LV Mass
As described in Chapter 9, the LV mass is determined from the LV muscle volume and the specific gravity of muscle.

LV muscle volume is equal to the total ventricular volume contained within the epicardial boundaries of the ventricle (epicardial volume) minus the chamber volume contained by the endocardial surfaces (endocardial volume) (see Fig. 9.9).

LV mass is then calculated by multiplying the LV muscle volume by the specific gravity of muscle (1.04 g/mL). Both the total epicardial volume and the endocardial volume can be estimated from linear LV measurements as described for the 2D linear estimation of LV mass (see Chapter 9).

Therefore, LV mass via M-mode is also estimated from measurements of the LVEDD, IVS, and PW (Fig. 10.6):

Equation 10.1

\[
LVM = [1.04 (LVEDD + PW + IVS) - LVEDD^3] × 0.8] + 0.6
\]

where

- LVM = left ventricular mass (g/mL)
- LVEDD = left ventricular end-diastolic dimension (cm)
- PW = left ventricular posterior wall thickness (cm)
- IVS = interventricular septal thickness (cm)

1.04 = specific gravity of muscle (g/mL)
0.8 = ‘correction factors’
0.6 = ‘correction factors’

LV mass has been shown to correlate with body surface area (BSA) and is significantly different between men and women. Therefore, LV mass should be indexed for the BSA by simply dividing the calculated LV mass by the BSA. The normal values and partition values for severity are listed in Table 9.3.

LV Volumes
As described in Chapter 9, LV volumes can be estimated from the LVEDD and the LVESV via the cubed method and the Teichholz equation.

The cubed method is based on the assumption that the LV is shaped as a prolate ellipsoid. Then assuming that: (1) the LV internal diameter (short axis) is equal to one of the minor axes of the ellipse (D1, D2) both axes are equal (D1 = D2), and (3) the major axis to minor axis ratio is 2.1, (L = 2 D), LV volume can be estimated as:

\[
LVEDV = \frac{7.0}{2.44} D^3
\]

where

- D = diameter at end-diastole or end-systole (cm)

The Teichholz equation essentially corrects for changes in the relationship between the major and minor axes as the LV dilates:

\[
LVEDV = \frac{\text{LV end-diastolic volume (mL)}}{LVEDV^3}
\]

Equation 10.3

where

- LVEDV = left ventricular volume (mL)

Using the Teichholz equation, the LV end-diastolic volume (LVEDV) and the LV end-systolic volume (LVESV) can be estimated from the LVEDV and the LVESV (see Practical Example 9.1 in Chapter 9).

Global LV Systolic Function
Measurements of global LV systolic function include the: (1) fractional shortening (FS), (2) ejection fraction (EF), and (3) stroke volume (SV), cardiac output (CO) and cardiac index (CI). As described in Chapter 9, these indices can be estimated from the LV end-diastolic and end-systolic diameters, and from the LV end-diastolic and end-systolic volumes. The definitions and equations for each of these indices have been described in Chapter 9 and are summarised below.

Additional M-mode measurements such as the mitral E-point septal separation (EPSS) and LV systolic time intervals have also been used in the assessment of global LV systolic function. While these parameters are no longer measured routinely, simple ‘eyeballing’ of these measurements may provide indirect clues to overall LV systolic function.

Fractional Shortening and Ejection Fraction
The fractional shortening (FS) or shortening fraction is the percentage of change in the LV cavity dimension with systole and is calculated as:

\[
FS = \frac{LVEDD - LVESD}{LVEDD} \times 100
\]

where

- FS = fractional shortening (%)
- LVEDD = left ventricular end-diastolic dimension (cm)
- LVESD = left ventricular end-systolic dimension (cm)

The ejection fraction (EF) is the percentage of the LV diastolic volume that is ejected with systole and is calculated as:

\[
EF = \frac{[LVEDD - LVESV]}{LVEDD} \times 100
\]

where

- EF = ejection fraction (%) (LVEDD = left ventricular end-diastolic volume (mL)
- LVESV = left ventricular end-systolic volume (mL)

The EF can also be calculated via the simplified Quiñones’s method:

\[
EF = \frac{[LVEDV – LVESV]}{LVEDV} \times 100
\]

where

- EF = ejection fraction (%) (LVEDV = left ventricular end-diastolic volume (mL)
- LVESV = left ventricular end-systolic volume (mL)

Practical Example 10.1 compares the estimation of the EF via the cubed method, the Teichholz method and the simplified Quiñones’s method.

Stroke Volume, Cardiac Output, and Cardiac Index
Stroke volume refers to the amount of blood pumped by the heart on each single beat. The cardiac output is the volume of blood pumped by the heart on each single beat. Both the cardiac output and stroke volume can be calculated using the end-diastolic and end-systolic volumes which can be derived from the M-Mode measurements of the LV. In order to compare measurements between individuals of different sizes, measurement of the cardiac output is often expressed in terms of the cardiac index which is simply the cardiac output divided by the BSA.

\[
CO = (SV × HR) ÷ 1000
\]

Equation 10.7

where

- SV = stroke volume (mL)
- HR = heart rate (bpm)

CO = cardiac output (L/min)
CI = cardiac index (L/min/m²)
BSA = body surface area (m²)
LVESV = left ventricular end-systolic volume (mL)
LVESV = left ventricular end-systolic volume (mL)
HR = heart rate (bpm)
1000 = conversion of mL to litres

The primary limitations of M-mode-derived measurements for LV systolic function parameters includes the geometric assumptions for estimating LV volumes from a linear measurement as well as errors related to measurement technique. The most common error is oblique measurements of the LV due to poor alignment of the M-mode cursor.