EDM Basics

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Doppler effect

- Pitch of the sound waves emitted by a car (object) moving towards you (receiver) will increase in frequency (Blue shift).
- Pitch decreases in frequency (Red shift) as the car moves away from you.
Doppler Equation

The Doppler equation is as follows:

\[ f_D = \frac{2 \cdot v \cdot f_T \cdot \cos \theta}{c} \]

this can be rearranged to measure velocity as:

• \[ v = \frac{c \cdot f_D}{2 \cdot f_T \cdot \cos \theta} \]

\( v \)  Velocity of the red blood cells
\( c \)  Speed of the ultrasound waves through body tissues\( (1540 \text{ m.s}^{-1}) \)
\( f_D \)  Doppler frequency shift
\( f_T \)  Transmitted frequency of the ultrasound
\( \cos \theta \)  cosine of the angle of insonation between the sound beam axis and the direction of blood flow.
Angle of insonation ($\theta$)

- $\theta$ is the angle between the Doppler ultrasound beam and the direction of blood flow in the aorta.
- If $\theta = 90^\circ$, there is no Doppler shift as the cosine of $90^\circ$ is zero.
- EDM devices assume a fixed angle of incidence of 45 degrees.
Nomogram

• Nomogram created by ‘calibration’ of
  – total left ventricular SV as measured by the Pulmonary Artery Catheter, against
  – descending aortic blood flow velocity and SD as measured by the EDM.[ 14 ]

*It has been suggested that any fluctuation of the aortic diameter is implicitly included in the calculation*

As calibration is against total cardiac output there is no assumption of distribution of blood before and after the measured point of descending aorta (e.g. 70:30 proportioning) required
EDM Parameters

PV  Peak Velocity measured during systole (in cm.s\(^{-1}\)).

FT  Flow Time is the time of systolic aortic blood flow (in ms).

FTp Flow Time to peak (FTp) is the time from the beginning of systole to the point when PV is detected (in ms).

FTc Flow time Corrected is calculated by dividing FT by square root of cardiac cycle time

Cycle time Time between identical successive points of the systolic waveform (in ms)
The peak of the triangle represents the Peak Velocity detected during systole.

The upslope of the triangle depicts the acceleration of blood as it is ejected down the descending thoracic aorta at the beginning of systole.

The area under the velocity-time waveform is the Stroke Distance.

Stroke distance is the distance a column of blood will travel down the aorta with each left ventricular contraction.
The Stroke Volume is calculated from the measured SD and a calibration constant derived from the nomogram.

Cardiac Output is then calculated by multiplying the SV by the HR.

The stroke volume can be indexed to a patient's body size by dividing by the body surface area to yield the stroke volume index (SVI).
How Flow time corrected (FTc) is calculated?

The measured FT is divided by the square root of the cardiac cycle time thus adjusting the heart rate to 60 bpm.

- Normally systole is approximately one-third of the cardiac cycle at a heart rate of 60 bpm, (i.e. a third of a second).
- The FTc is displayed on the EDM in milliseconds (ms) and 330 ms to 360 ms is considered normal.

(Bazett MC. An analysis of the time-relations of electrocardiograms. *Heart* 1920; 7:353-364.)
Peak Velocity (PV)

The Peak Velocity measured by the amplitude of the waveform, is a marker of contractility.

• An increase in afterload may be noted by a simultaneous reduction in both the FTc and PV, resulting in a narrow waveform with decreased amplitude.
  – any condition causing vasoconstriction, e.g. hypovolemia, flow obstruction, excess vasopressor, hypotension or hypothermia.

• A reduction in afterload will result in an increase in amplitude (increased PV) and a widening at the base (increased FTc), as the left ventricle has less resistance to pump against.
Thank You