Aortic Valve Leaflets

With the onset of ventricular ejection, the aortic leaflets snap open with the right coronary cusp moving anteriorly and the non-coronary cusp moving posteriorly. Both leaflets remain separated throughout the ejection period and lie parallel to the anterior and posterior aortic walls. Fine systolic fluttering of the aortic leaflets may be seen in the normal individual. With the onset of diastole, the leaflets close abruptly and coapt in the centre of the aortic root producing a single linear echo. Throughout the remainder of diastole the leaflets remain closed together following the posterior motion of the aortic root. This diastolic and systolic motion of the aortic leaflets forms a characteristic 'box-shape' within the aortic root; importantly this 'box' is not always seen on every trace. From the Q wave of the electrocardiogram (ECG) to the onset of ventricular ejection (opening of the aortic "box") is a period known as the pre-ejection period or the isovolumic contraction time.

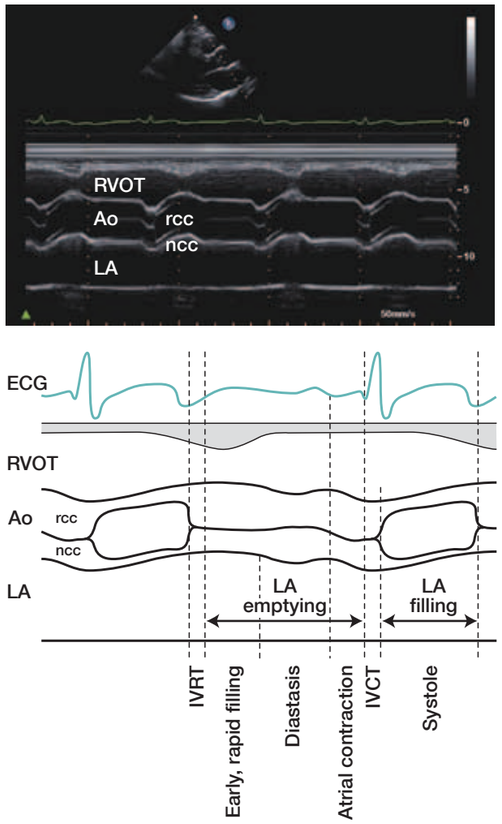

Figure 4.1 The top image shows the imaging plane, cursor position, structures transected and the M-mode trace for the aorta, aortic valve and left atrium (LA) as acquired from the parasternal long axis view. The schematic drawing illustrates the structures transected as well as their motion with respect to the various phases of the cardiac cycle. The isovolumic relaxation time (IVRT) is the period from aortic valve closure to mitral valve opening; this period as well as the onset of the rapid filling phase and diastasis is difficult to determine from this M-mode trace alone. Atrial contraction follows the P wave of the electrocardiogram (ECG). See text for other details.
Ao = aorta; IVCT = isovolumic contraction time; LV = left ventricle; ncc = non-coronary cusp; rcc = right coronary cusp; RVOT = right ventricular outflow tract.

Left Atrium

The LA lies directly posterior to the aorta. Although the anterior LA wall and the posterior wall of the aortic root are anatomically separate structures, their close proximity and spatial resolution limitations of the ultrasound machine result in the production a single echo. Therefore, the anterior LA wall follows the same phasic motion as that of the posterior aortic wall throughout the cardiac cycle. The posterior LA wall displays minimal motion and so remains relatively "flat" during the cardiac cycle. The specific phases of LA emptying may be appreciated by close observation of the anterior LA wall/posterior aortic root motion.

M-Mode Examination of the Mitral Valve

The M-mode examination of the mitral valve with respect to the cursor position, structures interrogated and the normal motion of these structures is displayed in Figure 4.2. Table 4.3 at the end of this chapter lists the abnormalities that may be detected from this M-mode examination.

Imaging Plane and Position of M-mode Cursor

The mitral valve can be examined from the PLAX view of the LV and from the PSAX view at the level of the mitral valve. From these views, the cursor is directed through the tips of the mitral valve leaflets.

Structures transected by the M-mode Cursor

From anterior to posterior, the ultrasound beam passes through the anterior chest wall, the anterior wall of the RV, the RVOT, the interventricular septum (IVS), the anterior and posterior leaflets of the mitral valve, and the posterior wall of the LV.

Normal Motion of the Mitral Valve during the Cardiac Cycle

As previously mentioned, motion of the mitral valve throughout the cardiac cycle is not as simple as that of the aortic valve (recall Fig. 2.7 in Chapter 2). During diastole, the mitral leaflets separate widely with the anterior leaflet approaching the IVS and the posterior leaflet moving toward the posterior wall of the LV. When the patient is in normal sinus rhythm, the anterior mitral valve leaflet (amvl) produces an "M-shaped" configuration while the posterior mitral valve leaflet (pmvl), which moves in the opposite direction to the anterior leaflet, may be seen to form a "W-shaped" pattern. During systole, the two mitral leaflets close posteriorly within the LV cavity producing multiple linear echoes that move slightly anteriorly throughout the systolic period. The longer amvl has a greater diastolic excursion than that of the shorter pmvl; hence, the amvl features more prominently on the M-mode trace.
Each characteristic point which forms the "M-shaped" pattern of the amvl throughout the cardiac cycle has been designated a letter from the alphabet and these points reflect various events within the cardiac cycle (Table 4.1). The pmvl can also be labelled in a similar manner with the addition of an apostrophe ('). For example, on the pmvl the E' point reflects the maximum posterior deflection of the posterior leaflet occurring with early, rapid diastolic filling while the A' point reflects the maximum posterior deflection following atrial contraction.

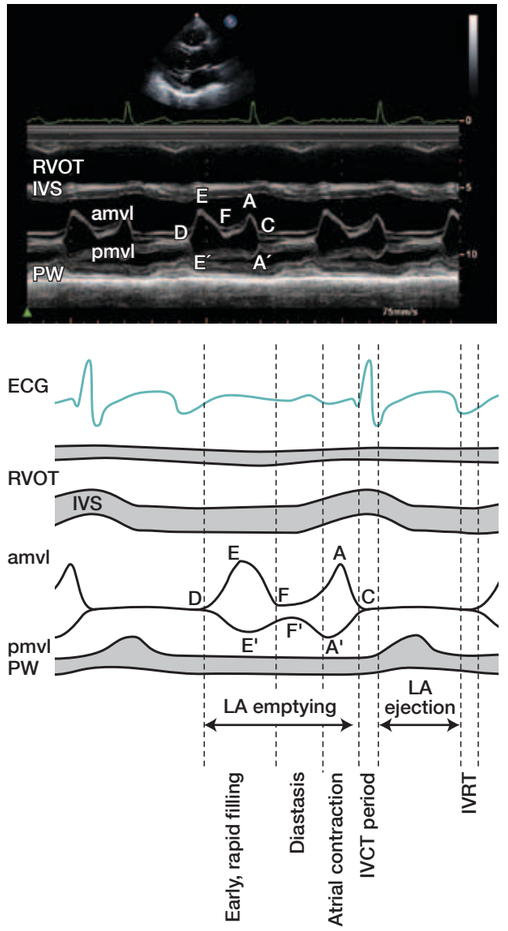

Figure 4.2 The top image shows the imaging plane, cursor position, structures transected and the M-mode trace of the mitral valve as acquired from the parasternal long axis view. The schematic drawing illustrates the structures transected as well as their motion with respect to the various phases of the cardiac cycle. Note that the end of systole (closure of the aortic valve) occurs at the end of the T wave of the electrocardiogram (ECG) so the isovolumic relaxation time (IVRT) is the period from the end of the T wave to the onset of mitral valve opening (D point). The isovolumic contraction time (IVCT) is the period from the closure of the mitral valve (C point) to the opening of the aortic valve; opening of the aortic valve can be estimated by the motion of the interventricular septum (IVS) and posterior wall as with ventricular ejection the IVS and posterior wall move inwards towards the left ventricular (LV) cavity. See text and Table 4.1 for further details.
LA = left atrium; amvl = anterior mitral valve leaflet; pmvl = posterior mitral valve leaflet; PW = posterior wall of LV; RVOT = right ventricular outflow.

Table 4.1 Anterior Mitral Leaflet Points

Points	Description
D Point	• marks position of the mitral valve leaflets at the onset of diastole
E Point	• reflects the maximal opening point of the mitral leaflet due to the early, rapid filling phase of diastole • early, rapid filling and opening of the mitral valve occurs when the pressure in the LV falls below the pressure in the LA
F Point	• the most posterior position of the leaflet immediately following the E point • posterior motion occurs when the pressure difference between the LA and LV decreases as the LV pressure rises as the LV fills and as the LA pressure falls as the LA empties
E-F slope	• represents the initial diastolic closing motion of the anterior leaflet • this slope is an indicator of the rate of LA emptying and/or LV filling • normally, LA emptying and LV filling is rapid resulting in a steep E-F slope
A point	• reflects the point of leaflet 're-opening' that occurs following atrial contraction • with atrial contraction the LA pressure increases resulting in another bolus of blood being ejected into the LV
B Point	• refers to the position of the anterior leaflet at the onset of ventricular systole • this point is usually absent when there are normal LV filling pressures
C point	• denotes the final position of leaflet closure immediately prior to ventricular systole

M-Mode Examination of the Left Ventricle

The M-mode examination of the LV with respect to the cursor position, structures interrogated and the normal motion of these structures is displayed in Figure 4.3. Table 4.3 at the end of this chapter lists the abnormalities that may be detected.

Imaging Plane and Position of M-mode Cursor

M-mode interrogation of the LV can be assessed from the PLAX view of the LV or PSAX view at the level of the papillary muscles. The cursor is positioned perpendicular to the long axis of the LV just distal to the tips of the open mitral valve leaflets. The preferred view for the M-mode interrogation of the LV is the PLAX view as the LV long axis and other anatomic landmarks are best seen from this view.

Structures transected by the M-mode Cursor

From anterior to posterior, the ultrasound beam transects the anterior chest wall, the anterior wall of the RV, the RVOT, the basal IVS, the LV cavity, the basal posterior (inferolateral) wall of the LV, and the pericardium. The posterior epicardial-visceral pericardial interface is identified by its much brighter echo appearance. Recognition of this interface is particularly important when measuring the posterior LV wall thickness.