Temporal Resolution Mahta Allsop

Definition: Temporal resolution is the ability to detect or resolve changes in time. If on and off pulses in a pulsed wave are not fast enough, the ability to detect quickly changing events or structures might be restricted (as in heart.)

Temporal resolution is limited by the frame rate and frequency:

To understand the temporal resolution and how it affects frame rate, we need to start with C or propagation speed, we know that speed of sound in soft tissue is 154000cm/s roundtrip. This speed is 77000 or 154000/2 cm/s one way. This is the maximum effective velocity and it is assumed to be a constant.

We know that Max FR=$\frac{77000}{Depth*LPF}$ Where LPF is lines per frame. Therefore: 77000=Depth*LPF*FR

This is simplified for now because we haven't added number of focal points and color packets for Doppler.

We can see that if depth remains constant when Lines per frame increases the frame rate will have to decrease, also, when number of lines per frame remains constant, and depth increases the frame rate will have to decrease.

The actual scanning and non scanning modalities that change frame rate are included in this more detailed temporal resolution equation:

(Depth)*(Lines per frame)*(# of foci)*(color packets)*(Frame Rate)≤ 77000

So if #of foci increases the Frame rate will have to decrease to keep the equation below 77000 also if we add color Doppler flow (scanning modality) or PW Doppler (non scanning modality) the Frame rate will decrease because the number of packets increases with both of those. Increasing field of view or width also works like adding depth and will decrease Frame Rate. Frame rate is also proportional to PRF. When PRF increases Frame Rate will increase because we know: Frame time= TPL* LPF where TPL is time per line or one pulse. When PRF increases Times per line will decrease (becomes faster) We know that FR=$\frac{1}{Frame\ time}$ so decreased frame time will result in increased Frame rate.

Here is a proportionality of Frame rate to scanning and non scanning modalities as seen in the lab:

FR inversely proportional to depth

FR directly proportional to PRF

FR inversely proportional to Field of view and number of focal points

FR inversely proportional to Color flow and pulse requiring technologies (m-mode and PW)

For the last relationship we need to add that since PRF is related to the time to transmit a single line and frame rate is related to the time to transmit an entire scan or frame, the temporal resolution is markedly decreased for scanned modalities as compared to non scanned modalities. This temporal resolution for color Doppler is even worst because color is multiple lines per one location of scanning for acquiring velocity coupled with a whole frame for scanning a 2D image so the frame rate is further reduced by color.