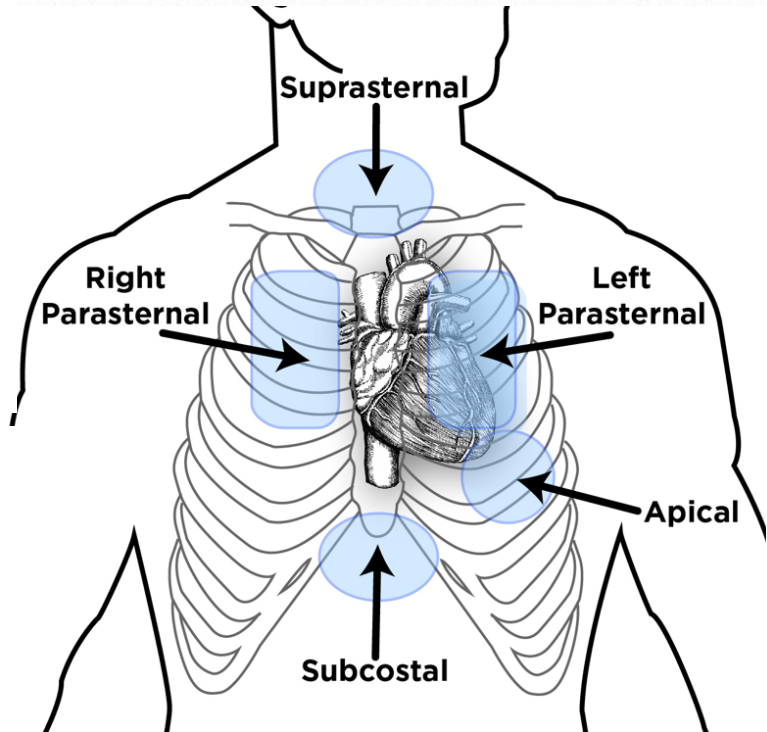
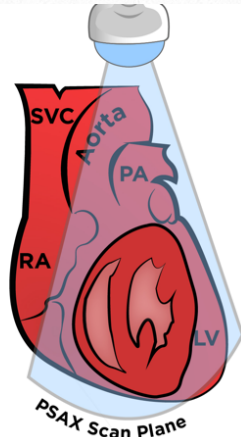
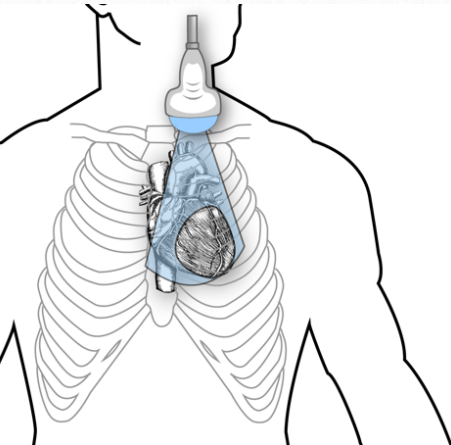
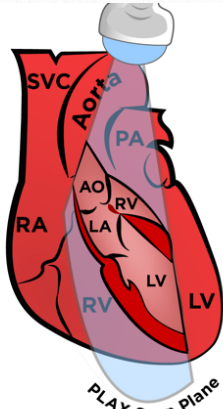
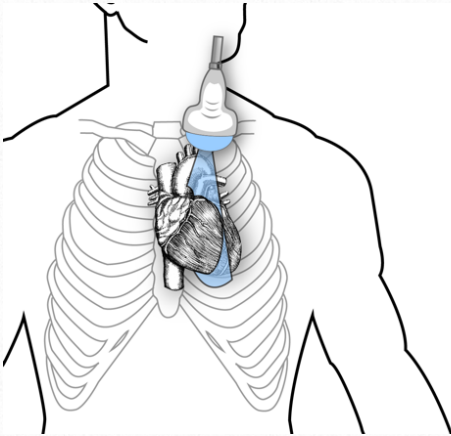


9

Cardiac Ultrasound: Parasternal Views and Methods of Assessing Contractility



III. CARDIAC: Ultrasound is an excellent modality to assess cardiac function/abnormalities. Surface ultrasound can provide an excellent minimally invasive tool to determine the mechanisms of the patient's current hemodynamic status. Each subsection will cover a cardiac ultrasound technique used to answer these questions.

Parasternal Views and Cardiac Contractility:

The parasternal window allows one to see the many cardiac structures with great resolution because these structures are perpendicular to the ultrasound plane. Because of this, one often will start with this window when performing a cardiac ultrasound examination. However, this window is NOT good to assess for blood flow directionality and therefore is a poor window to assess for valve regurgitation since the flow is perpendicular to the ultrasound image. This window has two major views: the parasternal left ventricle (LV) long axis view and the parasternal LV short axis view.

Parasternal Left Ventricle (LV) Long Axis View (LAX):

The parasternal LV long axis view allows one to assess the following: 1) left atrium size, structure of the mitral valve (NOT FLOW), 2) size/shape/contraction of the left ventricle, 3) structures of the aortic valve (NOT FLOW) and ascending aorta, and 4) RV size/shape/contraction. Of these items, one of the most important is **left atrial (LA) size**. The LA is a storage vessel for volume to the LV. In diastole the LV pressure reduces such that flow can move forward from the atrium. However, in any situation when the LV end diastolic pressure is elevated (diastolic dysfunction, severe aortic regurgitation, frequent episodes of tachycardia, severe systolic dysfunction, etc.) that pressure will get relayed to the LA. The way the LA handles this increased pressure is by dilating so it can hold more volume and therefore generate the necessary pressure to fill the left ventricle. **Because of this, the LA size is regarded as the HgA1c of the heart, since it is a marker for elevated left ventricular end diastolic pressures.** From the parasternal LV long axis view one can measure the diameter of the LA and determine if it is dilated (see table below). One can also get the LA area from apical window that will be discussed later. In this view, the RV should be seen as a very small structure. **If the RV diameter is larger than 3.3cm**, then concern for a dilated RV is raised. This view also allows an assessment of the ascending aorta, and we

can see if the aortic and mitral valves appear to open and close normally. This view also allows the assessment of LV contractility by a method called fractional shortening. **Fractional Shortening** is determined by taking an M-Mode picture across the LV at the papillary level and comparing the LV internal diameter in end diastole (LVIDd) minus the LV internal diameter in end systole (LVIDs). The equation is $((LVIDd - LVIDs) / LVIDd)$, see pic below. **IT IS IMPORTANT TO REALIZE, HOWEVER**, that this method of assessing contractility only takes into account one level of myocardium (of three) and only two wall segments (out of six), so it is the least accurate when compared to other methods of assessing contractility. This is further discussed below.

Parasternal Left Ventricle (LV) Short Axis View (SAX):

The parasternal SAX view allows one to assess for contractility of both the LV and RV, diameters of the LV/RV, and detection of regional wall motion abnormalities. The left ventricle can be cross-sectioned into three levels: 1) closest to the atrium is the basal level, 2) mid-papillary level, and 3) the apical level, which is the most distal from the atria at the apex (see pic below). The walls of left ventricle are divided into six sections (shown below) for the first two levels: 1) anterior, 2) lateral, 3) infero-lateral (posterior), 4) inferior, 5) infero-septal, and 6) antero-septal. The last apical level is divided into four sections: 1) anterior, 2) lateral, 3) inferior, 4) septal.

The coronary distribution (shown below) is as follows:

LAD - anterior and antero-septal segments

RCA - right ventricle, the infero-septal segments, most of the inferior segments and depending on what supplies the PDA the infero-lateral segments (only 20% of the time does the PDA come from the RCA),

Circumflex - lateral segments, and in 80% of the population it supplies the PDA for the infero-lateral segments and part of the inferior segments.

The diameter and/or area of left ventricle in end diastole represents the filling of the left heart and can indicate the patient's filling status. Using the measure or caliber feature one can assess the diameter of the left ventricle in either a standard 2-D image or an M-mode image. **IT IS IMPORTANT TO REALIZE THAT EVEN THOUGH THIS MODALITY CAN HELP**

PREDICT LEFT VENTRICULAR VOLUME, IT DOES NOT INDICATE VOLUME RESPONSIVENESS. In addition to measuring the diameter or area of the LV in diastole to determine LV volume, these views can also be used to assess cardiac contractility by measuring the change in the diameter of LV in diastole to systole. Measuring this change in area is called **fractional area change (FAC)** and indicates myocardial contractility (see figure below). FAC is more accurate than fractional shortening because now you are looking at one level (same as fractional shortening) and at all six wall segments as well (compared to two). REMEMBER THAT FAC AND LV DIAMETERS ARE MEASURED AT THE MID-PAPILLARY LEVEL. Also you can assure the LV is sectioned appropriately by comparing the size of the papillary muscles. If they are equal in size then you can reliably calculate the FAC and obtain accurate measurements.

It is important to remember that markers for LV systolic function, such as ejection fraction and fractional area change are significantly affected by preload, after load, and ventricular contractility. Remember diastolic dysfunction is an issue with ventricular relaxation and often these patients have normal systolic ventricular contractility

Finally, with these views one is able to help identify the **mechanism of shock:**

- 1. Cardiogenic shock:** increased LV area/diameter and a decreased FAC (from decreased contractility)
- 2. Hypovolemic shock:** decreased LV area/diameter (from decreased preload) and a increased or normal FAC
- 3. Vasogenic shock:** normal LV area/diameter and a increased or normal FAC (from low SVR state)

Patient Position: Left-Lateral with L arm Extended

Probe type: phased array cardiac probe

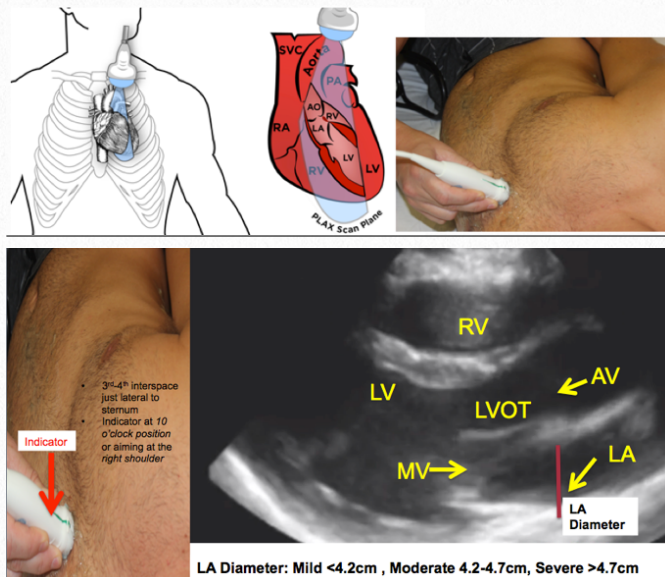
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Probe position:

Position 1. Left parasternal long axis view: 3rd-4th inter-space just lateral to the patients left's side of their sternum with index approximately at 10 o'clock position or aiming at the right shoulder (REMEMBER WHEN ROTATING TO SAX VIEW KEEP THE DESIRED STRUCTURE IN THE MIDDLE OF THE SCREEN)

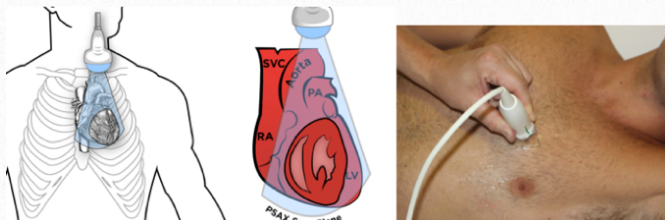
Position 2. Left parasternal short axis view: 3rd-4th inter-space just lateral to the patients left's side of their sternum with the index marker approximately. At the 2 o'clock position or aiming towards the patients left shoulder (90 degrees to LAX view).

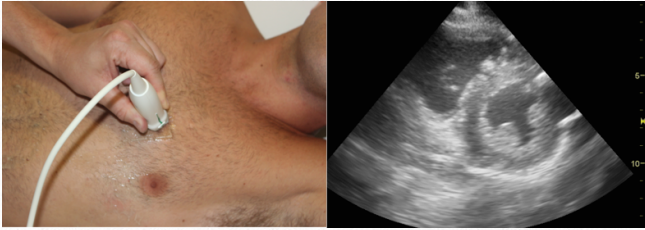
LV Parasternal LAX view Anatomy



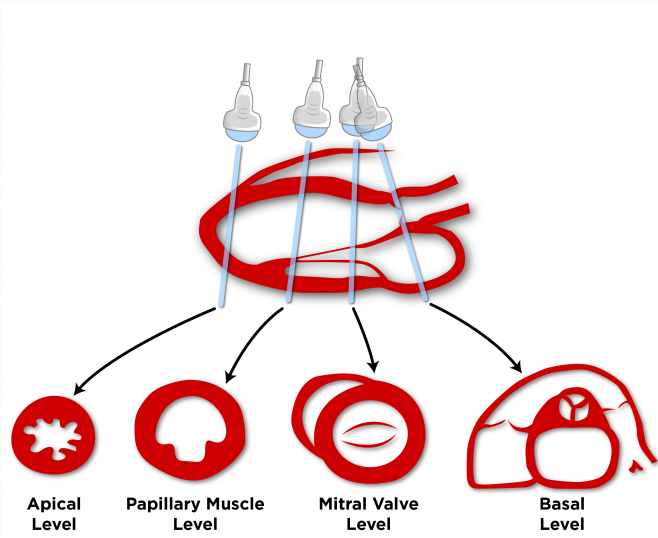
Parasternal Long Axis View (indicator at 10 o'clock position "right shoulder") (LV= left ventricle, MV= mitral valve, LVOT = left ventricular outflow tract, LA = left atrium, AV = aortic valve, RV = right ventricle)

LV Parasternal SAX view Anatomy

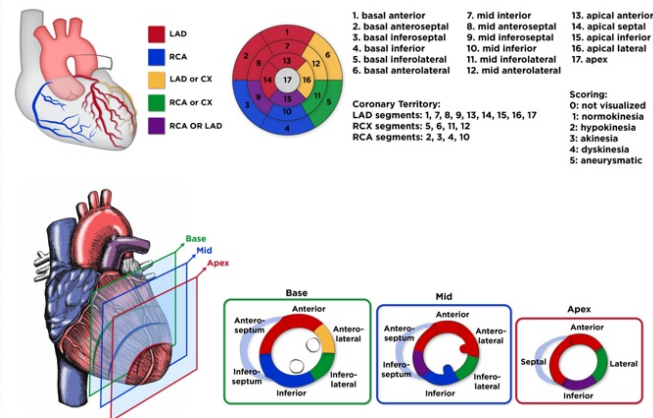




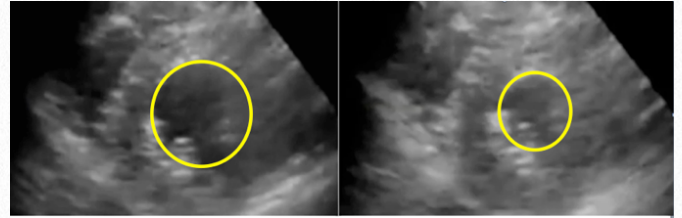
Position: 3rd-4th interspace with index approx. at 2 o'clock position (90 degrees to LAX view)



Coronary Distribution



Fractional Area Change (FAC)



FAC: (End Diastolic Area - End Systolic Area) / End Diastolic Area X100

Normal > 50%

Reduced LV volume: EDA < 8 cm 2

Normal LV volume: EDA 8-14 cm 2

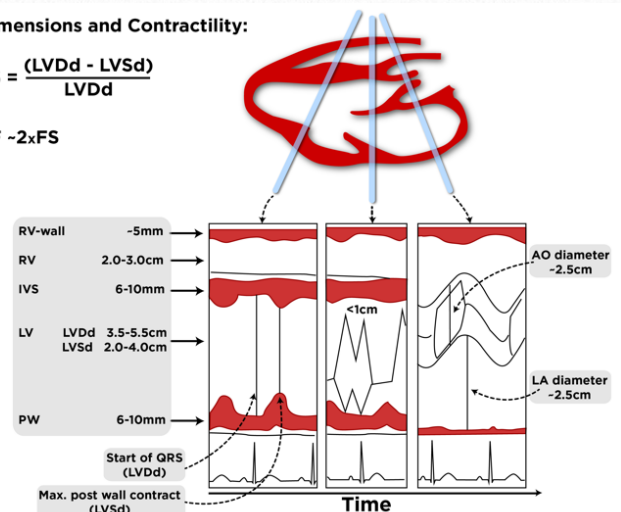
Dilated LV volume : EDA > 14 cm 2

Fractional Shortening:

Dimensions and Contractility:

$$FS = \frac{(LVDd - LVSD)}{LVDd}$$

$$EF \sim 2 \times FS$$



Evaluation of Shock with POC US

Shock Mechanism

Ideally assessed in L parasternal SAX view

Diastole

Systole

Cardiac Shock – decreased contractility, dilated left ventricular end-diastolic & end-systolic diameters, + RWMA



Hypovolemic Shock – increased contractility, REDUCED left ventricular end-diastolic diameter (LVIDd)



Vasogenic Shock (Low SVR) – increased contractility, NORMAL LVIDd



Using Parasternal SAX view to Determine Mechanism of Shock

- 1. Cardiogenic shock:** increased LV area/diameter and a decreased FAC (from decreased contractility)
- 2. Hypovolemic shock:** decreased LV area/diameter (< 8cm² area or 3.5cm diameter) from decreased preload) and a increased or normal FAC
- 3. Vasogenic shock:** normal LV area/diameter and a increased or normal FAC (from low SVR state)