Basic Assessment of Left Ventricular Systolic Function

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LV GLOBAL SYSTOLIC FUNCTION

- Fractional Shortening (FS)
- Fractional Area Change (FAC)
- Volumetric Ejection Fraction (EF)
- Long Axis Function (MAPSE)
Outline

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It is important to remember that the heart functions as a true pump. While most people view systolic heart function only as shortening along its short axis - or radial shortening, it also shortens in the linear axis where the base of the heart moves towards the apex, and also circumferential by contraction of circumferential cardiac fibers.
The concept of the feasibility of visual estimation of systolic heart function by inexperienced echo practitioners was well established in past years precisely as concerns LV systolic function. Various publications demonstrated that visual estimation of systolic function by 2D echocardiography can be learned quickly if immediate feedback is available during training. It is the case of this study, where correlations between the EF estimation by absolute novices (medical students) and experts echocardiographers and MRI quantification was excellent. A tendency towards slight overestimation of bad LV function and underestimation of Normal or Supernormal LV function is to be expected.
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What we train our eyes to assess is not truly the inotropic state of the LV but rather its capability to reduce its dimensions from ED to ES.

This can be done by judging this capability of changing throughout the cardiac cycle:

its linear (transversal) dimension
its cross sectional surface
its volume

The issue in Focused Echo is TO GENERALLY AVOID MEASUREMENTS, AND TO USE VERY SIMPLE MEASUREMENTS (LINEAR ONES) AS A SELF-CHECK WHILE TRAINING YOUR EYE.
LV Systolic Function

“Assess the LV capability to reduce its size from end-diastole to end-systole”

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Fractional Shortening (FS)

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

**NORMAL ≥ 30%**

**SEVERELY IMPAIRED < 20%**

This is very well done from a PLAX view, by aligning an M-Mode beam just below the mitral leaflets tips. Expressed as %, it is a measure we can easily take (you just need the calipers, no area tracking, no volume calculations): very simple. Measure to train your eyes to visual estimation.
Fractional Shortening (FS)

Regional wall motion abnormality ➔ UNRELIABLE

Septal dyskinesia ➔ INAPPLICABLE

Normal, Severely impaired
Easy to measure, but
UNRELIABLE IN THE PRESENCE OF REGIONAL WALL MOTION ABNORMALITIES.
FS CANNOT BE USED IN SITUATIONS OF SEPTAL DYSKINESIA (complete left bundle branch block, Wolff-Parkinson White, paradoxical septal motion, left to right shunt), where the two explored LV walls don’t have opposite (physiological) but rather parallel motion.
Fractional Shortening (FS)

But FS is not limited only to M-mode. Same concept can be applied to 2D echo, where we basically get the same information, provided adequate image quality.

Here is an example of such measurement during diastole, on the left side of the slide, and then advanced to systole on the right side of the slide. With proper calculation package, which most modern echo machine has, the computer will calculate fractional shortening from these measurements, the stroke volume using two different algorithm, and ejection fraction.

Same limitations apply here, namely arrhythmia and wall motion abnormalities, both of which can affect accuracy of EF assessment.
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Fractional Area Change (FAC)

The LV systolic index that can be derived is called Fractional Area Change, which is a percentage variation in LV area from end diastole (LVEDA) to end systole (LVESA) at that level. This gives you a better clue on LV global function, as it considers all ventricular walls (even if at just one level). Normal values are greater than 35%.

To make it more simple and…
Fractional Area Change (FAC)

\[
\text{FAC} \% = 100 \times \frac{\text{LVEDA} - \text{LVESA}}{\text{LVEDA}}
\]

NORMAL 35% - 65%

...to avoid the measurement of the area and learn to assess visually, again refer to the centimetric scale and estimate reduction of diameter on different axis, remembering that normality for linear reduction is greater than 1/3.
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NORMAL $\geq \frac{1}{3}$

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FAC – example
FAC – example

\[
\frac{22.4 \text{ cm}^2 - 16.2 \text{ cm}^2}{22.4 \text{ cm}^2} \times 100 = 28\%
\]
## FRACTIONAL AREA CHANGE

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And here are the patterns that you should learn to distinguish. This is more of a “visual” FAC -- learning to look at the LV in short axis in diastole and systole and assessing just by visualization the FAC and LV systolic function. It takes time to calibrate your eyes to an expert's eye and eventually be able to assess LV systolic function just by looking at the walls contracting.
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Ejection Fraction (EF)

\[
EF(\%) = 100 \times \frac{(LVEDV - LVESV)}{LVEDV}
\]

NORMAL \geq 55%

Performing the measurement at ED and ES allows for calculation of the 2 volumes and the percentage variation. Normal LV systolic function is considered with an EF > 55% (when the LV empties more than half of its volume it is normal...)
Ejection Fraction (EF)

\[
EF(\%) = 100 \times \frac{LVEDV - LVESV}{LVEDV}
\]

LV DYSFUNCTION

- Mild: 45 - 55%
- Moderate: 30 - 44%
- Severe: < 30%

International Guidelines grade LV dysfunction according to EF as follows....
Methods: 89 consecutive patients after MI or prior to CAG
LAX & SAX, 4C 2C : FS, EF, WMSI Simpson biplane & AVPD obtained
Results: All formal methods correlated significantly with eyeballing ejection fraction (p < 0.001)
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Note the interpersonal variability of the different methods
2D: “eyeballing”

Advantages
- Comparable to quantitative methods (Mcgowan JH et al. Am Heart J 2003; 146:388-97)
- Easy
- Quick

Limitations:
- Need several planes
- Conduction abnormalities increases difficulty
- Tachycardia increases difficulty
- Requires some learning curve (40-60 supervised exams) (Clin Cardiology 1995;18:726-9)
But with Focused Echo we don’t want to measure but rather visually judge the EF with a trained eye.

...i.e. to distinguish between these patterns:....
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Finally, as concerns LV systolic global function, apical displacement of mitral annulus can be measured with M-Mode. It's simpler than other LV global systolic function indices, and very quick. It might be the only way to assess LV function when bad 2-D imaging is present. As with FS, the presence of RWMA can lead to great inaccuracy of this measurement as an index of LV global function.
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LV Long Axis Function

Mitral Annulus Plane Systolic Excursion (MAPSE)

Unreliable with Regional Wall Motion Abnormality

| NORMAL | SEVERELY ABNORMAL |
| SEPTAL (mm) | > 10 | < 7 |
| LATERAL (mm) | > 10 | < 7 |

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MAPSE – “HOW TO”
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MAPSE -LV Long Axis Function

Here an example
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