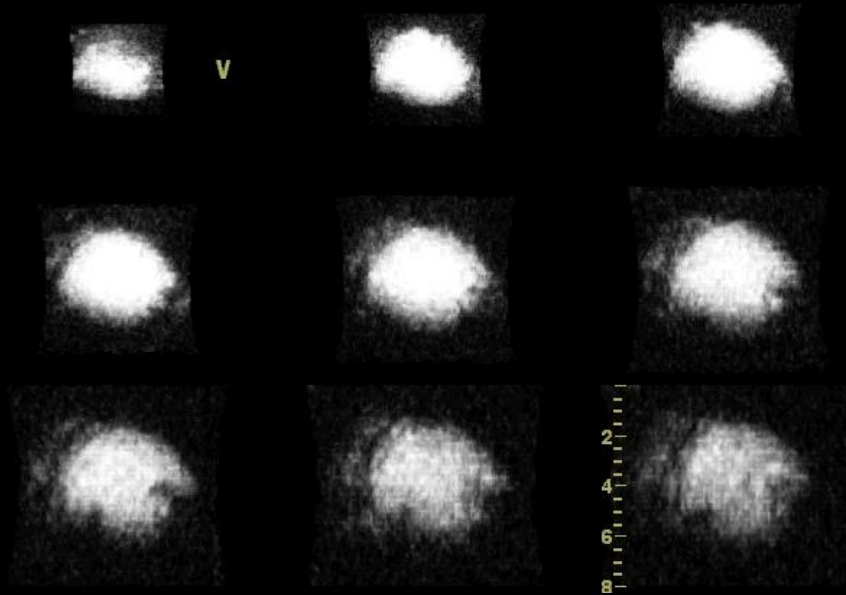


Kathleen Rosendahl Garcia, RDCS, RVT, RDMS

Wyle

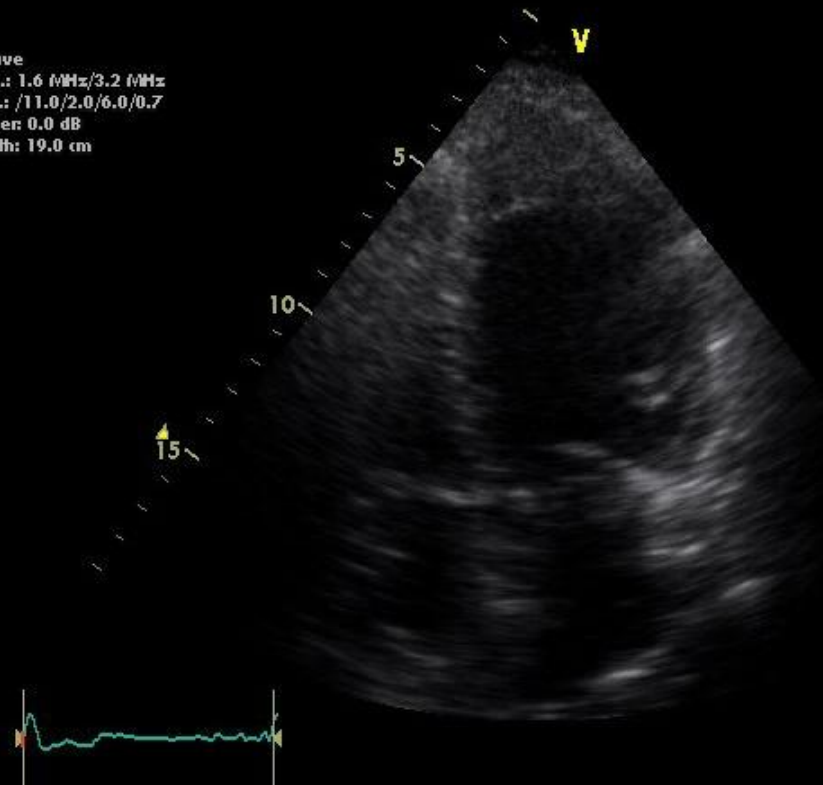
Houston, TEXAS



# CONTRAST

# What would you do?

Octave  
Freq.: 1.6 MHz/3.2 MHz  
Proc.: /11.0/2.0/6.0/0.7  
Power: 0.0 dB  
Depth: 19.0 cm



*Hint: this is a  
contrast talk...*

- a) Order a CCTA
- b) Recommend anticoagulants
- c) Administer contrast
- d) Cardiac trabeculations - Normal

# What would you do?

Octave  
Freq.: 1.6 MHz/3.2 MHz  
Proc.: /11.0/2.0/6.0/0.7  
Power: 0.0 dB  
Depth: 19.0 cm



- a) Order a CCTA
- b) Recommend anticoagulants
- c) Administer contrast**
- d) Cardiac trabeculations - Normal

# Learning Objectives

Evolution of Contrast

List General Properties

Describe Interaction

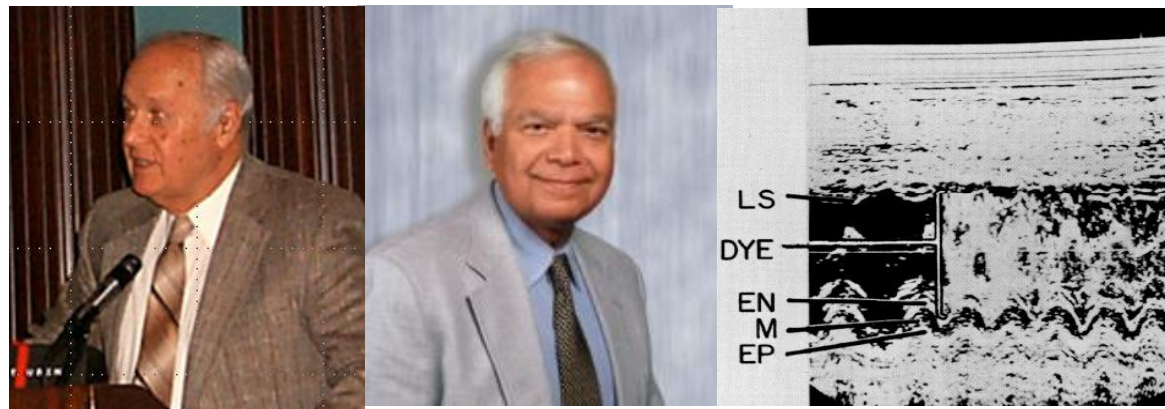
Instrumentation

Artifacts

# Ultrasound Contrast Discovery

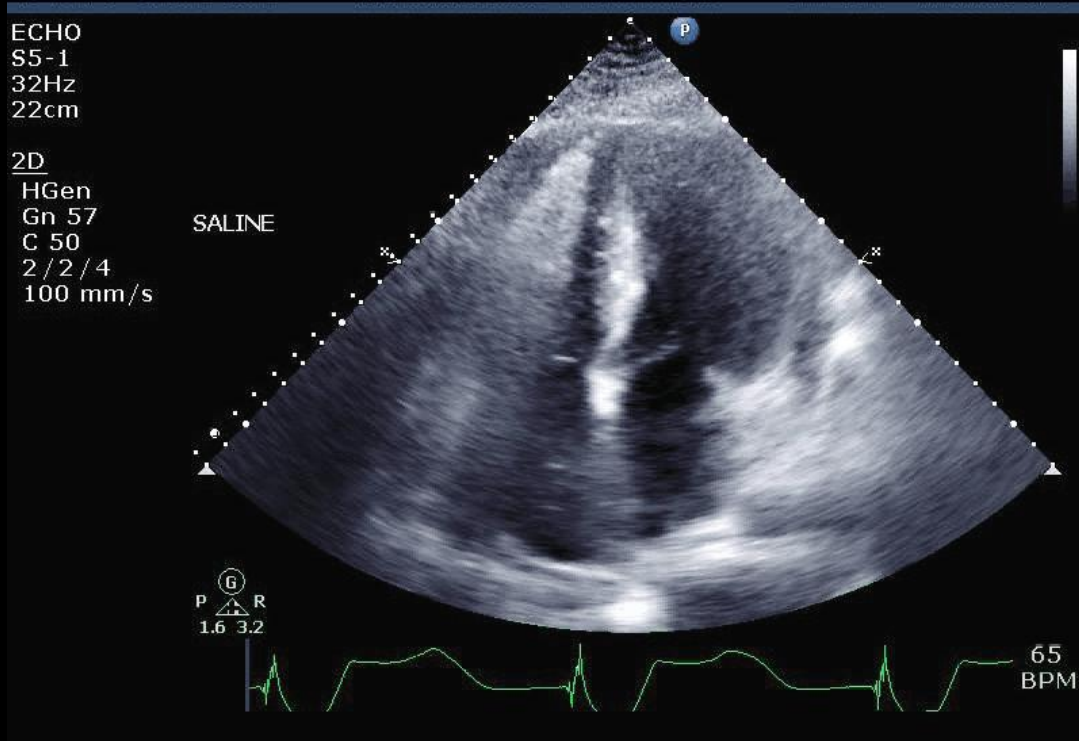
## Agitated Saline

- Observed in 1968, after intra-aortic injection of saline
- Short-lived air bubbles formed by agitation
- Suitable only for right heart opacification, detection of tricuspid regurgitation and intracardiac shunts
- Unable to traverse pulmonary circulation



# ICU patient 2 days post IHSS –

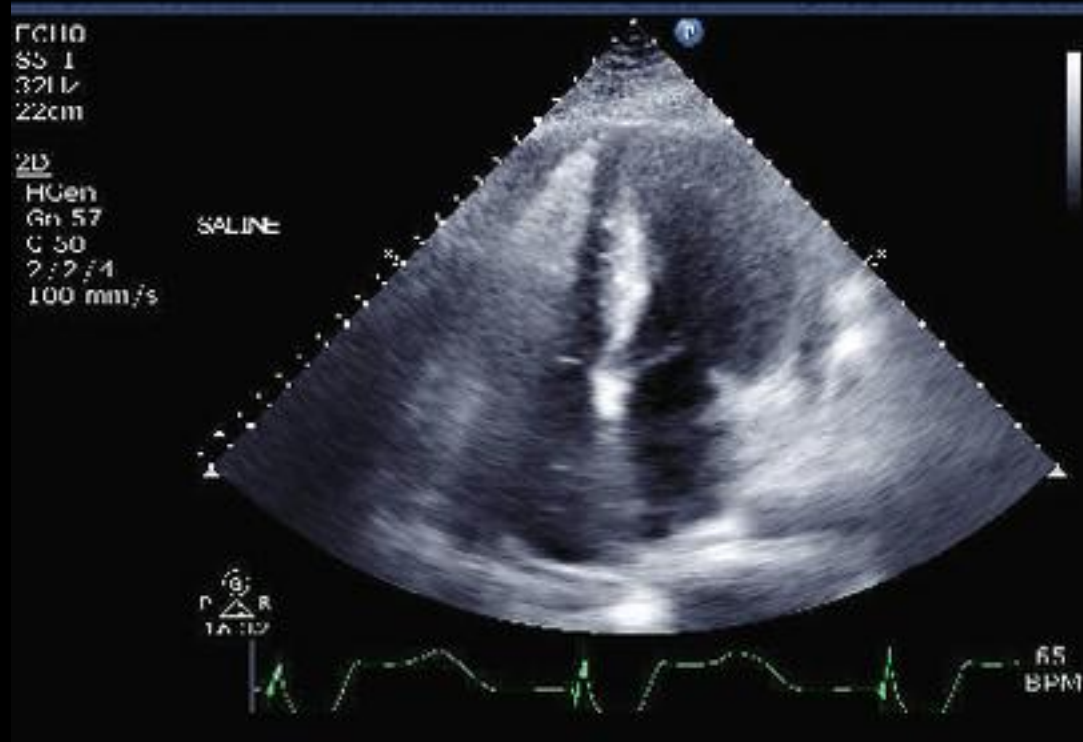
## What is noted post saline injection?



- a. Normal study
- b. ASD
- c. PFO
- d. VSD

ICU patient 2 days post IHSS –

What is noted post saline injection?



- a. Normal study
- b. ASD
- c. PFO
- d. **VSD**



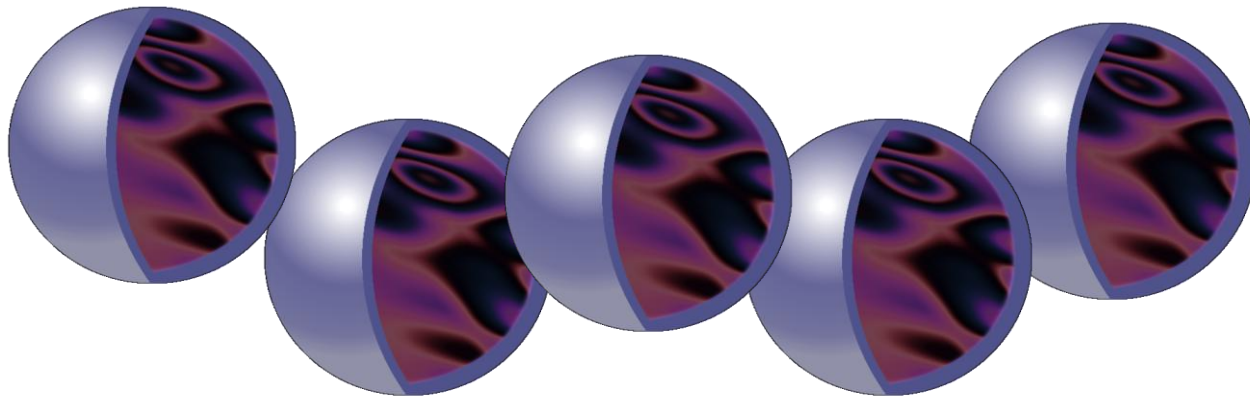
# Stable Microbubbles

- Introduced in 1994 Albunex 1<sup>st</sup> generation air based, low Molecular weight
- 2<sup>nd</sup> generation high molecular weight contrast agent, Optison began clinical trials in 1995
- Because of contrast equipment changed forever..... 1996, Harmonics are added to 40 ultrasound systems specifically for contrast....1997, Harmonic imaging on ALL ultrasound systems



# Stable Microbubbles

- Optison<sup>®</sup> introduced in clinically 1998 2<sup>nd</sup> generation high molecular weight contrast agent
- Definity<sup>®</sup> introduced in 2001 another second 2<sup>nd</sup> generation high molecular weight contrast agent
- Lumason<sup>®</sup> a third 2<sup>nd</sup> generation high molecular weight contrast agent introduced in 2014



# Stable Microbubble

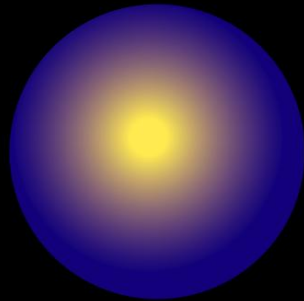
- Contrast agents showed an increase in stability, longevity and signal intensity
- Second generation contrast agents showed an increase in stability, longevity and signal intensity
- All 2<sup>nd</sup> generation contrast agents consist of a shell made from a proprietary high molecular weight gas blend.

# Ideal Contrast Agent

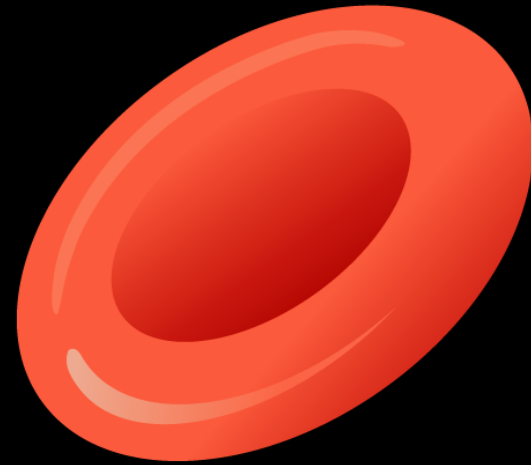
- Nontoxic / easily eliminated breathing/ metabolized
- Administered intravenously
- Easy passage through microcirculation
- Physically stable
- Acoustically responsive
  - Stable harmonics
  - Capable of rapid disruption

# Contemporary Contrast Agents

- **Size**
- **Shell**
- **Gas**



Microbubble  
2–8  $\mu\text{m}$



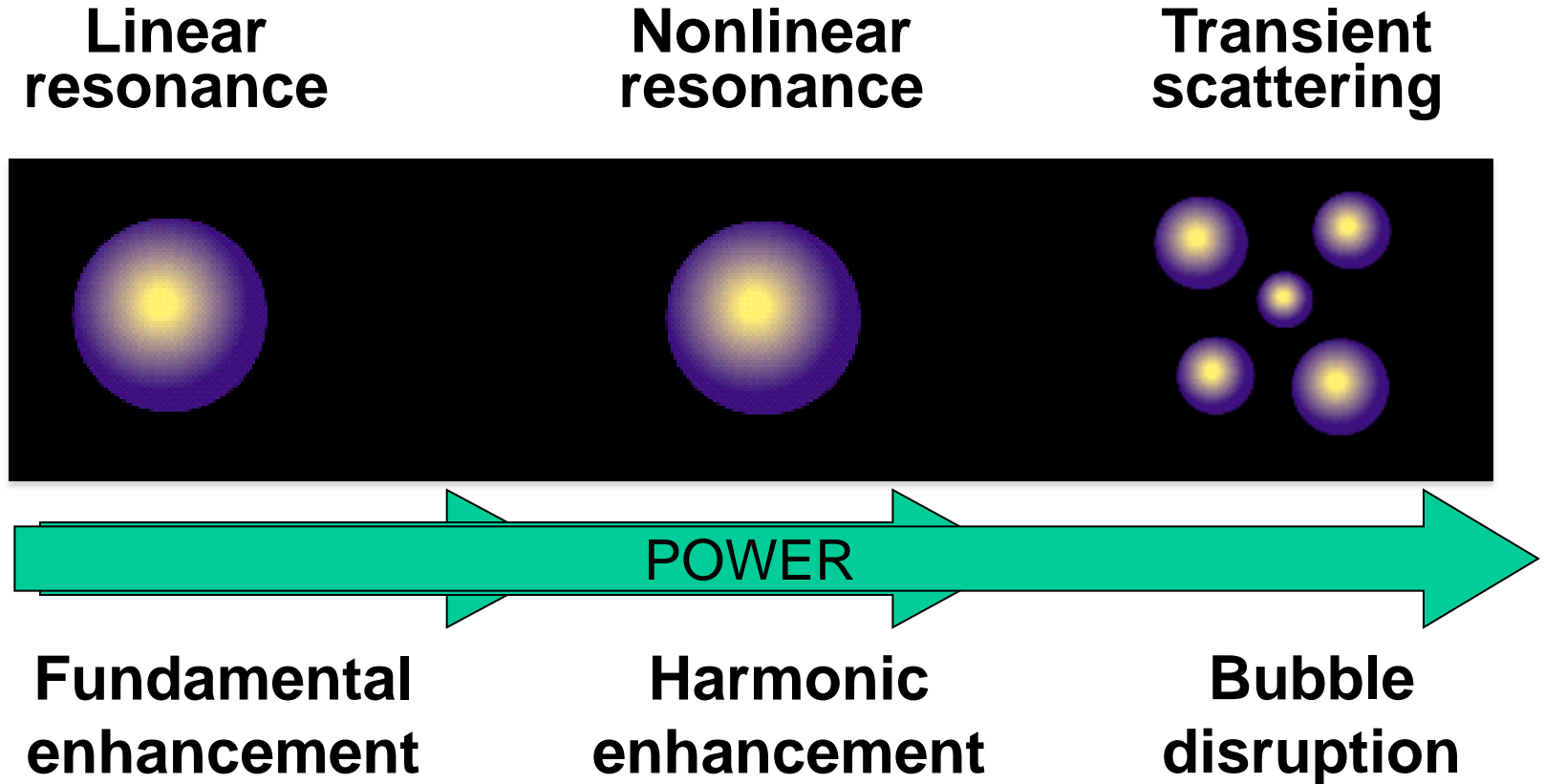
RBC  
6–8  $\mu\text{m}$

Stabilized gas microbubbles  
sized to pass through the  
smallest capillaries



# Interaction of Ultrasound

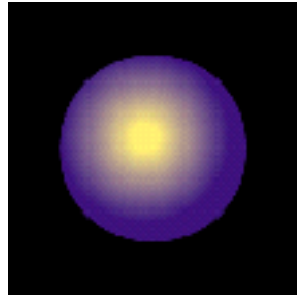
## with Contrast



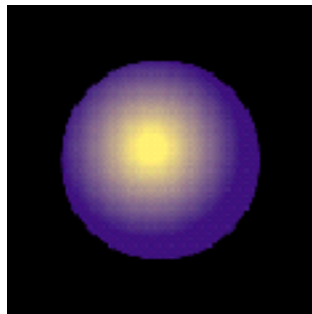
# Resonance and Harmonics

## Resonance

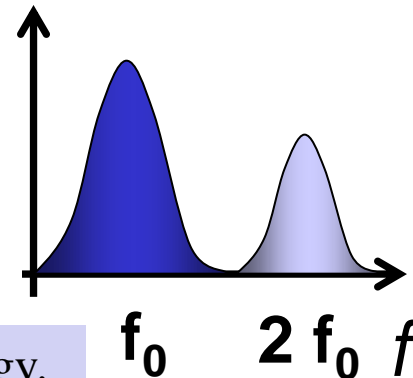
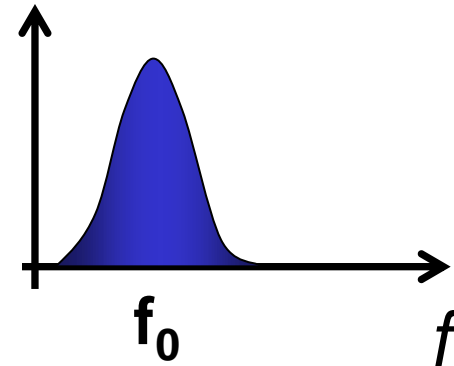
Linear



Non-linear

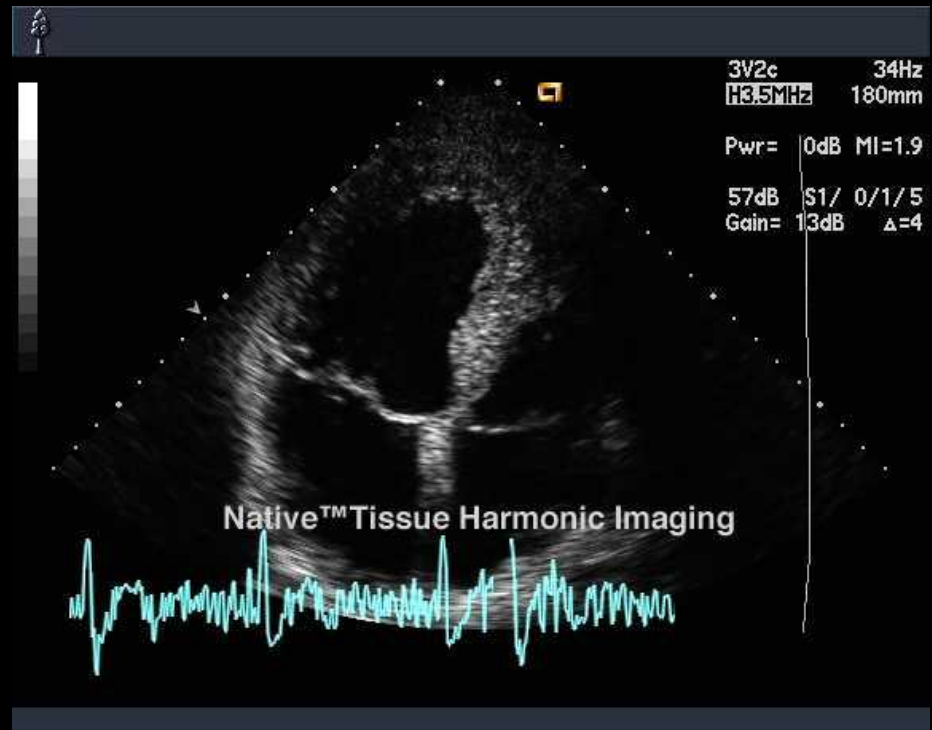
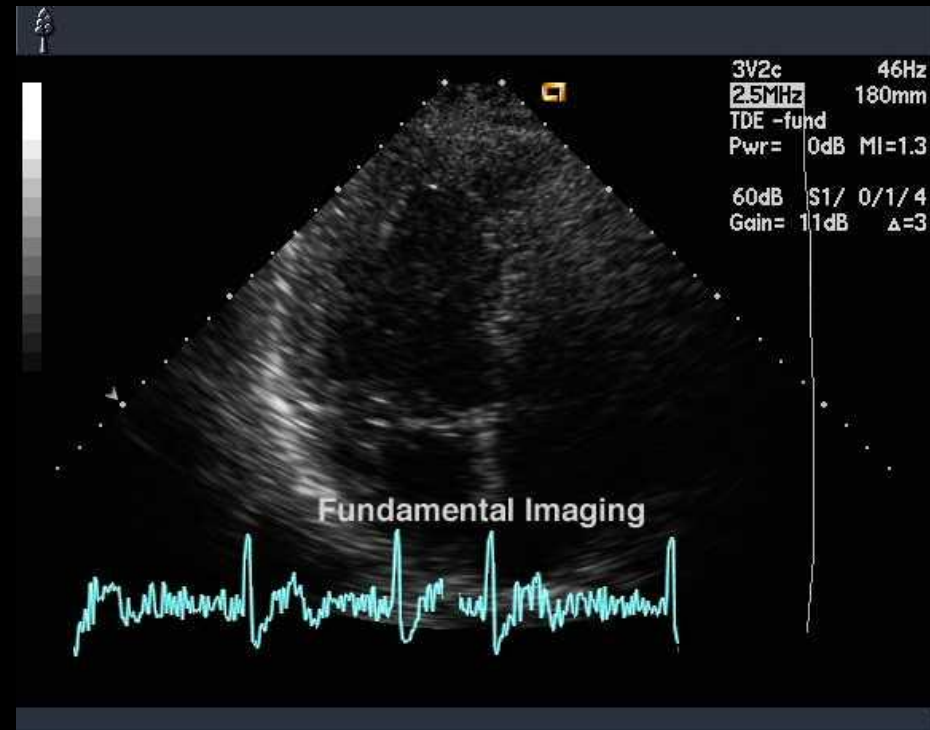
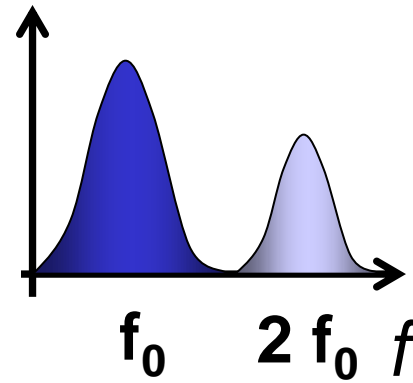
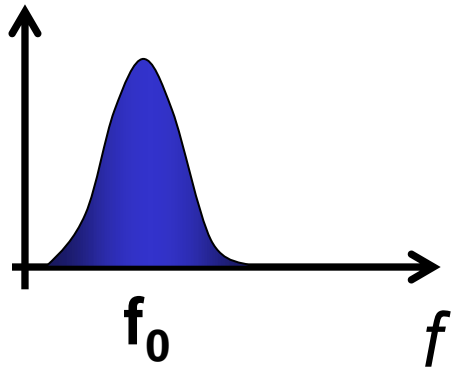


## Reflected spectrum



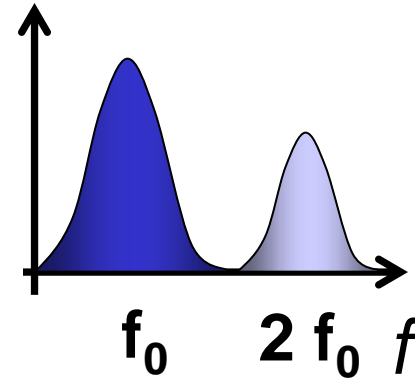
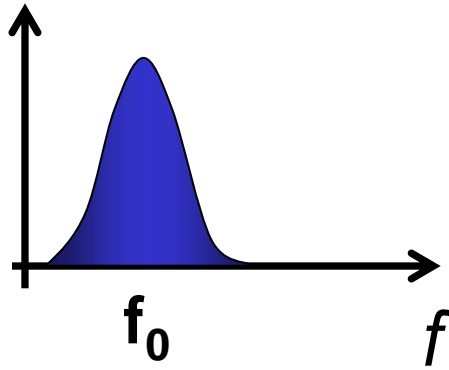
Contrast microbubbles are active generators of sound energy.

# Fundamental vs Tissue Harmonic



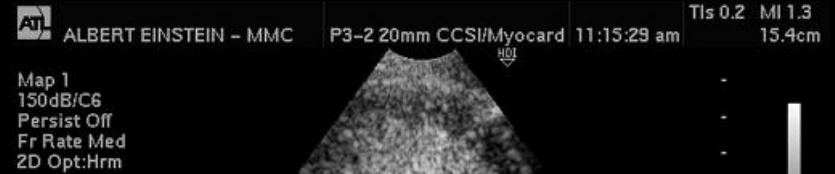


# Fundamental vs Harmonics



FUNDAMENTAL IMAGING

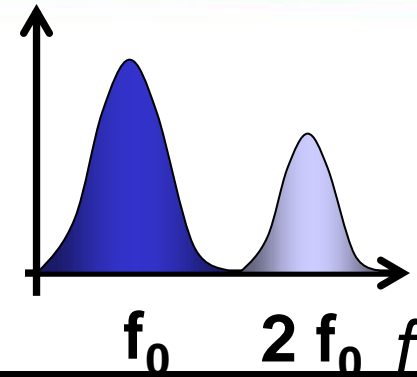
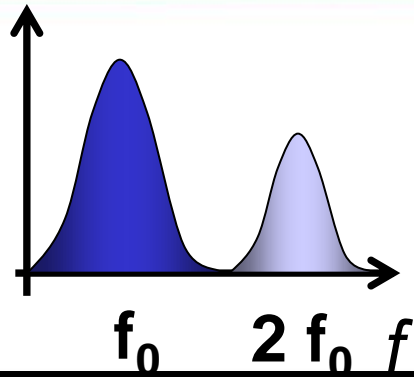
67  
BPM



CONTRAST HARMONIC IMAGING

40  
BPM

# Tissue vs Contrast Harmonics



Tissue harmonic mode



Contrast harmonic mode

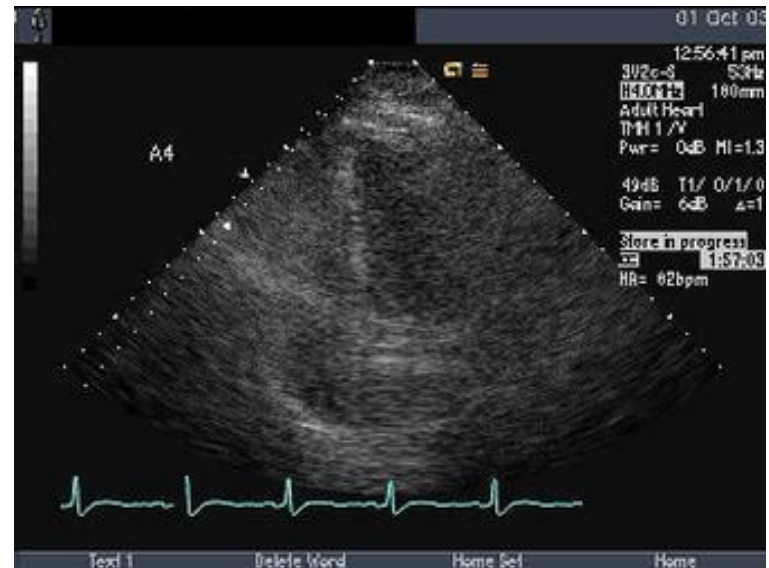
# Clinical Echocardiography

- Echocardiography is the most commonly used cardiac imaging modality
- Provides real time information
  - Cardiac anatomy
  - Cardiac physiology
- Common usage is LV Func.
  - Global function
  - Regional wall motion



# Limitations of Echocardiography

- Visualization of endocardium essential for assessment of LV function
- Operator dependent
- Endocardial dropout in 5%-15% of the studies
  - Obesity
  - Pulmonary disease
  - Chest deformity
- ICAEL
  - 30% of stress echo are non-diagnostic or reduced quality





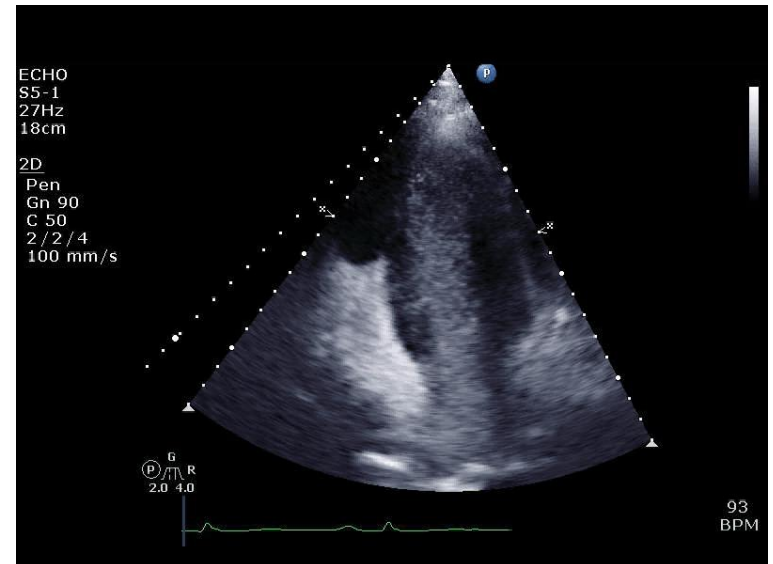
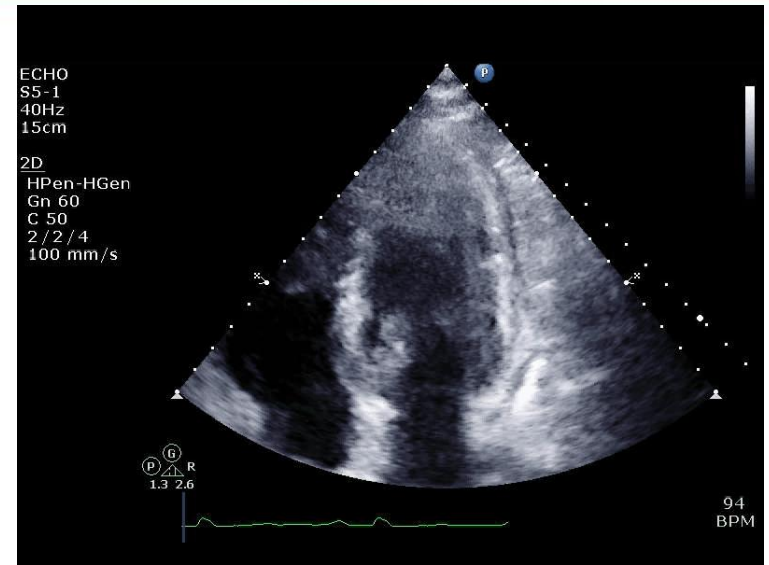
Difficult

Echo



# Limitations of Echocardiography

- Consequences of suboptimal images
  - Misdiagnosis
  - Low diagnostic confidence
  - Need for additional tests
  - Inter-observer variability
  - Increase in further downstream testing



Kurt et al. *JACC*. 2009;53:9.

Ikonomidis et al. *Coronary Artery Dis*. 1998;9:567.

Zotz et al. *J Am Soc Echocardiogr*. 1996;9:1.

**EXPEDITED PUBLICATION**

# **Impact of Contrast Echocardiography on Evaluation of Ventricular Function and Clinical Management in a Large Prospective Cohort**

Mustafa Kurt, MD, Kamran A. Shaikh, MD, Leif Peterson, PHD, Karla M. Kurrelmeyer, MD, FACC,  
Gopi Shah, MD, FACC, Sherif F. Nagueh, MD, FACC, Robert Fromm, MD,  
Miguel A. Quinones, MD, FACC, William A. Zoghbi, MD, FACC

*Houston, Texas*

*Houston, Texas*

Miguel A. Quinones, MD, FACC, William A. Zoghbi, MD, FACC

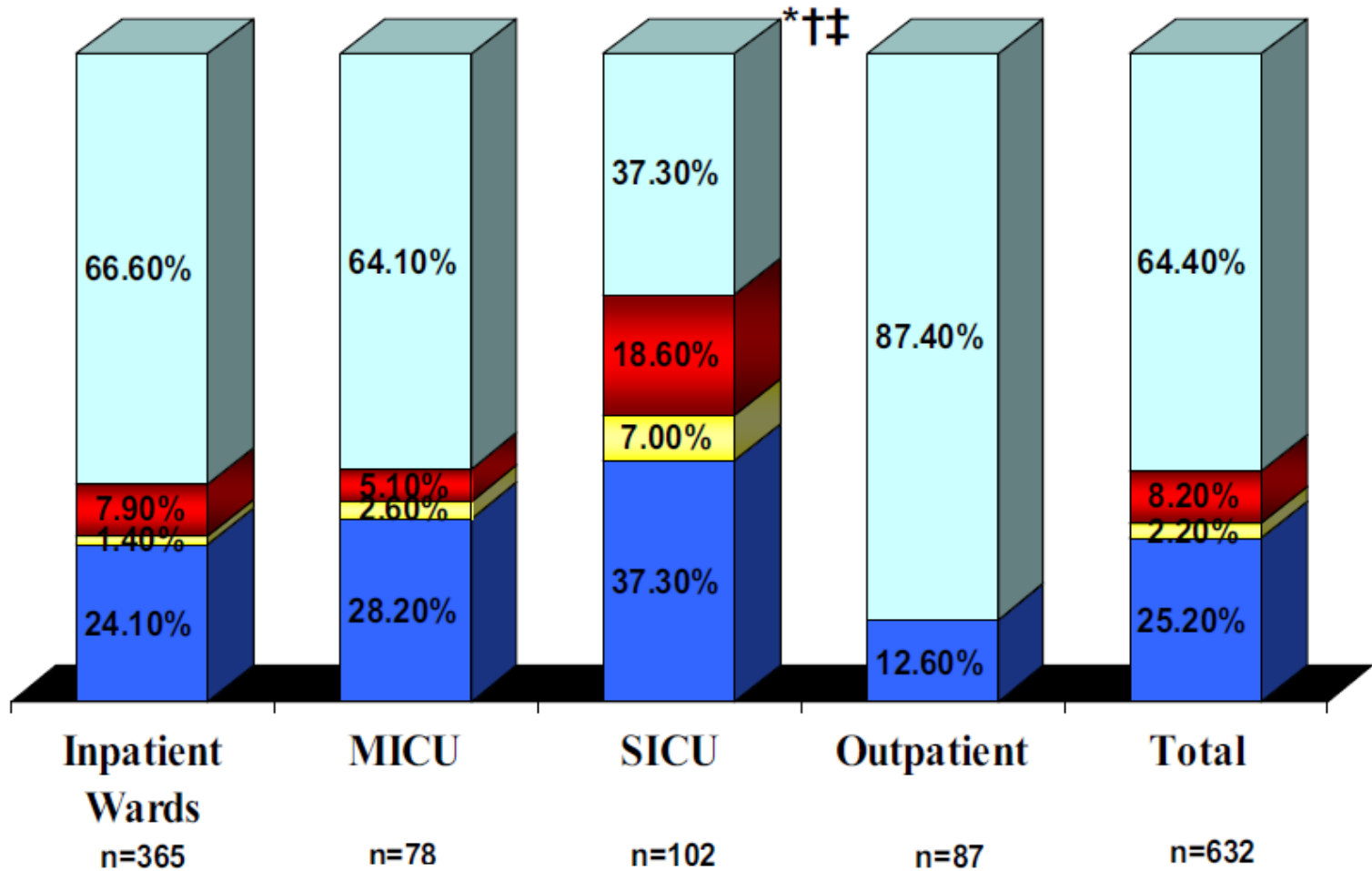
Gopi Shah, MD, FACC, Sherif F. Nagueh, MD, FACC, Robert Fromm, MD,

Mustafa Kurt, MD, Kamran A. Shaikh, MD, Leif Peterson, PHD, Karla M. Kurrelmeyer, MD, FACC



# Cost Benefit

- Procedure Avoided, only
- Medication Change, only
- Both Medication and Procedural Change
- Unchanged



## REST & STRESS Echo- Effective 12/1/2010

“Contrast is indicated for use when 2 continuous segments are not visualized as it provides greater accuracy in determining LV function”

- If contrast is used there must be a written policy for the use of contrast agents.
- If contrast is not able to be used there must be a policy for alternative imaging.
- Contrast should be used in the presence of poor endocardial border definition for quantification of chamber dimensions, volumes, ejection fractions and assessment of regional wall motion.
- Poor endocardial border definition is defined as the inability to detect 2 or more continuous segments in any 3 apical views.
- Contrast should also be used to assess conditions such as hypertrophic cardiomyopathy or when ventricular thrombus is suspected.

# Black Box Warning

*FDA Black Box Warning the risk of serious cardiopulmonary reactions during or within 30 minutes following the administration of these products and recommend that high risk patients with pulmonary hypertension or unstable cardiopulmonary conditions be closely monitored during and for at least 30 minutes post administration of these contrast agents.*

# Contraindication ultrasound contrast

- Known Allergy to Any of the ingredients
- Any known Right to Left Shunt, Bidirectional Shunt, or Transient Right to Left Shunt.

# What would you do?

Octave  
Freq.: 1.6 MHz/3.2 MHz  
Proc.: /11.0/2.0/6.0/0.7  
Power: 0.0 dB  
Depth: 19.0 cm



61  
HR

- Order a CCTA
- Recommend anticoagulants
- Administer contrast
- Look at more images

# What would you do?

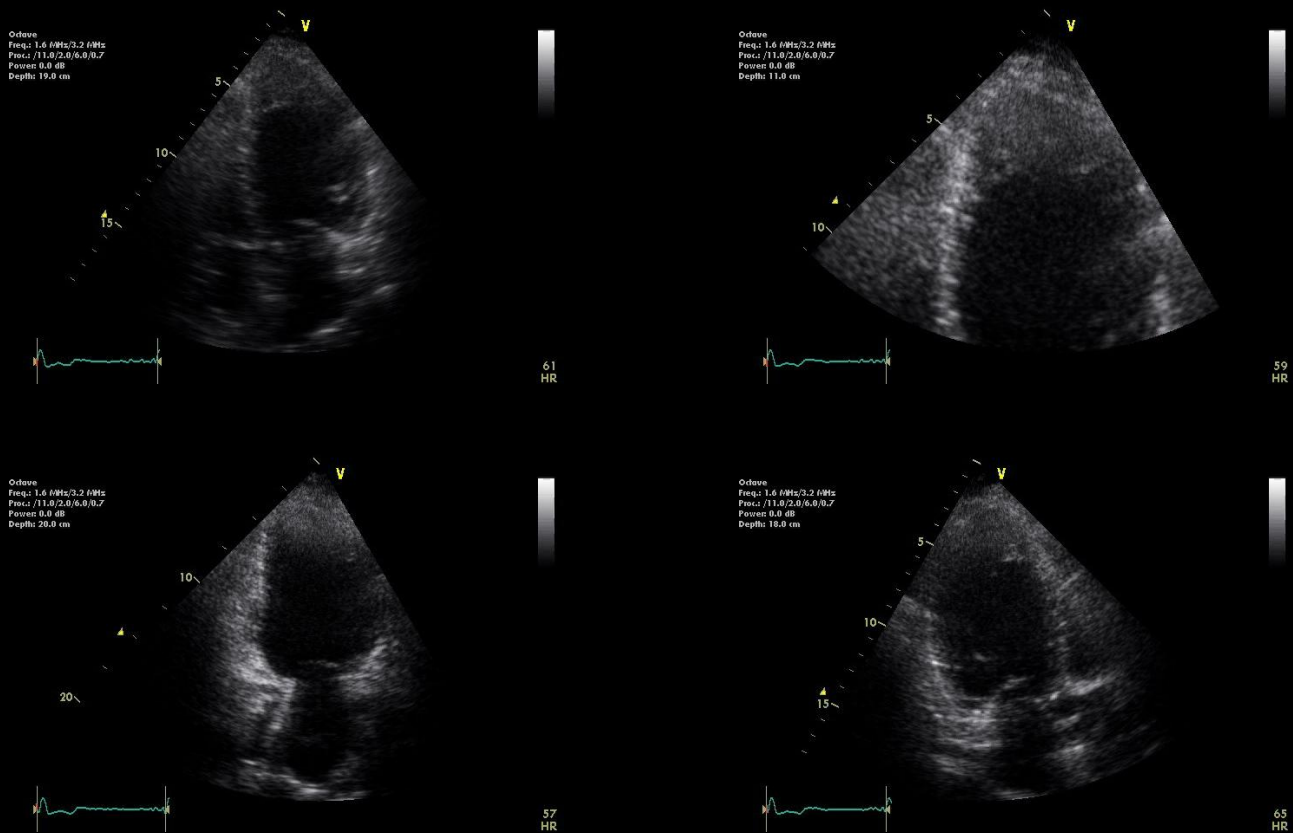
Octave  
Freq.: 1.6 MHz/3.2 MHz  
Proc.: /11.0/2.0/6.0/0.7  
Power: 0.0 dB  
Depth: 19.0 cm



- a) Order a CCTA
- b) Recommend anticoagulants
- c) Administer contrast
- d) **Look at more images**

# Cost Benefit

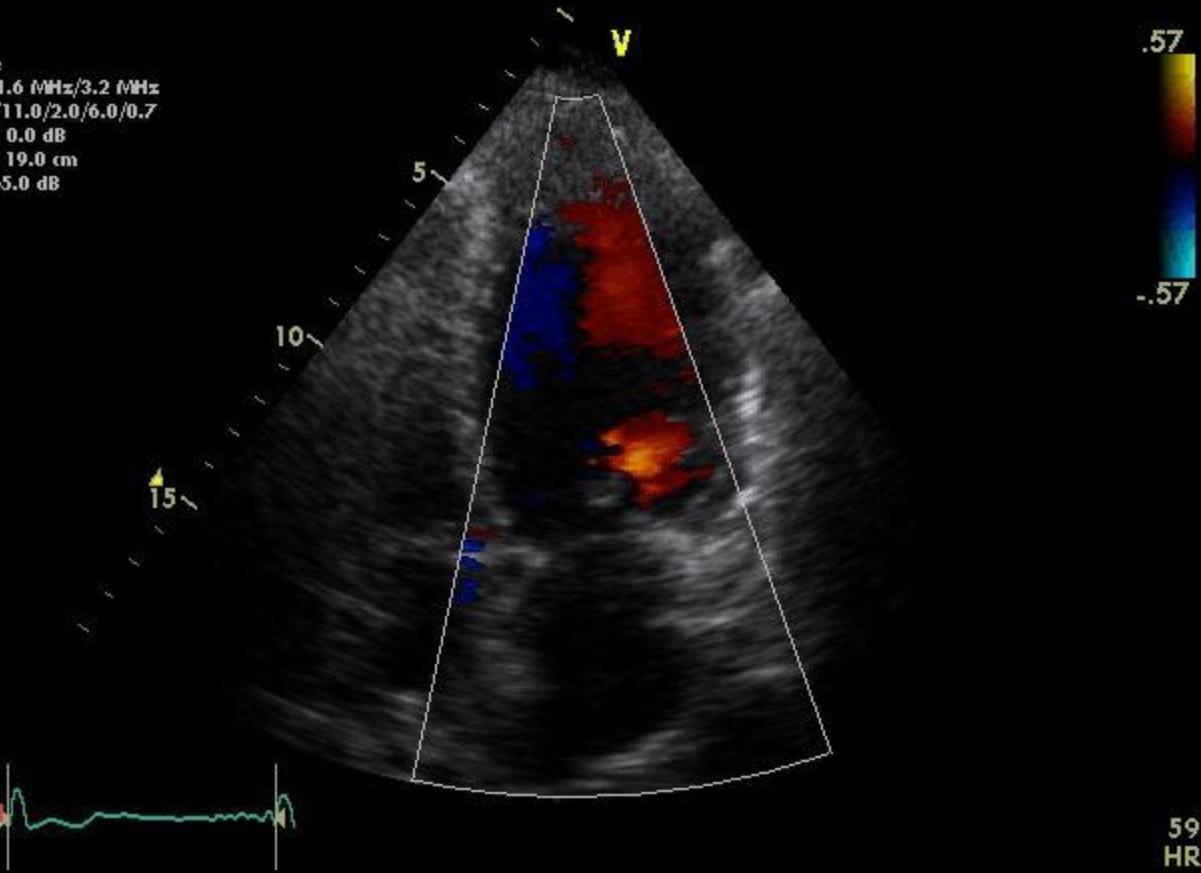
## QUESTIONABLE APEX





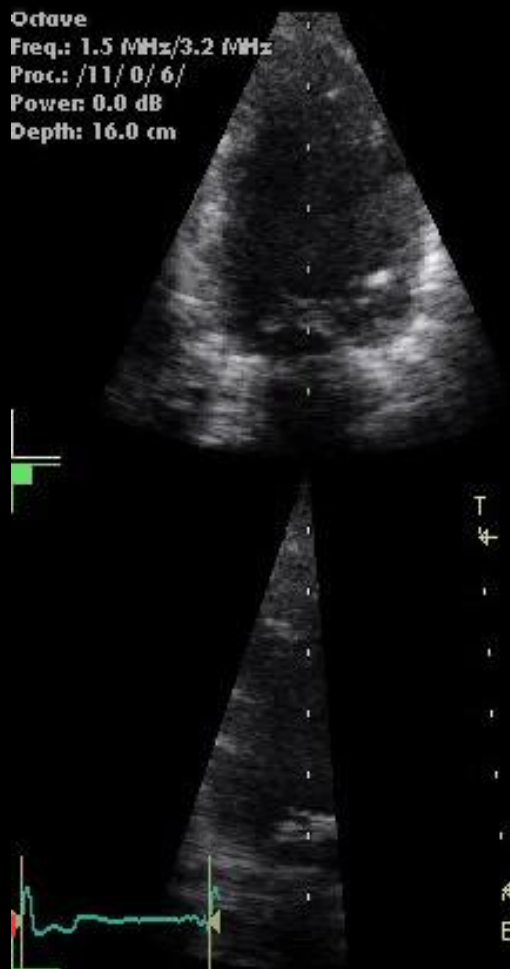
# Cost Benefit

Octave  
Freq.: 1.6 MHz/3.2 MHz  
Proc.: /11.0/2.0/6.0/0.7  
Power: 0.0 dB  
Depth: 19.0 cm  
Gain: -5.0 dB



# How would you interpret?

Octave  
Freq.: 1.5 MHz/3.2 MHz  
Proc.: /11/ 0/ 6/  
Power: 0.0 dB  
Depth: 16.0 cm

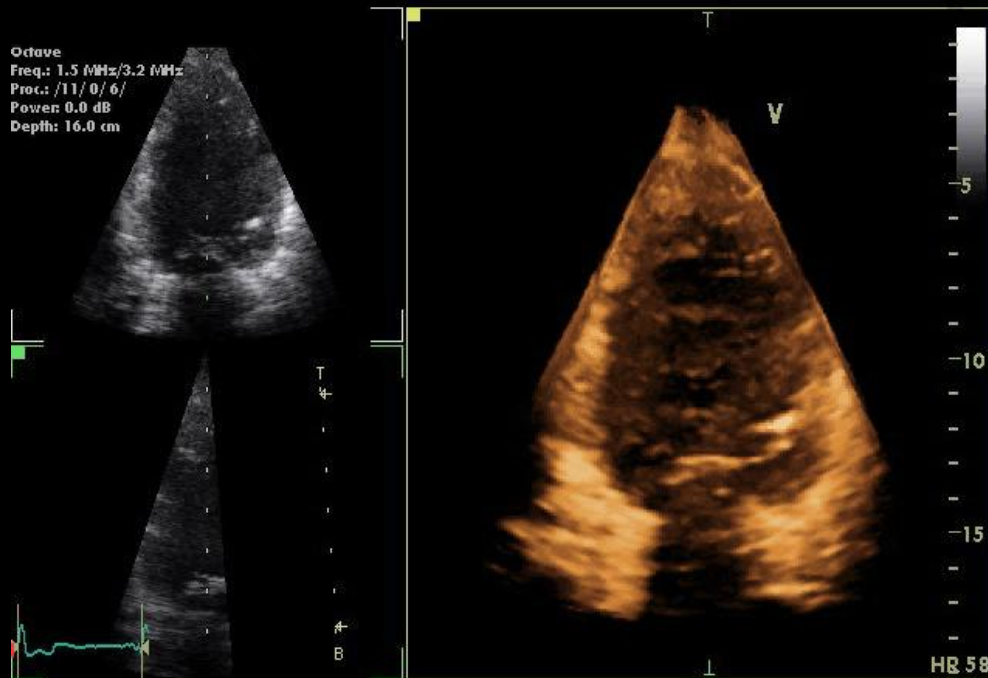


# How would you interpret?



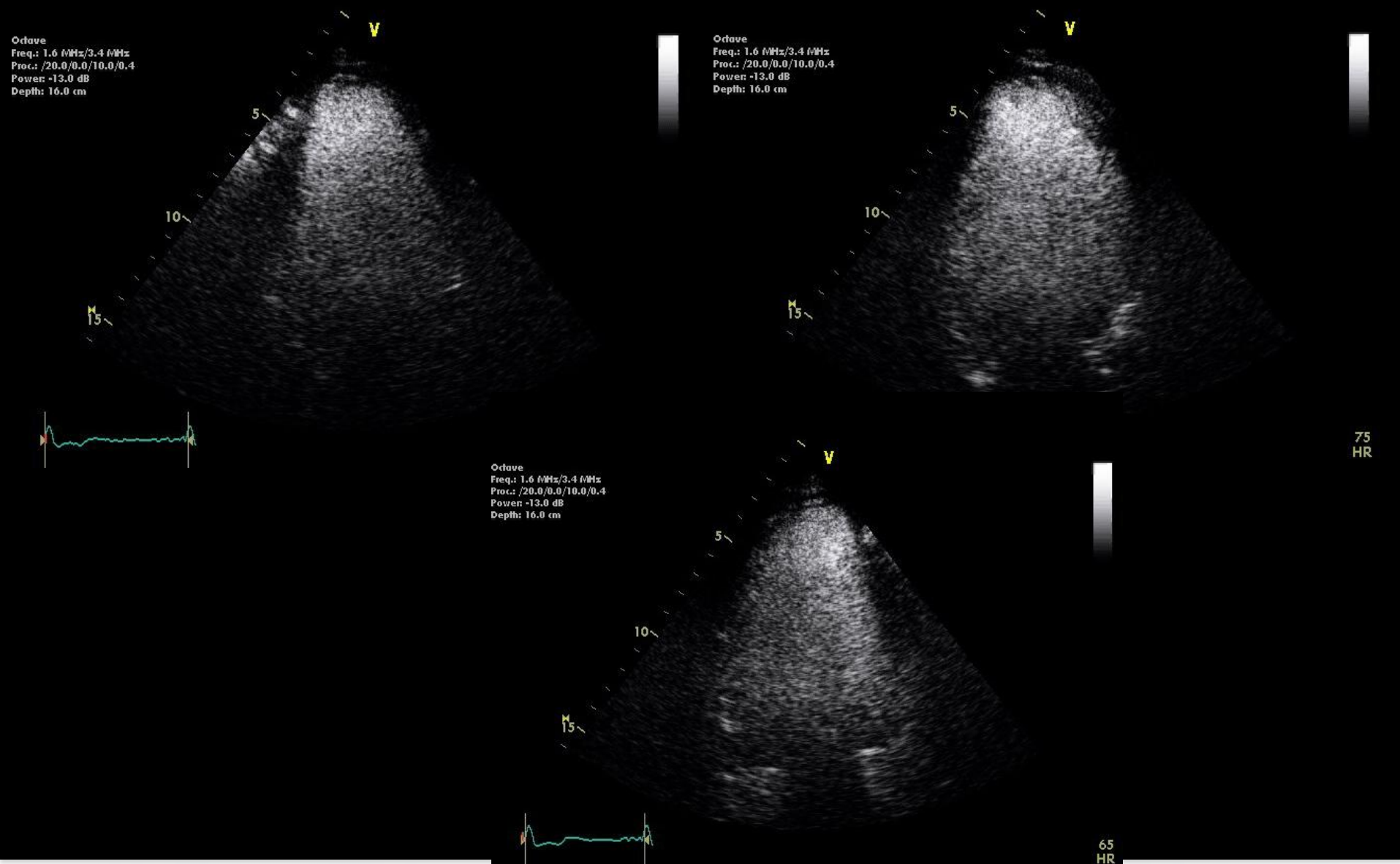
- a. Add contrast
- b. Thrombus
- c. Main bang artifact
- d. Normal Apex

# How would you interpret?



- a. **Add contrast**
- b. Thrombus
- c. Main bang artifact
- d. Normal Apex

# Cost Benefit



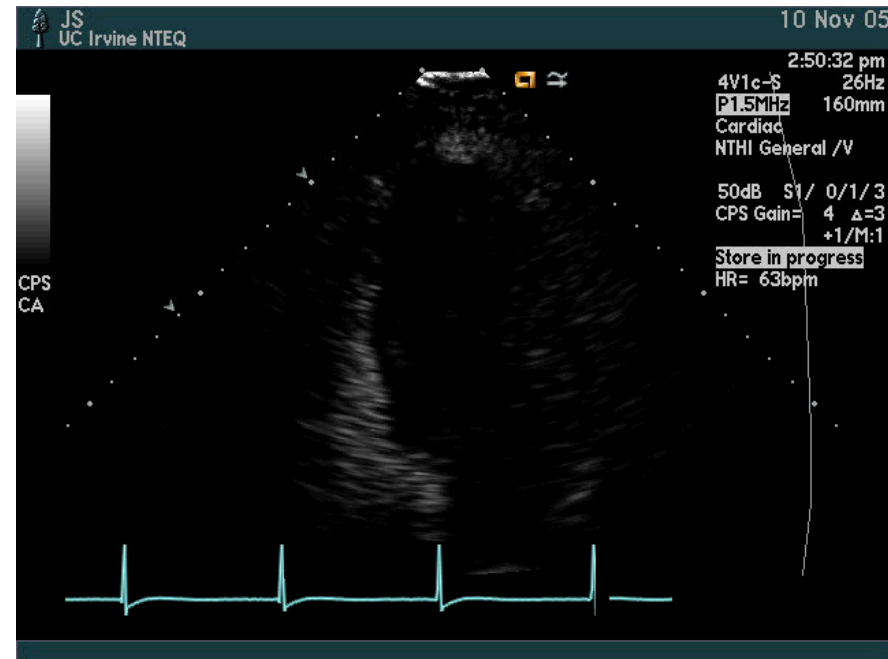
# Cost Benefit





# Contrast Echocardiography

- Reduce additional testing/medication changes
- Increased sensitivity
- Heightened diagnostic confidence
- Improved accuracy and reproducibility
- Enhanced clinical utility



Kurt et al. *JACC*. 2009

Main and Grayburn. *Am Heart J*. 1999;137:144.



# Additional Uses of Ultrasound Contrast

- Detection of intracardiac masses (eg, thrombi, tumors)
- Doppler enhancement
  - Pulmonary vein flow
  - Aortic stenosis
  - Valvular disease



# Controls to be Adjusted

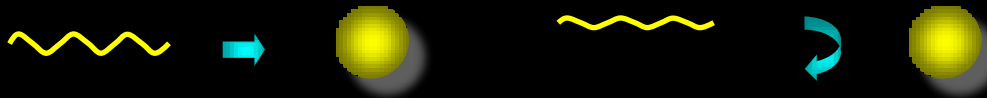
- Mechanical index (MI) - acoustic power output
  - Low MI decrease bubble destruction
  - High MI increases bubble destruction
    - Causes apical swirling
    - Decrease MI to eliminate swirling &/or re-inject
- Focus
  - Placement at level of Mitral Valve
    - minimize bubble disruption
    - reduce swirling at apex
- Gain - amplifies intensity of received echoes
- Dynamic Range - adjusts shades of gray

# Acoustic Power

The higher the MI the more bubble destruction



The lower the MI the less bubble resonance



Balance between acoustic resonance and bubble destruction



# Optimizing System Settings

<b>Control</b>	<b>Feature</b>	<b>Setting</b>	<b>Benefit</b>
<b>Transmit Power (MI)</b>	Regulates intensity of ultrasound sent into the body	Range of MI display of .2 to .8	Prolongs visualization by reducing bubble destruction
<b>Focus</b>	Narrows the beam at the focus increases intensity in the focus	Mid to far field	Decreases swirling effect at apex
<b>Dynamic Range or Compression</b>	Displays range of “shades of gray” on 2D image	Wide or High	Boosts visibility of softer echoes from contrast
<b>Receiver or Overall Gain</b>	Boosts amplification of received echoes	High	Compensates for lower transmit power (has no effect on bubbles)

# CONTRAST ARTIFACTS

- Attenuation
- Swirling
- Rib artifact
- Respiratory interference
- No contrast (Whaaaat?)

HE**ART**IFACT



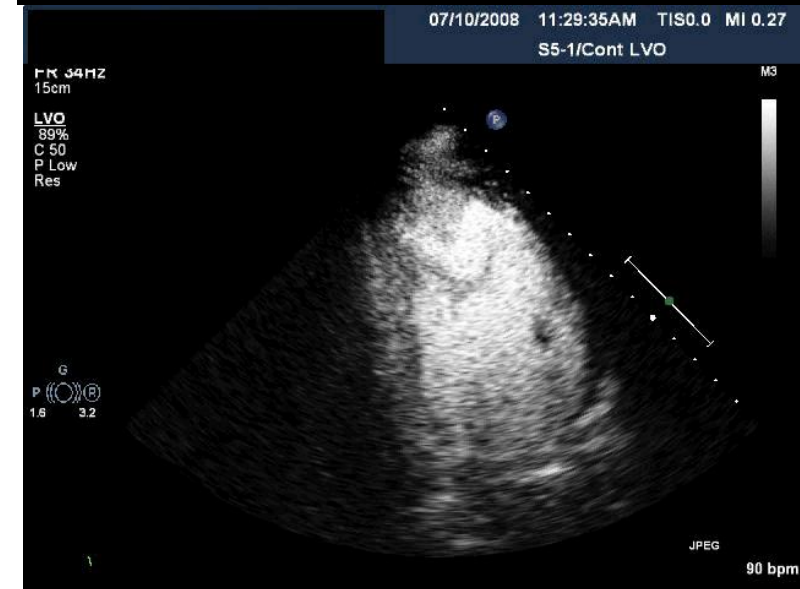
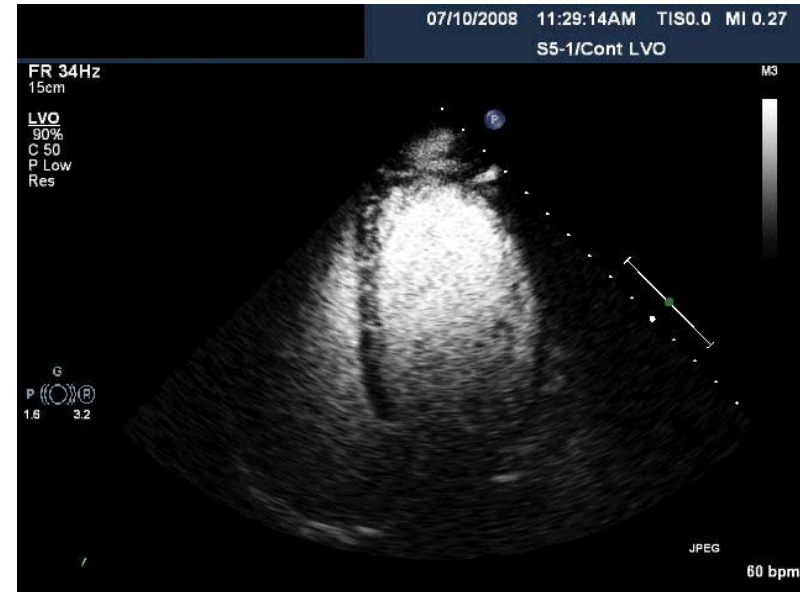
# ATTENUATION

## CAUSES

- Contrast dose too high
- Flush too fast
- Infusion rate too high

## CORRECTION

- Adjust MI
- Decrease dose
- Decrease the injection or infusion rate



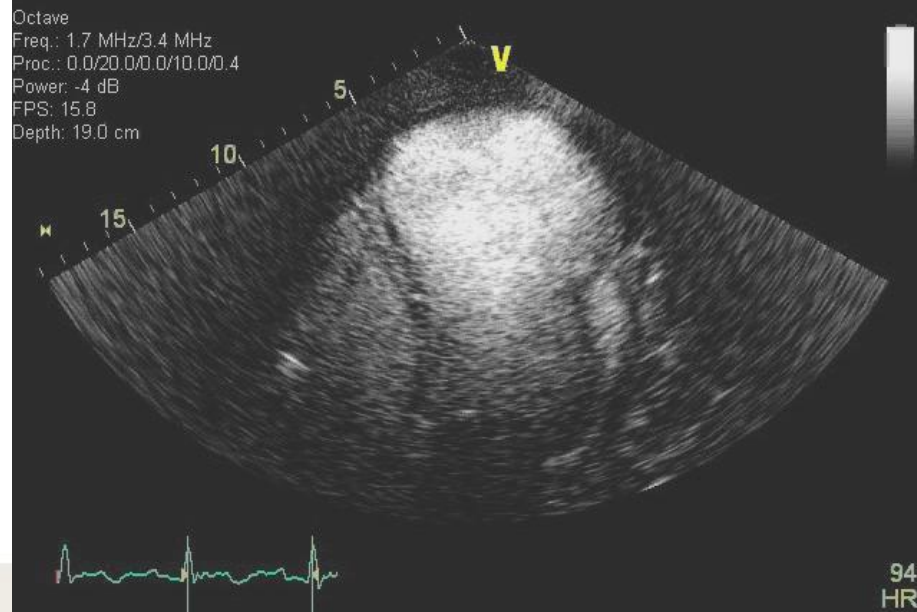
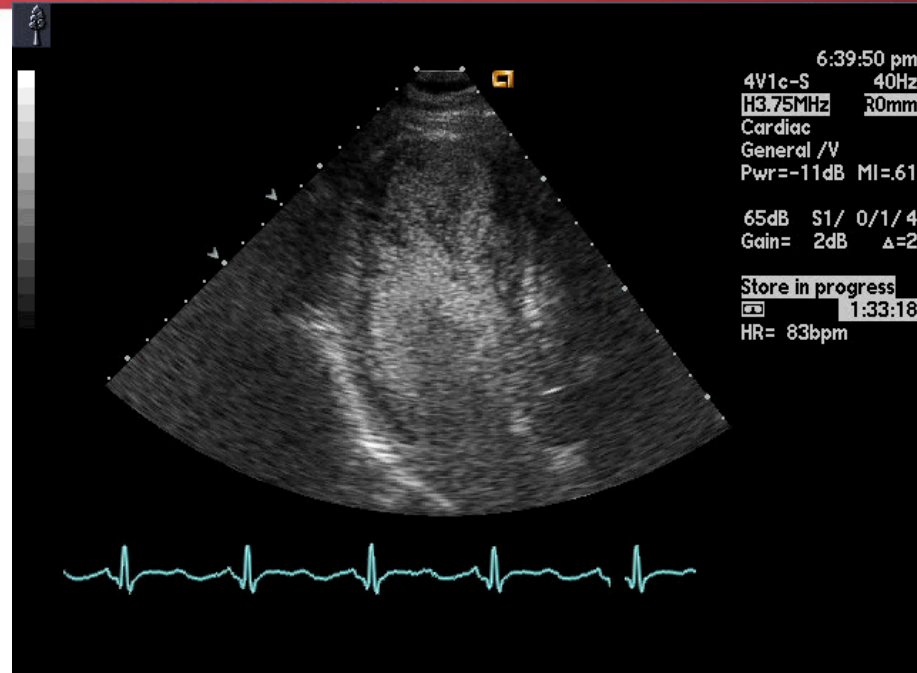
# SWIRLING

## CAUSES

- MI too high
- Incorrect focal placement
- Inadequate dosing
- Decreased LV function

## CORRECTION

- Increase dose &/or flush rate
- Decrease MI
- Reposition the focus





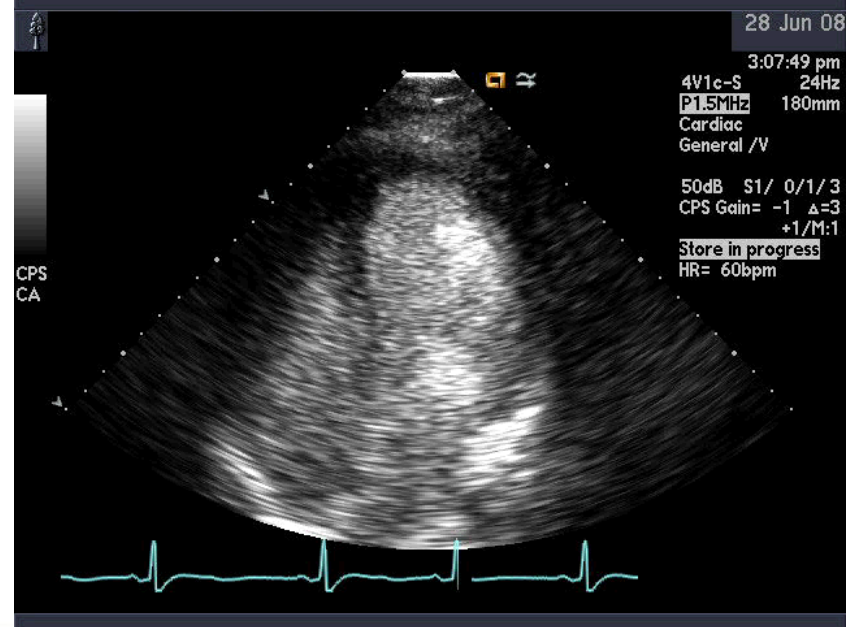
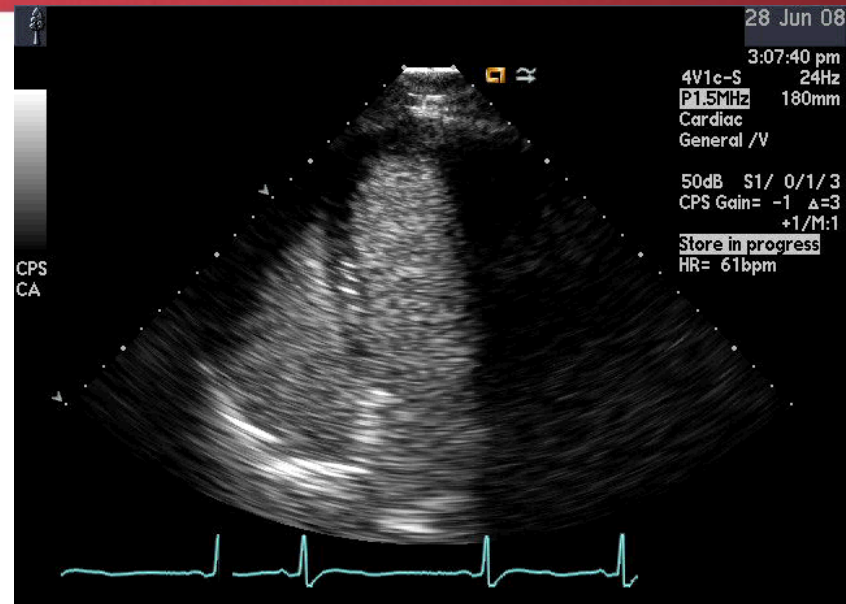
# RIB ARTIFACT

## CAUSES

- Limited acoustic window
- Small intercostal spaces

## CORRECTION

- Reposition patient
- Obtain off axis views



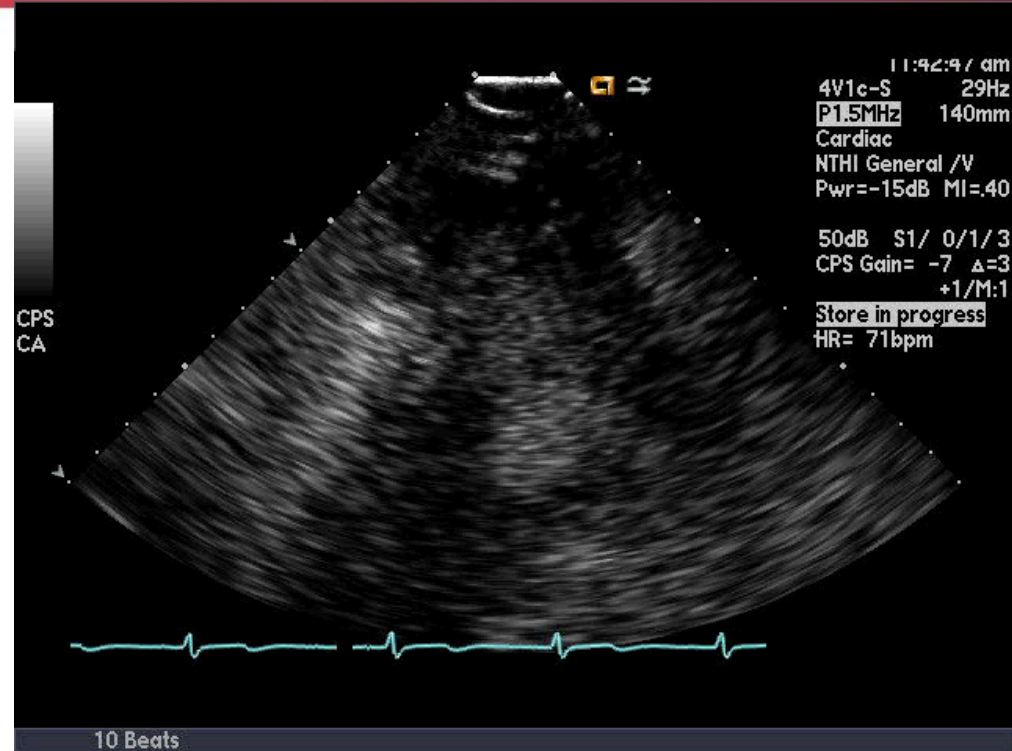
# RESPIRATORY INTERFERENCE

## CAUSES

- Patient breathing
- Lung placement

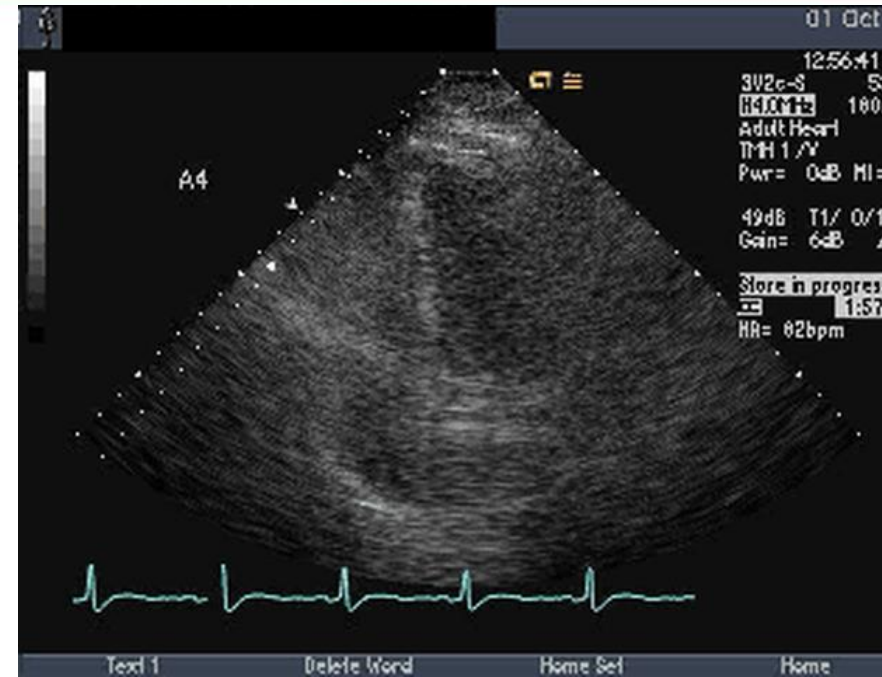
## CORRECTION

- Reposition patient
- Observe pt respiratory cycle
- Explain to pt about holding breath when told



# No Contrast Effect

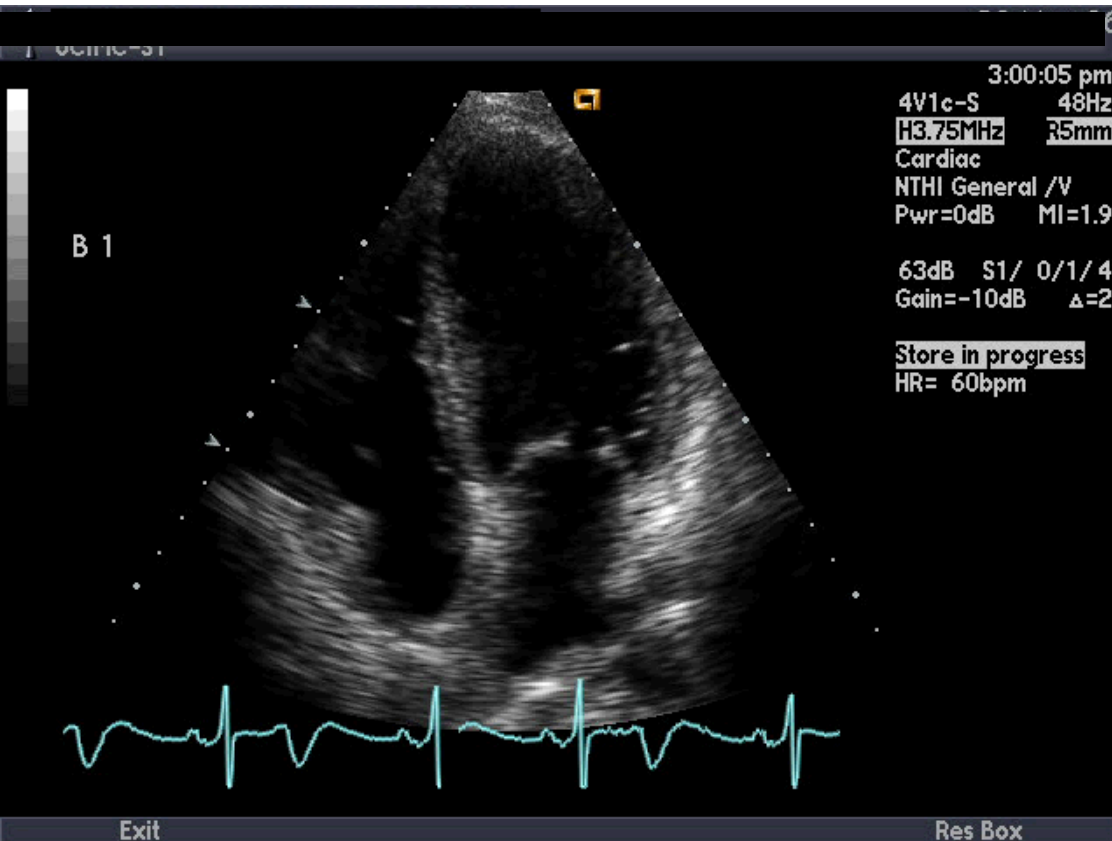
- Slow heart rate
- Possible infiltration
- Deflate BP cuff
- Straighten patient's arm
- Stopcock position
- Insure that contrast was activated



D'OH!

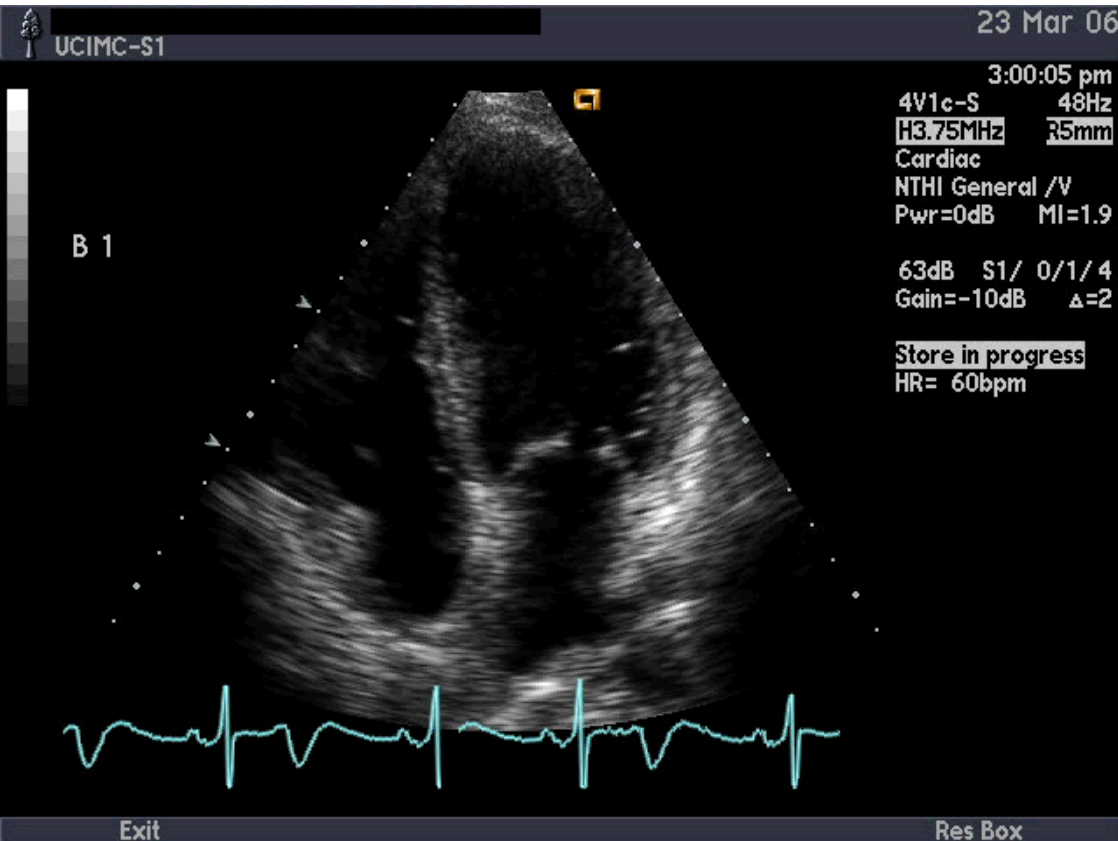


# Name this contrast...



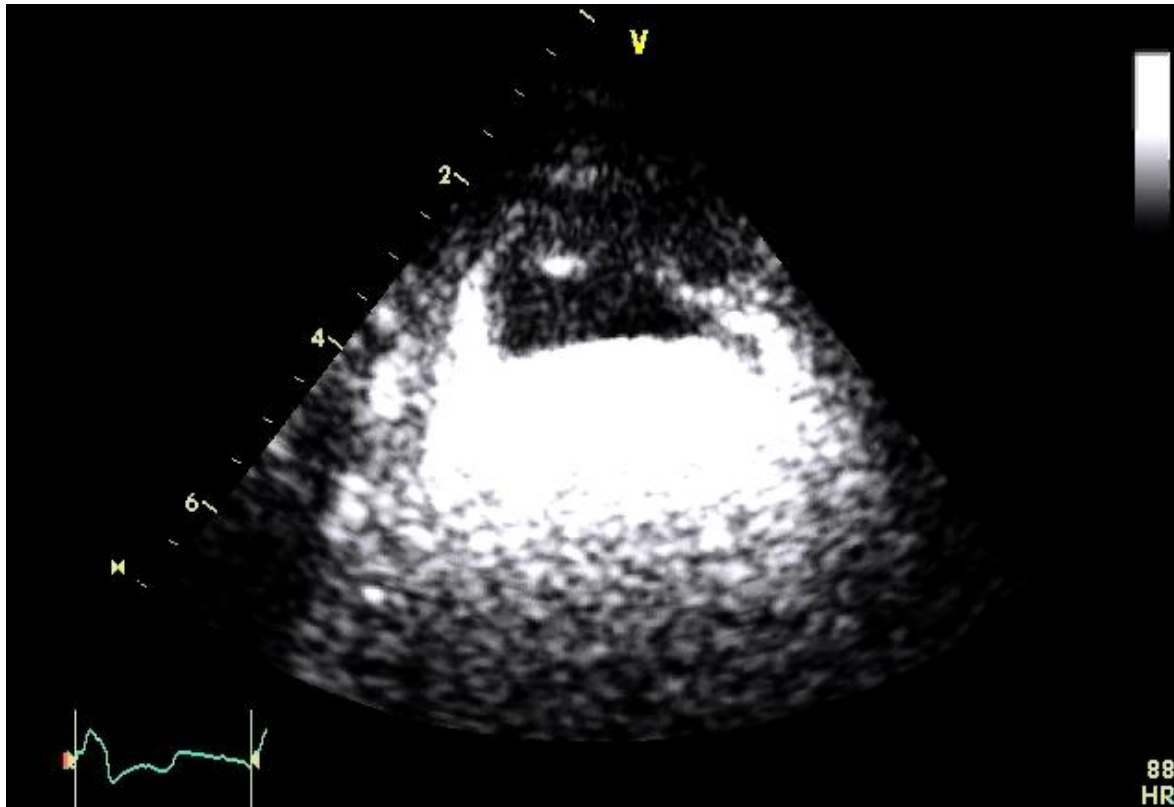
- a. Agitated Saline
- b. Optison
- c. Definity
- d. Lumason

# Name this agent...



- a. **Agitated Saline**
- b. Optison
- c. Definity
- d. Lumason

# The following represents...



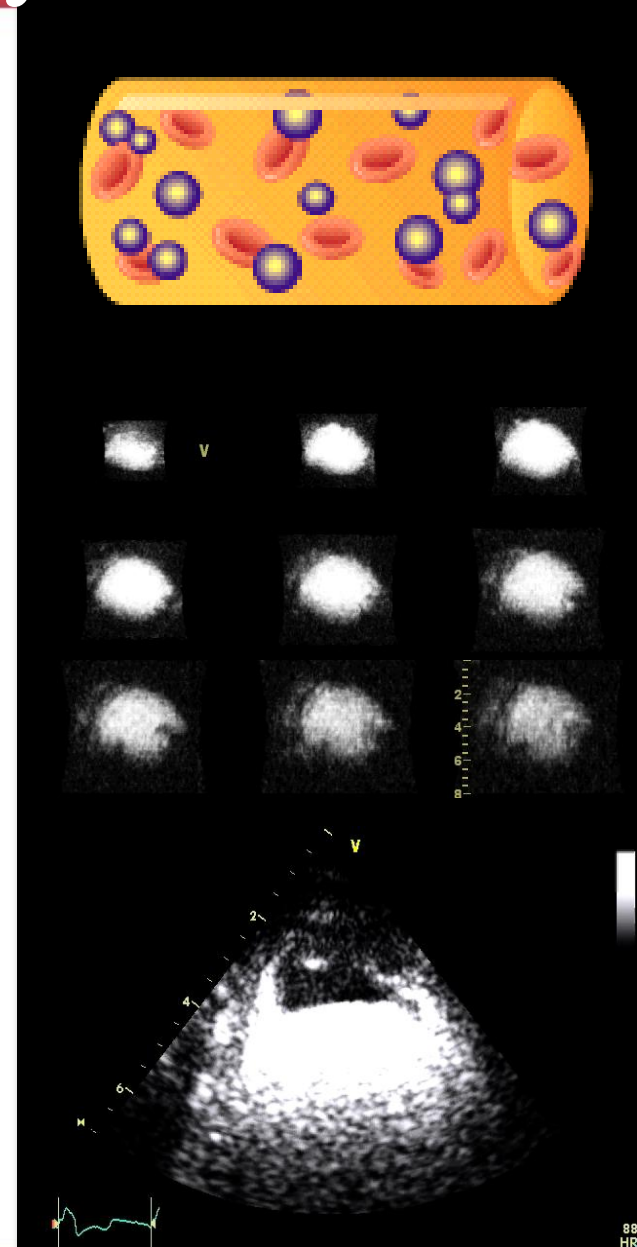
- a. PFO
- b. VSD
- c. ASD
- d. None of Above



# Contrast Echocardiography

## Summary

- Non toxic – easily eliminated
- Traverse pulmonary bed
- Instrumentation and controls
- Improved determination of
  - LV volume
  - Regional and global LV function
- Improved visualization
- Rescue of non-diagnostic exams
- Detection of structural abnormalities
- Doppler signal enhancement





# Thank You!

