding the orientation of anatomic structures as they are viewed on the screen: relationship of the probe indicator to the image on the screen (indicator-to-screen) and relationship of the probe indicator to the patient (indicator-to-patient). The standard US image is a plane directed through various areas of the body. The top of the screen typically represents the probe face. General US uses an imaging convention where the indicator (a bump or groove) on the probe corresponds to the left side of the screen as it is viewed. However, in cardiology echo the indicator corresponds to the opposite (right) side of the screen (Figure 1).

Anatomic orientation follows based on where the indicator is directed on the patient. For example, in general imaging when the indicator is directed to the patient’s right, right sided structures will be seen on the left side of the screen (transverse plane); when the probe is turned towards the patient’s head (longitudinal plane), the left side of the screen will then correspond to the patient’s head. Most general imaging takes place in this 90° arc, with the indicator directed to the patient’s right, or head. The indicator can also be considered to be on the *examiner’s* left as he or she “looks through” the body from below or from the patient’s right. Conversely, transthoracic echo by cardiologists is

performed from the patient’s left, using an opposite screen orientation as well as opposite indicator directions for most windows.

CONTROVERSY IN EMERGENCY MEDICINE

When imaging the heart, the sonographer must be aware of both indicator-to-screen and indicator-to-patient orientation to fully grasp how cardiac anatomy is represented on the US screen. Unfortunately, because of the differing imaging conventions, there have been different approaches to echo within EM.

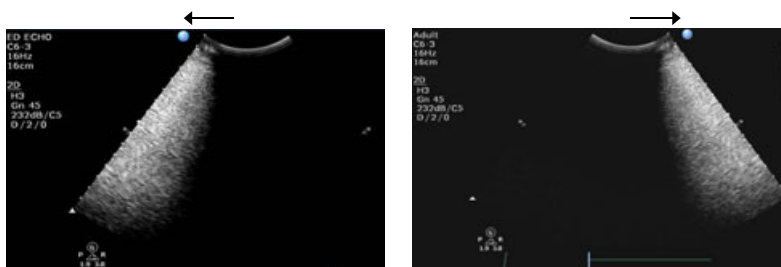
When transitioning from general to cardiac imaging or vice versa, there are two possible choices regarding indicator-to-screen orientation: perform echo in a cardiology screen orientation, being aware of the reversal in indicator-to-screen orientation relative to other US, or scan the heart using a general imaging screen orientation.

There is significant variation in teaching and practice regarding which indicator-to-screen orientation should be chosen. One of the earliest texts in EUS mentions differing imaging conventions, but does not clearly explain them and appears to use both conventions, showing a backward subcostal image.²³ A more recent review article describes using the cardiology screen orientation, but states the incorrect probe orientation for the apical four-chamber view.²⁴ Other texts have ignored the issue, alternated between general and cardiac imaging, used one or the other, or discussed both, often with inconsistencies.^{25,26} In a recent informal

↔ Arrow on top of image shows screen orientation relative to indicator. Also note position of  on the screen.



Gel and thumb placed on side of indicator, gel shows on screen below for different orientations.



General Orientation. The indicator corresponds to the left side of the screen as it is viewed.

Cardiology Orientation. The indicator corresponds to the right side of the screen as it is viewed.

Figure 1. Indicator-to-screen orientation for general and cardiology imaging.

survey, two-thirds of respondents used a general indicator-to-screen orientation, and this is the recommendation recently published in the 2006 Emergency Ultrasound Imaging Compendium.^{27,28}

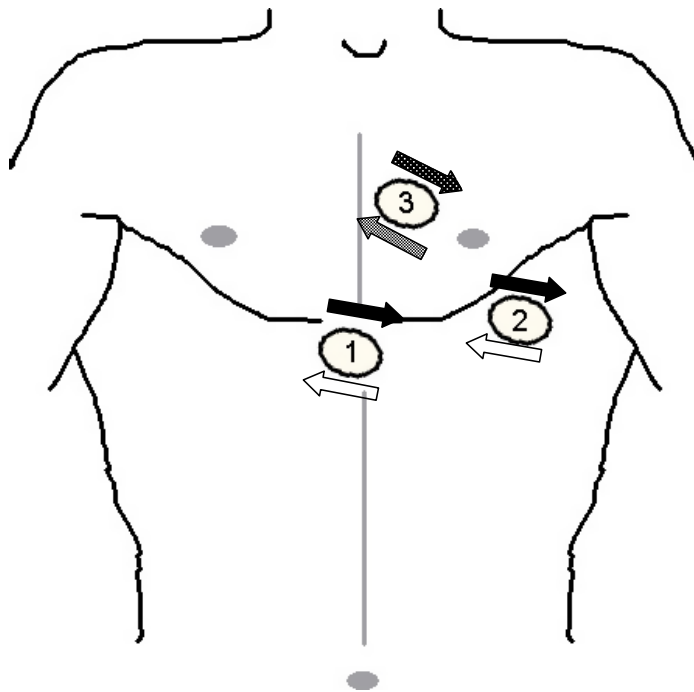
The second issue is indicator-to-patient (and/or indicator-to-sonographer) orientation. A consistent orientation is important in allowing correct anatomic interpretation and integration of hand-eye-image coordination. Positioning of the examiner relative to the patient is important. Most EUS is done from the patient's right and can be thought of as looking through the patient from the feet upward, or from the right side. Conversely, if cardiac imaging is done from the patient's left, it can be thought of as looking through the patient from the left side. Probe positions

differ based on imaging convention and window and are summarized in Figures 2 and 3. There are three primary cardiac windows that are typically utilized by EPs for transthoracic cardiac imaging: the subcostal, apical, and parasternal windows. Of these, the parasternal long axis has proven the most problematic, as in the cardiology convention it requires reversing the probe to obtain an image that is reversed. Probe orientation for specific windows is discussed below.

SPECIFIC WINDOWS

Subcostal Window

This window is probably the most familiar to EPs and surgeons and is most frequently included as the



Subcostal (1)

- ← Indicator direction in general screen orientation
- Indicator direction in cardiology screen orientation

Apical (2)

- ← Indicator direction in general screen orientation
- Indicator direction in cardiology screen orientation

} Net result same image

Parasternal (3) window

- ← Indicator direction for general screen orientation **OR** cardiology screen orientation

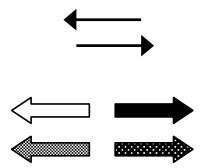
} Consistent screen and probe orientation

OR

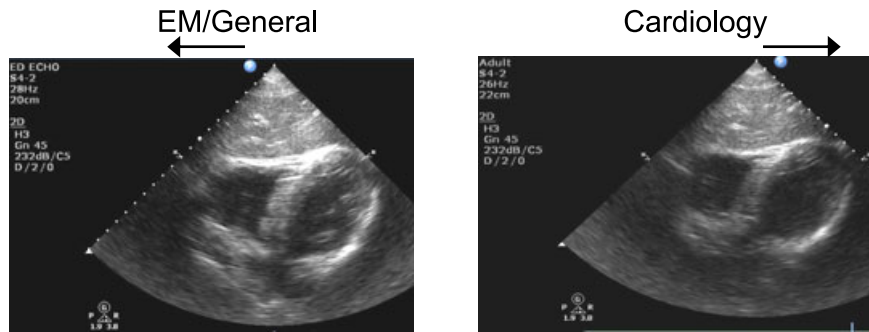
- Indicator direction for "fourth and long" (four o'clock position) in general screen orientation

} Probe reversed but image consistent with cardiology

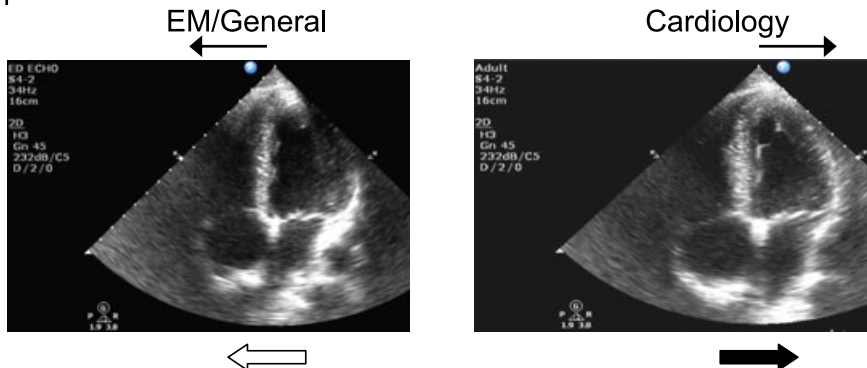
Figure 2. Indicator-to-patient directions for three primary cardiac windows.

Key:  Top of image: Indicator-to-screen direction (note position of **P** on the screen, see Figure 1.)
Bottom of image: Indicator-to-patient direction (see Figure 2.)

1. Subcostal window

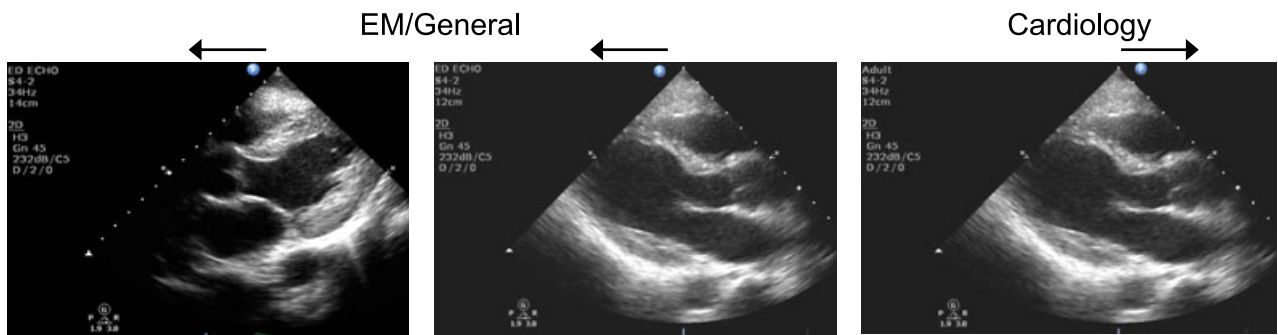


2. Apical window



Net result: same image on screen

3. Parasternal window



Consistent screen and probe orientation

OR

Probe reversed but image consistent with cardiology

Figure 3. Primary cardiac windows.

primary view of the heart in the FAST examination. The window is obtained by placing the probe under the xiphoid process and angling the plane of the US into the left chest. The view should include both atria and ventricles. The apex of the heart, a left-sided structure,

should be seen on the right side of the screen as it is viewed, with the right-sided structures toward the left of the screen and adjacent to the liver. In a cardiology orientation, the probe indicator should be directed to the patient's left, while in a general imaging orientation

it should be directed to the patient's right, resulting in the same image on the screen.

Apical Window

This window is obtained by placing the probe at the apex of the heart, typically slightly inferior and lateral to the nipple in males and under the breast in females. While probably the most difficult of the three primary windows to consistently visualize, it provides some of the best information when correctly obtained. The four-chamber view includes both ventricles and atria, with the apex at the top of the screen and the interventricular septum running vertically down the screen. In a cardiology orientation, the probe indicator is directed to the patient's left (or down to the bed when patient is in a supine position), while in a general imaging orientation the probe indicator is directed to the patient's right (or toward the ceiling in a supine patient). The net result is that in either convention, the same image is seen on the screen, with the left side of the heart on the right side of the screen as it is viewed and the right side of the heart on the left side of the screen as it is viewed.

Parasternal Window

The parasternal window is one of the most consistently available windows to the heart. The long axis view is obtained by placing the probe just to the left of the sternum in the second or third intercostal space with the US plane running from the base to the apex of the heart. The view should include the right ventricle anteriorly and the left atrium, ventricle, and aortic outflow tract posteriorly.

The parasternal view is obtained in cardiology by directing the probe to the patient's *right* shoulder (opposite to the probe direction in other cardiology views) providing an image that is reversed from other windows, with the apex (a left-sided structure) on the left of the screen as it is viewed. This indicator direction makes sense when the examiner is on the patient's left, as the view can be thought of as looking *down* through the long axis of the heart. However, this orientation is not intuitive when scanning from the patient's right (where other US examinations are typically performed from) and essentially involves switching the probe indicator direction in order to obtain an image that is reversed from other cardiac images.

There are two potential solutions for the parasternal window when scanning from the patient's right using a general imaging screen orientation. An attempt can be made to mimic the cardiology screen image by pointing the indicator to the patient's left hip. This is sometimes called the "fourth-and-long" approach, as it involves directing the indicator to the 4 o'clock position (or left hip) to obtain the long axis view. This is based on a partial but incomplete adoption of the cardiology approach and will result in an image that mimics what is seen in cardiology and many emergency medicine texts.

An alternate approach is to orient the indicator to the patient's right in a general screen orientation, consistent with the indicator direction for the other windows to the heart. This provides an image that is flipped from that commonly seen in cardiology texts,

but allows for a consistent probe orientation with consistent position of anatomic structures on the US screen, (i.e., the apex [patient's left] on the right side of the screen as it is viewed). This approach has been previously described in the literature and is listed as an alternate approach in the Emergency Ultrasound Imaging Compendium.^{28,29}

Other Windows

Similar principles apply to other windows. Using a general indicator-to-screen convention, windows such as the parasternal short axis (indicator to right hip) and subcostal long axis (indicator to head) will produce images consistent with cardiology as well as with EM orientation conventions.

ADVANTAGES, DISADVANTAGES, AND EXPERIENCE WITH DIFFERENT APPROACHES

Adopting a standard indicator-to-screen orientation for all exams (cardiac and noncardiac) results in less confusion as it does not require either physically or mentally switching the indicator-to-screen orientation when changing applications. Some physicians have been reluctant to do this because choosing the "Echo" preset, which is standard on many machines and results in better cardiac images, defaults to a cardiology indicator-to-screen orientation. However, it is usually straightforward to create an "ED Echo" preset on the machine, which maintains cardiac settings while using a general imaging orientation. This is consistent with the way most EPs use both FAST and cardiac US and is backed by the Imaging Criteria Compendium,²⁸ although it is not consistent with the cardiology convention.

Using the general indicator-to-screen orientation allows for the subcostal and apical views of the heart to be obtained using an indicator direction that is consistent with other EUS (directed to patient's right). Directing the probe to the patient's left (4 o'clock) for the parasternal long axis will provide an image consistent with those seen in cardiology texts. However, it has the disadvantage of both reversing the probe direction from other views and obtaining a screen image that is reversed from other US images. Unless the physician is physically positioned on the patient's left, the image and hand movements will be counterintuitive from other scanning.

The alternate approach of directing the indicator to the patient's right shoulder to obtain a parasternal long axis is currently less widely used, but has the advantage of not having to remember to switch either the probe orientation or the screen orientation for any type of scanning. Utilizing a consistent probe orientation (i.e., indicator to patient's right) allows for quicker assimilation of cardiac orientation and anatomy and integration of cardiac scanning into US scanning as a whole. This method provides an image that is consistent with the other views: a parasternal window in this orientation is very similar in appearance to the subcostal window, only higher, including the aortic root rather than the right atrium. There are situations where a nontraditional window may be the only one available; windows

such as a low parasternal/high subxiphoid/medial apical view, and obtaining these windows does not require switching the indicator direction.

The drawback to this alternate approach is that the parasternal image seen on the screen will appear differently from that currently seen in many textbooks. There is concern that using a different convention will result in problems communicating images with cardiologists, although cardiologists versed in echo usually grasp the issue quickly. Within cardiology, the Mayo Clinic, one of the leading teaching and research echo labs in the country, uses a probe orientation convention that differs from the standard cardiology approach for the apical four chamber view.³⁰

A benefit of a consistent approach is that physicians do not have to remember to switch the probe direction for certain windows and not others. In addition to consistent anatomic orientation on the screen, this helps to ensure that other windows will not be inadvertently switched. In the apical four-chamber view in particular, it can be critical to distinguish left from right side, and when physicians are confused about probe direction, they can easily mistake right for left heart or vice versa.

Differentiating right from left heart may not be problematic in nonpathologic hearts, but can be critical in sicker patients. In particular, the identification of right and left ventricular pathology may be of diagnostic or prognostic importance in patients with undifferentiated shock or dyspnea, suspected pulmonary embolism, myocardial infarction, or congestive heart failure, among other pathologies.^{12,21,31-36} Specifically, a pathologic right heart may be missed when it is thought to be the left side, an error that occurs when images are oriented based on how they appear on the screen rather than using a consistent approach to probe placement. Errors such as this are unlikely to be reported in the literature; while the widespread use of echo by EPs for these conditions has not yet been realized, they are likely to increase as training and equipment improve.^{2,37} Adopting consistent habits early on will ensure correct application.

Using a consistent indicator to patient orientation also means that the hand-eye coordination that is ingrained from other types of scanning is not upset. This may be of critical importance during procedural guidance, such as US-guided pericardiocentesis, when it is crucial to direct the probe based on image orientation. We are aware of a center who recently adopted a consistent probe orientation after difficulty was encountered directing the needle correctly, using an image with the probe reversed.³⁸

RESOLUTION

Consensus is unlikely to be achieved as long as EPs are trying to mimic both cardiac and general imaging conventions on the same patient, and unfortunately, confusion is likely to continue when the cardiology approach is partially adopted. While adopting a consistent approach to all EUS that is unique but merges the two conventions is possible, differences exist in how to approach this issue. It is the goal of this article to explain the origins and possible approaches, particu-

larly to physicians who are in the position of teaching others how to perform this exam.

CONCLUSIONS

Early on, cardiac and general US imaging adopted conventions that differed from each other. As cardiac US scanning is reassimilated into use by physicians who scan all parts of the body, it is reasonable to adopt a consistent orientation and approach to all parts of the body, rather than trying to use two disparate US approaches on a single patient. In either case, it is essential to understand the issues regarding US image orientation in both diagnostic and procedural uses of US.

References

1. Moore CL, Gregg S, Lambert M. Performance, training, quality assurance, and reimbursement of emergency physician-performed ultrasonography at academic medical centers. *J Ultrasound Med.* 2004; 23:459-66.
2. Moore CL, Molina AA, Lin H. Ultrasonography in community emergency departments in the United States: access to ultrasonography performed by consultants and status of emergency physician-performed ultrasonography. *Ann Emerg Med.* 2006; 47:147-53.
3. Kendall JL, Hoffenberg SR, Smith RS. History of emergency and critical care ultrasound: the evolution of a new imaging paradigm. *Crit Care Med.* 2007; 35(5 Suppl):S126-30.
4. Koertzen M, George SJ. Echocardiography in cardiac anaesthesia and intensive care. *Anaesth Intensive Care Med.* 2006; 7:321-5.
5. Scalea TM, Rodriguez A, Chiu WC, et al. Focused Assessment with Sonography for Trauma (FAST): results from an international consensus conference. *J Trauma.* 1999; 46:466-72.
6. Mazurek B, Jehle D, Martin M. Emergency department echocardiography in the diagnosis and therapy of cardiac tamponade. *J Emerg Med.* 1991; 9:27-31.
7. Mayron R, Gaudio FE, Plummer D, Asinger R, Elsperger J. Echocardiography performed by emergency physicians: impact on diagnosis and therapy. *Ann Emerg Med.* 1988; 17:150-4.
8. Plummer D, Brunette D, Asinger R, Ruiz E. Emergency department echocardiography improves outcome in penetrating cardiac injury. *Ann Emerg Med.* 1992; 21:709-12.
9. Tayal VS, Kline JA. Emergency echocardiography to detect pericardial effusion in patients in PEA and near-PEA states. *Resuscitation.* 2003; 59:315-8.
10. Moore CL, Rose GA, Tayal VS, Sullivan DM, Arrowood JA, Kline JA. Determination of left ventricular function by emergency physician echocardiography of hypotensive patients. *Acad Emerg Med.* 2002; 9:186-93.
11. Jones AE, Tayal VS, Sullivan DM, Kline JA. Randomized, controlled trial of immediate versus delayed goal-directed ultrasound to identify the

- cause of nontraumatic hypotension in emergency department patients. *Crit Care Med.* 2004; 32:1703-8.
12. Moore CL, Chen J, Lynch KA, Osborne M, Solomon D. Utility of focused chest ultrasound in the diagnosis of patients with unexplained dyspnea [abstract]. *Acad Emerg Med.* 2006; 13:S201.
 13. Jones AE, Craddock PA, Tayal VS, Kline JA. Diagnostic accuracy of left ventricular function for identifying sepsis among emergency department patients with nontraumatic symptomatic undifferentiated hypotension. *Shock.* 2005; 24:513-7.
 14. Blaivas M. Incidence of pericardial effusion in patients presenting to the emergency department with unexplained dyspnea. *Acad Emerg Med.* 2001; 8:1143-6.
 15. Edler I, Hertz C. Use of ultrasonic reflectoscope for the continuous recording of movements of heart walls. *Kungl Fysiogr Sallsk Lund Forh.* 1954; 24:40.
 16. Feigenbaum H. Evolution of echocardiography. *Circulation.* 1996; 93:1321-7.
 17. Gowda RM, Khan IA, Vasavada BC, Sacchi TJ, Patel R. History of the evolution of echocardiography. *Int J Cardiol.* 2004; 97:1-6.
 18. Woo J. A Short History of the Development of Ultrasound in Obstetrics and Gynecology. 2006. Available at: <http://www.ob-ultrasound.net/history1.html>. Accessed Dec 2, 2007.
 19. Fleming JEE, Spencer IH, Nicolson M. Medical ultrasound—germination and growth. In: Baxter GM, Allan PLP, Morley P, eds. *Clinical Diagnostic Ultrasound*. Boston, MA: Blackwell Publishing; 1999, pp 1-20.
 20. Use of ultrasound imaging by emergency physicians. *American College of Emergency Physicians. Ann Emerg Med.* 1997; 30(3):364-5.
 21. Rose JS, Bair AE, Mandavia D, Kinser DJ. The UHP ultrasound protocol: a novel ultrasound approach to the empiric evaluation of the undifferentiated hypotensive patient. *Am J Emerg Med.* 2001; 19:299-302.
 22. Jehle D, Heller MB. *Ultrasonography in Trauma: The FAST Exam*. Dallas TX: American College of Emergency Physicians, 2003.
 23. Snoey ER. Echocardiography. In: Simon BC, Snoey ER, eds. *Ultrasound in Emergency and Ambulatory Medicine*. St. Louis, MO: Mosby, 1996: 221-49.
 24. Ciccone TJ, Grossman SA. Cardiac ultrasound. *Emerg Med Clin North Am.* 2004; 22:621-40.
 25. Moscati RM, Reardon RF. Clinical Application of the FAST Exam. In: Jehle D, Heller MB, eds. *Ultrasonography in Trauma: The FAST Exam*. Dallas, TX: American College of Emergency Physicians, 2003: 39-60.
 26. Noble VE, Nelson B, Sutingco AN. *Emergency and Critical Care Ultrasound*. New York, NY: Cambridge University Press, 2007.
 27. Personal communication, Gillian Baty, MD, November 26, 2007.
 28. Emergency ultrasound imaging criteria compendium. *American College of Emergency Physicians. Ann Emerg Med.* 2006; 48:487-510.
 29. Moore C, Lin H. *Echocardiography. A Practical Guide to Emergency Ultrasound*. Philadelphia, PA: Lippincott Williams & Wilkins, 2005, pp 93-122.
 30. Personal communication, Brian Stockard, RCS, e-mail November 26, 2007.
 31. Grifoni S, Olivotto I, Cecchini P, et al. Utility of an integrated clinical, echocardiographic, and venous ultrasonographic approach for triage of patients with suspected pulmonary embolism. *Am J Cardiol.* 1998; 82:1230-5.
 32. Johnson ME, Furlong R, Schrank K. Diagnostic use of emergency department echocardiogram in massive pulmonary emboli. *Ann Emerg Med.* 1992; 21:760-3.
 33. Jones AE, Tayal VS, Sullivan DM, Kline JA. Randomized, controlled trial of immediate versus delayed goal-directed ultrasound to identify the cause of nontraumatic hypotension in emergency department patients. *Crit Care Med.* 2004; 32:1703-8.
 34. Ribiero A, Lindmarker P, Juhlin-Dannfelt A, Johnson H, Jorfeldt L. Echocardiography doppler in pulmonary embolism: right ventricular dysfunction as a predictor of mortality rate. *Am Heart J.* 1997; 134:479-87.
 35. Sanfilippo AJ, Arthur E. The role of echocardiography in managing critically ill patients. *J Crit Illness.* 1988; 3:27-44.
 36. Moore CL, Rose GA, Tayal VS, Sullivan DM, Arroyo JA, Kline JA. Determination of left ventricular function by emergency physician echocardiography of hypotensive patients. *Acad Emerg Med.* 2002; 9:186-93.
 37. Jones AE, Tayal VS, Kline JA. Focused training of emergency medicine residents in goal-directed echocardiography: a prospective study. *Acad Emerg Med.* 2003; 10:1054-8.
 38. Personal communication, Heidi Ladner, MD, e-mail October 15, 2007.

APPENDIX B – INSTRUCTIONS AND IMAGE SAMPLES FROM COMMONLY USED US MACHINES



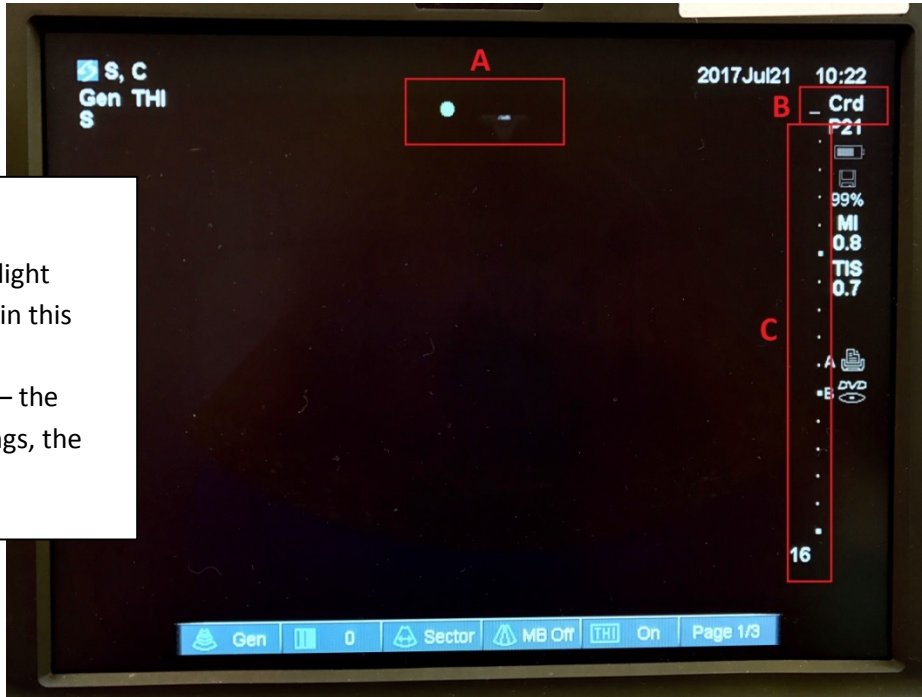
Keyboard layout:

- A. Depth control
- B. Gain control
- C. AutoGain

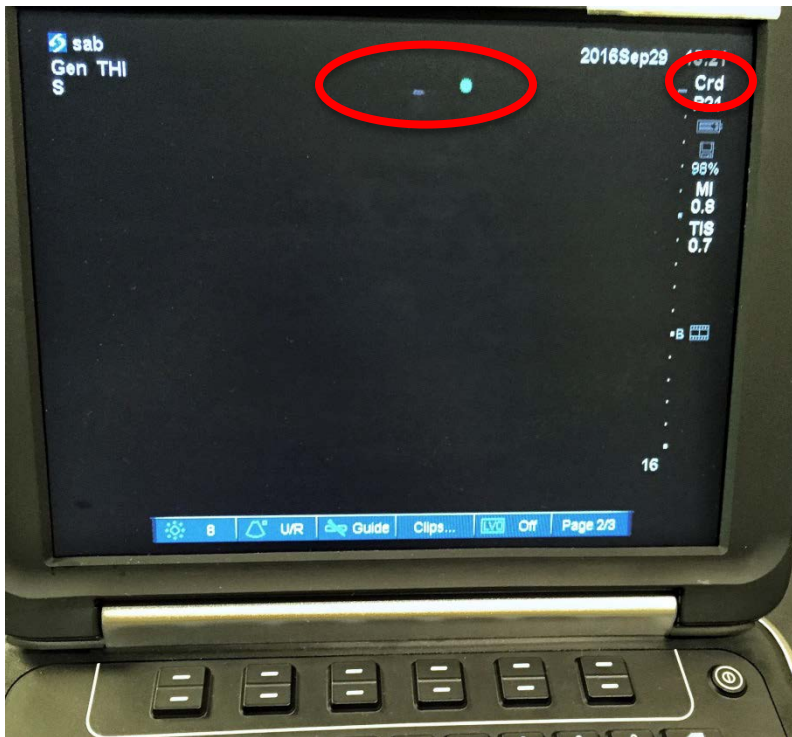


Screen display:

- A. Probe indicator light
- B. Probe selected (in this case: Cardiac)
- C. Depth markers – the more cm markings, the more depth



Changing Probe Indicator Light (for Cardiac sessions)

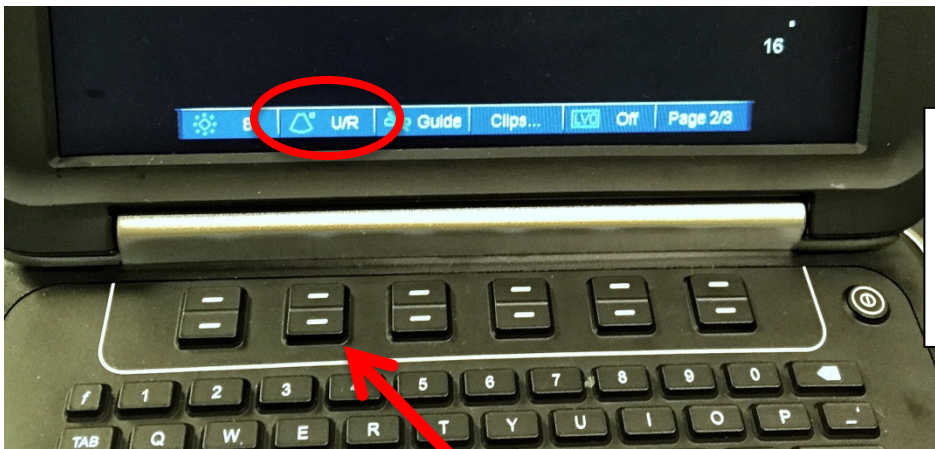
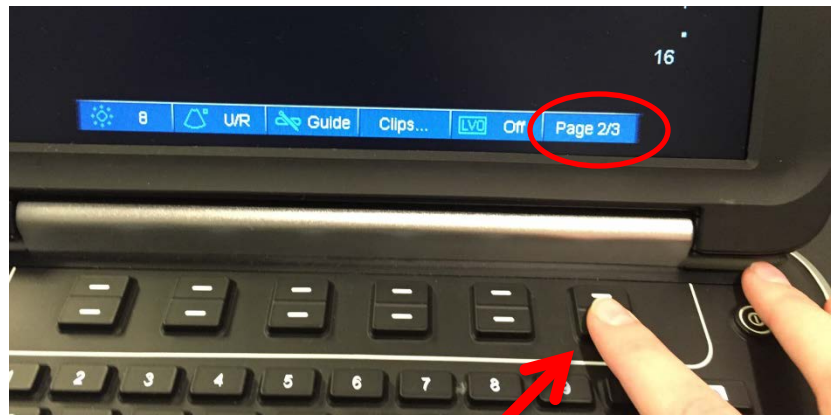


Often the screen will default to a specific setting when the Cardiac probe is selected.

You can see that the onscreen orientation marker (green light) is to screen right.

For Clinical Skills Cardiac Ultrasound sessions, the screen marker should always be to **screen left**.

To change the probe orientation you must first change the page by pressing the top right button on the keyboard.



On page 2/3 you can see the probe marker is set to U/R (upper right).
Press the button second from the left until it indicates U/L.

You can now see that the onscreen marker is on **screen left**.

This is properly set up for use by Clinical Skills students during their Cardiac Ultrasound session. (See Cardiac Ultrasound Student Guide for more information on this probe orientation).

