Imaging settings and protocols for contrast echocardiography

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Mechanical Index

Power Doppler Imaging

High-power contrast imaging

Low-power contrast imaging

Left ventricular opacification

Microvascular flow assessment

Stress contrast echocardiography
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The acoustic power generated by ultrasound beam in an acoustic field is measured as mechanical index (MI)

MI reflects the transmit power of the transducer, that is the normalized energy to which a target (such as a bubble) is exposed in an ultrasound field

Mechanical Index (MI) = peak ultrasound pressure / ultrasound frequency
Mechanical Index

- Normal linear response
- Fundamental frequency
- Harmonic response
- High frequency harmonic echoes (trigger mode)
- Intermittent imaging
- Microbubbles destruction

Galiuto et al, EAE Textbook of Echocardiography, 2011
Mechanical Index

- High
  - Harmonic power Doppler
  - Intermittent

- Low
  - Pulse Inversion
  - Power Modulation
  - Coherent (Cadence) Imaging
  - Real time
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For several years, power Doppler modality, which has the characteristic of imaging the total energy (power) of moving particles as detected by Doppler system, has been the most sensitive method for detection of microbubbles.
Movement of the heart muscle causes additional echoes, which can impair the contrast recordings.

Furthermore, fragmentation of bubbles produces rapid dissolution of contrast agent volume, thus reducing the efficiency of contrast detection.

Different imaging modalities, recently developed, are able to distinguish microbubbles signal from tissue signal.
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MI greater than 1.0 produces bubbles fragmentation optimally visualized as Doppler signal.

Dual-pulse technique: the first pulse hits the microbubbles (destroys them) and any tissue targets; the second pulse will only generate a signal from tissue. The backscattered data from pulse 1 are subtracted from that derived from pulse 2, and the difference represents the contrast signal
Trigger or intermittent imaging

Ultrasounds with high MI, intermittently pulsed and synchronized with cardiac cycle, allow the creation of triggered imaging frames.

Although myocardial contractile function assessment is sacrificed, intermittent mode offers the best visualization of changes in microbubbles signal over time, with optimal signal-to-noise ratio.
High mechanical index: trigger or intermittent modality

3 chamber view
High mechanical index: trigger or intermittent modality

4 chamber view
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- Stress contrast echocardiography
Pulse Inversion or Cadence Imaging

Galiuto et al, EAE Textbook of Echocardiography, 2011
Real time imaging

Image acquisition is continuous along some cardiac cycles.

MI should be kept low and low-power contrast specific imaging modality should be preferred. Continuous real-time imaging is very effective for LV endocardial border enhancement and myocardial perfusion assessment, combined with real-time assessment of contractile function.
Low mechanical index: real time modality

4 chamber view
Low mechanical index:
real time modality

4 chamber view
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Achieved by administration of microbubbles throughout:

- Continuous infusion, with the advantage that uniform LVO can be achieved without any significant attenuation artefacts.

- Slow bolus injection followed by 15–20mL saline flash, in order to avoid significant attenuation artefacts.

Because the microbubbles are destroyed during high power ultrasound imaging, it is preferable to perform lower-power imaging.
Endocardial border detection
Endocardial border detection
Apical hypertrophic cardiomyopathy

Galiuto et al, EAE Textbook of Echocardiography, 2011
LV non-compaction

Galiuto et al, EAE Textbook of Echocardiography, 2011
Left ventricular thrombus
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Flash - replenishment

3 chamber view
Analysis of microbubble signal

Galiuto et al, EAE Textbook of Echocardiography, 2011
Replenishment curve

\[ y = A \left( 1 - \exp(-\beta t) \right) \]

A: video intensity at the plateau level (microbubbles concentration = blood volume)

\( \beta \): rate constant (blood flow velocity)

Wei K et al, Circulation 1998
Replenishment curve
Quantification of myocardial blood flow

\[ y = A \left(1 - \exp^{-\beta t}\right) \]

Galiuto et al, EAE Textbook of Echocardiography, 2011
A: myocardial blood volume

\( \beta \): myocardial blood velocity

\( A \times \beta = \text{myocardial blood flow} \)
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Stress contrast echo: protocols

Contrast
agitating ——
Infusion ——
or bolus injections

Dobutamine (μg/kg/min)
0 10 20 30 40

Atropine 0.3 mg*

recording:
LV wall motion
+ Perfusion

*Atropine (0.3 mg, maximum 1.2 mg) is given, if there is no adequate increase in heart rate

Galiuto et al, EAE Textbook of Echocardiography, 2011
Stress contrast echo: protocols

Vasodilator protocol

6 min

Adenosine 140 μg/kg/min

Rest Images → 3 min → Stress Images

4 min

Dipyridamole 56 mg/kg/min

Rest Images ← 2 min → Stress Images

Galiuto et al, EAE Textbook of Echocardiography, 2011
Stress contrast echo: dypiridamole
Stress contrast echo: dypiridamole
Stress contrast echo: dypiridamole

Rest

Stress
Thank you for attention

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