MCE for Perfusion Myocardial Viability

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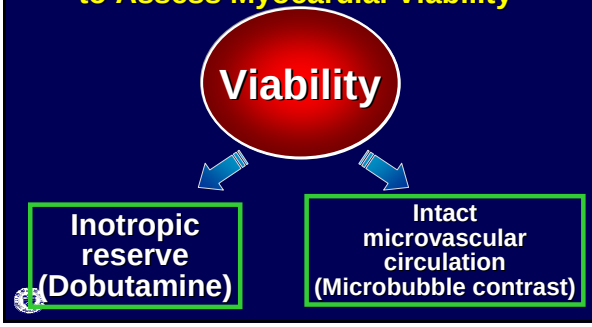
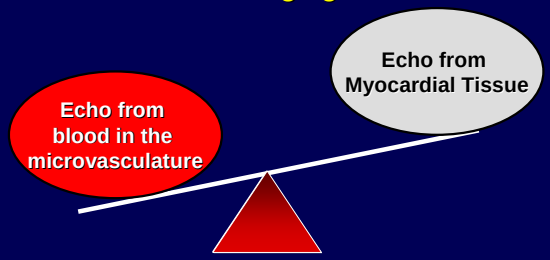
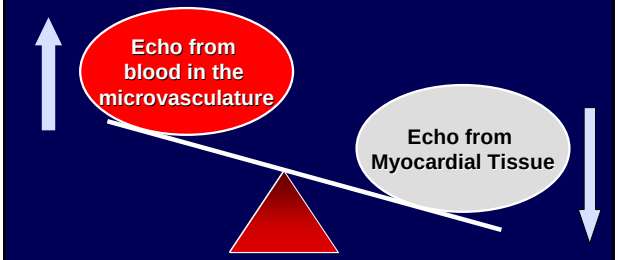
Echocardiographic Methods to Assess Myocardial Viability



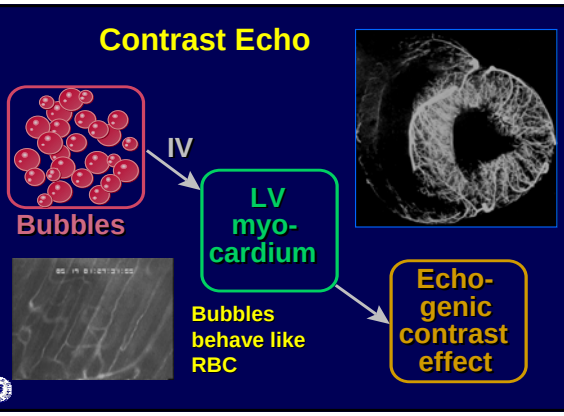
Echo from Blood and Myocardial Tissue -Not ideal for Imaging of Perfusion-



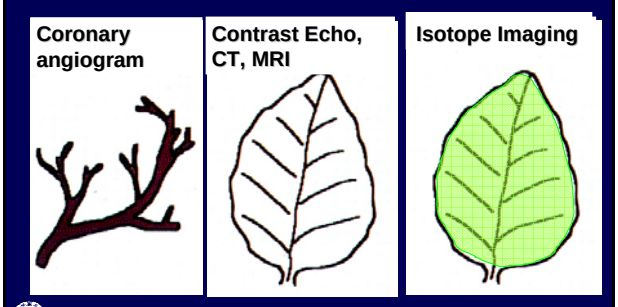
Ideal Method to to enhance echo from blood in the microvasculature



Contrast Echo



Myocardial Perfusion Imaging

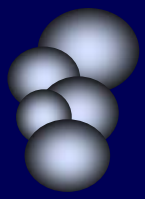


Beppu, 1997

Methods to Enhance Echo from Blood in the Microvasculature

1. Contrast Agents
2. Imaging Technologies and Techniques

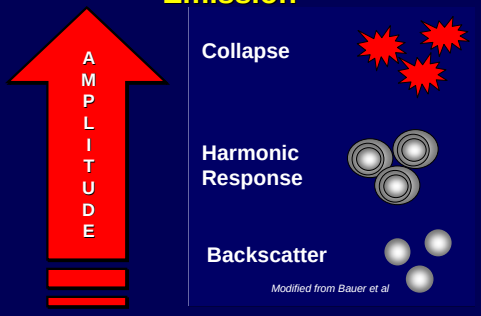
Newer Microbubbles



- Fluorocarbon or hexafluoride
- Polymer coated

- High density
- Low diffusivity
- Low saturation constant

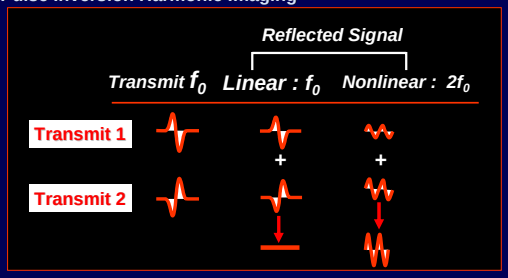
Micbubbles:Stimulated Acoustic Emission



Real-Time (Non-Destructive) Imaging

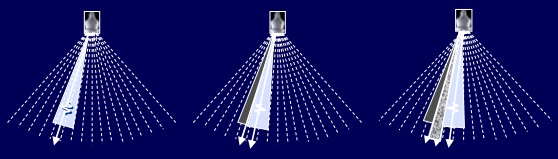
Multiple - Pulse Transmission

- Pulse Inversion Harmonic Imaging

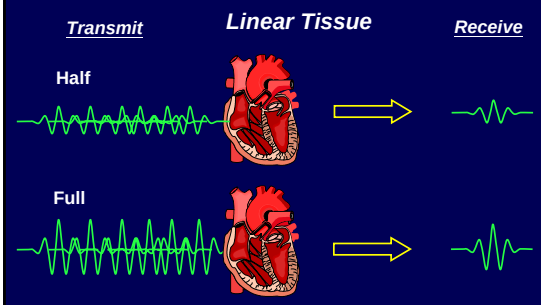


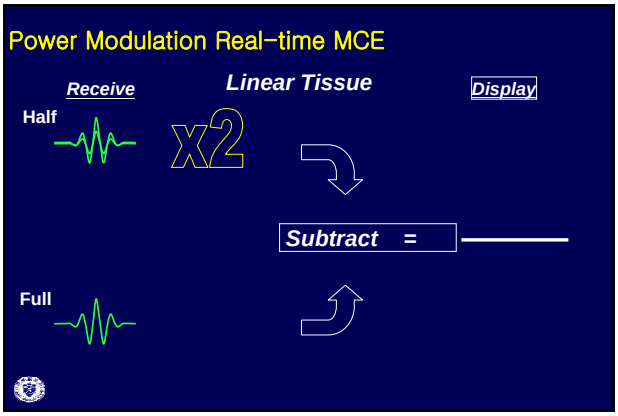
Real-Time (Non-Destructive) Imaging

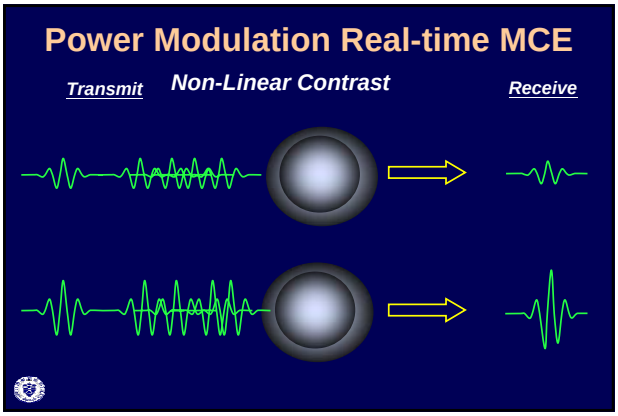
Single- Pulse Transmission

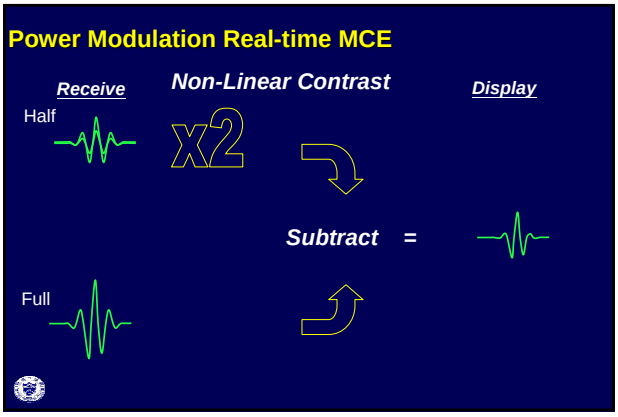


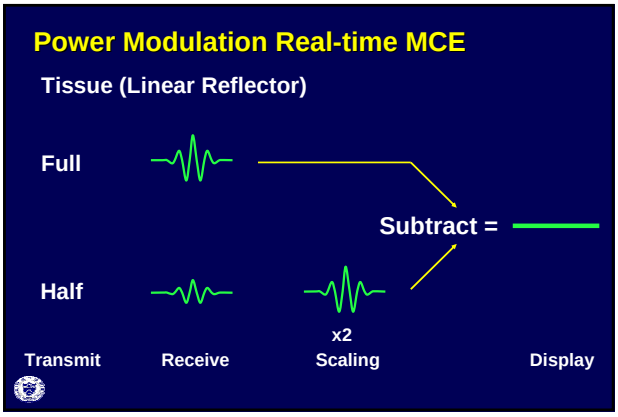
Power Modulation Real-time MCE

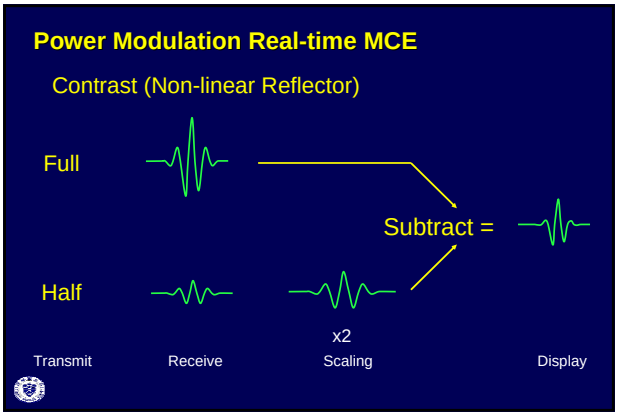


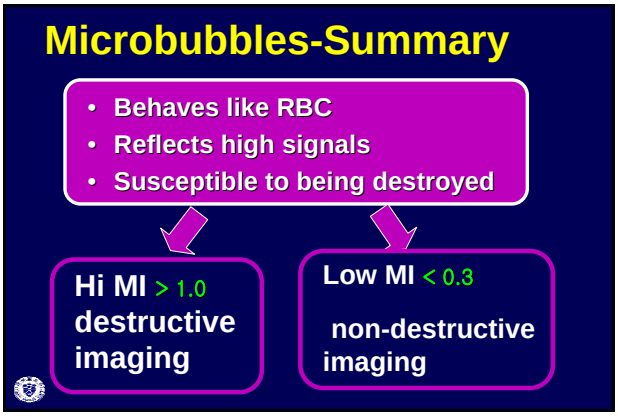

Power Modulation Real-time MCE
Receive
Linear Tissue
Display
Half
x2
Subtract =
Full


Power Modulation Real-time MCE
Transmit
Non-Linear Contrast
Receive


Power Modulation Real-time MCE
Receive
Non-Linear Contrast
Display
Half
x2
Subtract =
Full


Power Modulation Real-time MCE
Tissue (Linear Reflector)
Full
Subtract =
Half
x2
Transmit
Receive
Scaling
Display


Power Modulation Real-time MCE
Contrast (Non-linear Reflector)
Full
Subtract =
Half
x2
Transmit
Receive
Scaling
Display


Microbubbles-Summary
• Behaves like RBC
• Reflects high signals
• Susceptible to being destroyed
Hi MI > 1.0
destructive
imaging
Low MI < 0.3
non-destructive
imaging

High MI Bubble-Destructive Imaging

Pitfalls

1. Respiratory variation
   - *lose regional comparability*
2. Inability to evaluate wall motion abnormality
3. *Tissue motion artifacts*
4. *Blooming artifacts*

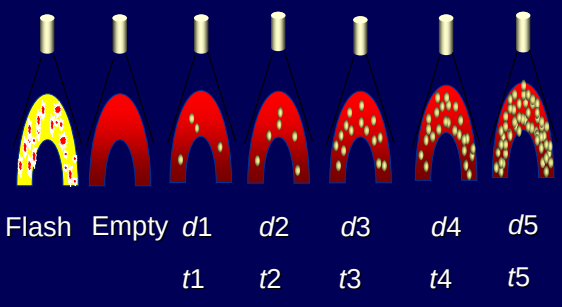
Low MI Non-destructive Imaging

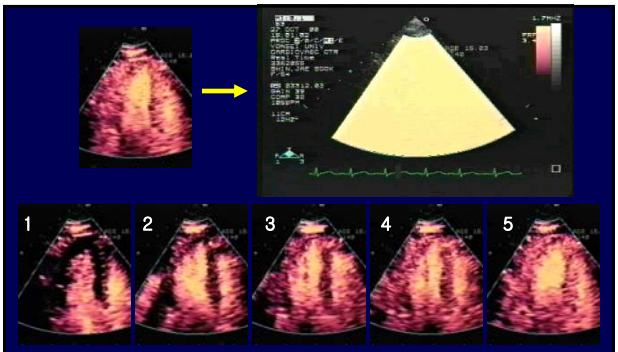
Simultaneous Assessment

Microvascular perfusion

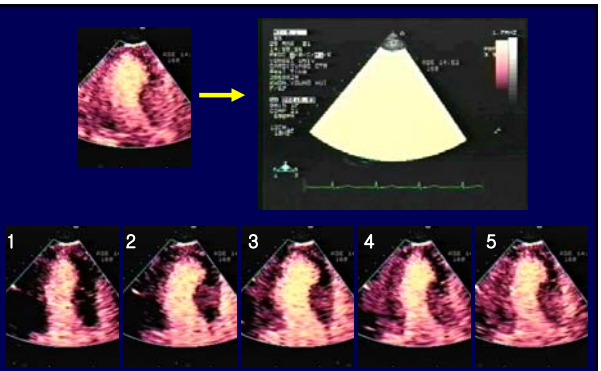
LV wall motion

- Power modulation
- Power pulse inversion
- Coherent imaging

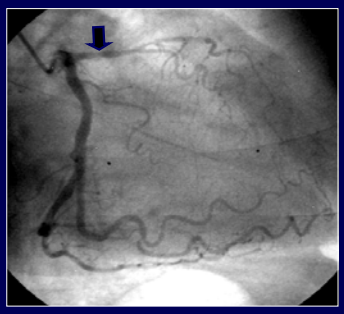


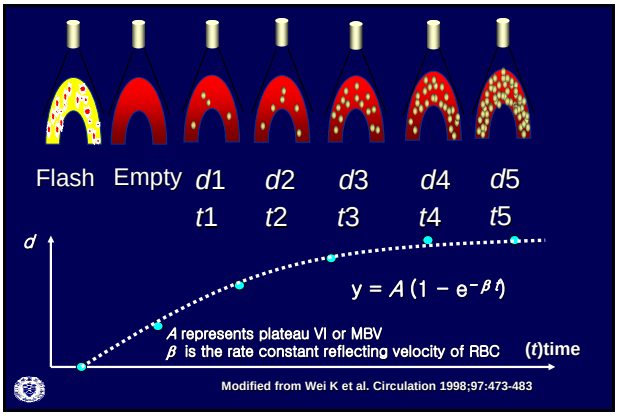


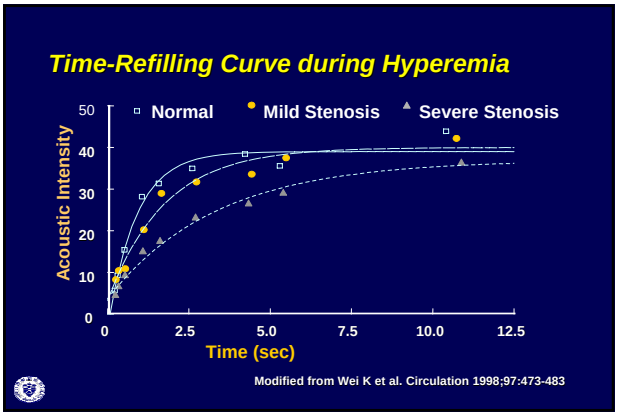
Normal coronary artery



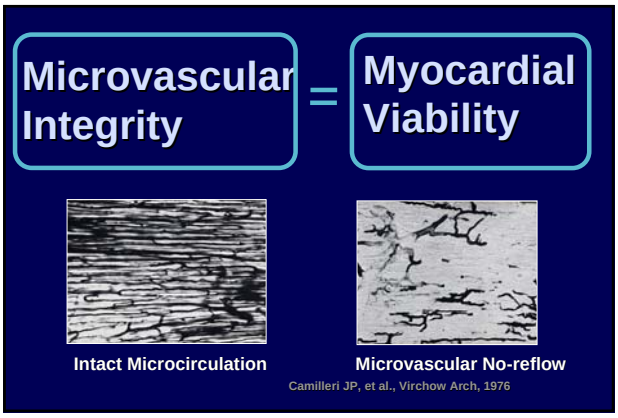
LAD Lesion

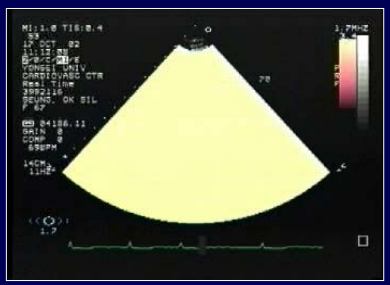


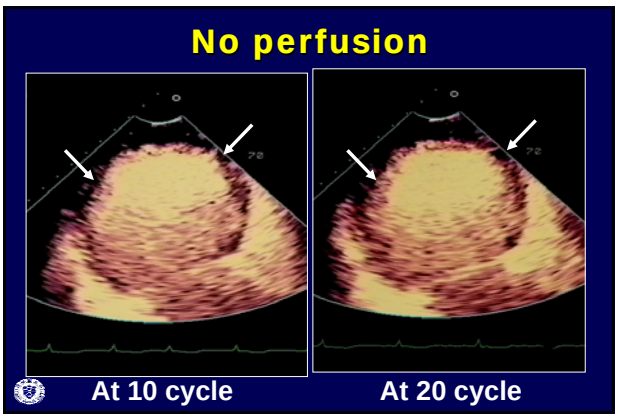




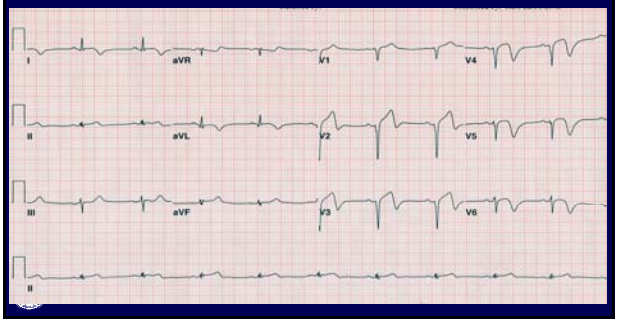
MCE in myocardial viability



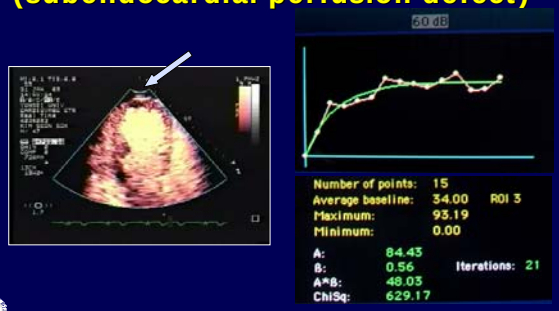




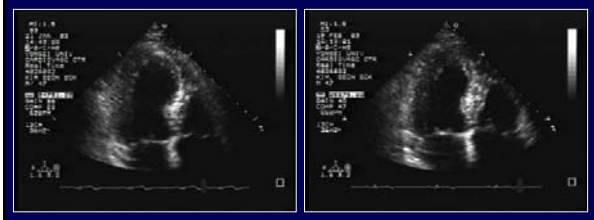
Case 1 : A 47 year-old male presented with chest pain for 1 hour.



MCE
(subendocardial perfusion defect)



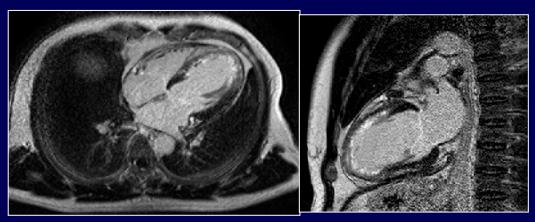
Wall motion improvement



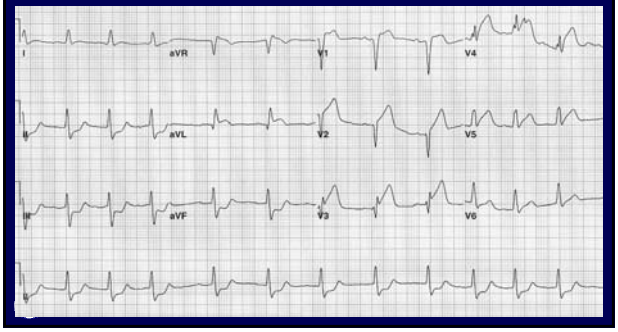
At acute stage :
Akinesia of
mid LV to apex

F/U 2 D Echo
Mild focal hypokinesia
at apical septum

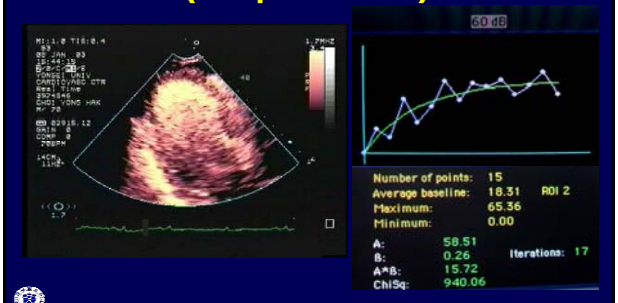
MRI at acute stage



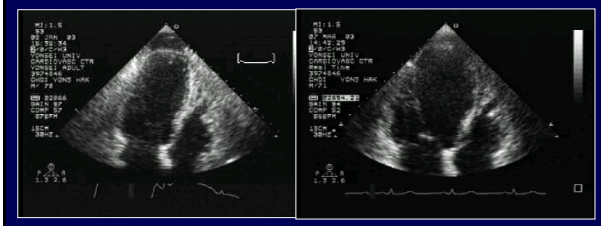
Case 2 : A 60 year old male presented with chest pain for 40 min.



MCE
(No perfusion)

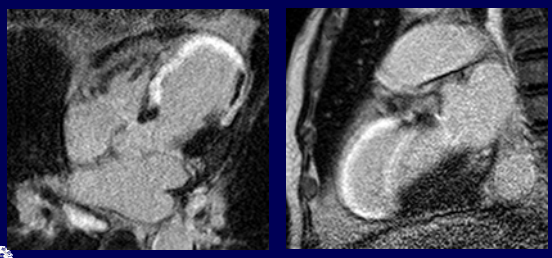


No functional recovery after revascularization

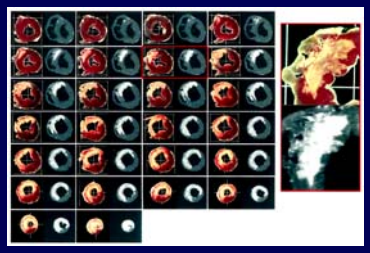


Acute stage F/U 2 D Echo

MRI (100% hyperenhancement)



CeMRI-derived extent of delayed enhancement (DE) accurately represent transmural extent of infarction (TEI)



Kim RJ et al. N Engl J Med 2000;343

Study 1

Quantitative MCE and contrast enhanced MRI in prediction of myocardial viability after primary PCI in AMI : comparative study

YUMC data

Methods (1)

- 20 patients with AMI who were successfully revascularized by primary PCI
  (age : 59±10years, 16 males)
- Real time MCE and MRI within 7 days after revascularization
  (LAD:12, LCx:3, RCA:5)

Methods (2)

- **Myocardial perfusion by MCE**

  Quantitative analysis of rate of microbubble velocity ($y = A(1 - e^{-\beta t})$)

- **Quantitative measurement of transmural delayed hyperenhancement on MRI**
- **Improvement in contractile function**
  : 2D Echo initial & 12 weeks later

Quantitative assessment of myocardial perfusion by MCE
Rate of microbubble velocity(β) ≥ 0.4

	Beta		
	Beta < 0.4	Beta ≥ 0.4	total
Wall motion no improve	21 70.0%	9 30.0%	30 100%
Wall motion improve	4 11.8%	30 88.2%	34 100%
Total	25 39.1%	39 60.9%	64 100%

- Sensitivity : 88.2%
- Specificity : 70.0%
- Positive predictive value : 84%
- Negative predictive value : 76.9%

Transmural extent of delayed hyperenhancement(≤ 50% on MRI)

	MRI		
	hyperenhancement ≥ 50%	hyperenhancement < 50%	total
Wall motion improvement (-)	53 84.1%	10 15.9%	63 100%
Wall motion improvement (+)	16 30.2%	37 69.8%	53 100%
Total	69 59.5%	47 40.5%	64 100%

- Sensitivity : 69.8%
- Specificity : 84.1%
- Positive predictive value : 78.7%
- Negative predictive value : 76.8%

Conclusion

- MRI showed better **specificity** (sensitivity 69.8%, specificity 84.1%) while MCE showed better **sensitivity** (sensitivity 88.2% , specificity 70%).
- Combining of **quantitative MCE** and **MRI** provided the best diagnostic characteristics, with a **sensitivity of 88.2%, a specificity of 84.1%** in the prediction of myocardial viability following AMI

Study 2

Prediction of Transmural Extent of Infarction and Wall Motion Recovery With MCE-Derived MBVF and Index of MBF

: Comparison With Contrast-Enhanced MRI

E Choi, N Chung et al JASE 2006

Methods

1. Low MI (<0.2) MCE

Wei K et al. Circulation 1998; 97:473-83

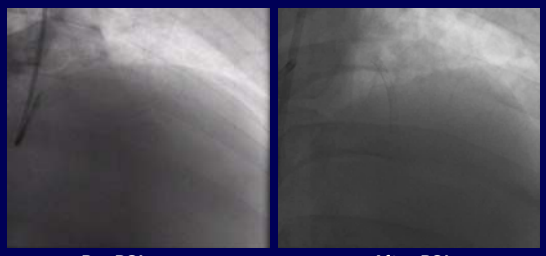
- Real time power modulation mode (DR :20 dB)
- MBF assessment using replenishment curve which fit $y=A\,(1-e^{-\beta t})$
- Analysis with Q-Lab ™ (Philips, Bothel, USA)

2. High MI (>1.0) MCE

Yano A et al. J Am Coll Cardiol 2004;43:1799-806
Yamada S et al. Heart 2004;91:183-8

- Ultraharmonic mode (DR:60dB)
- 1:5 triggered image (end-systole, peak T wave gated)
- MBV (mL/100g)=100x10$^{\text{calibrated CI}/10}$
- Analysis with VoluMap-445™ (YD Ltd, Ikoma, Japan)

Case, M/53, Ant. AMI



Pre PCI | After PCI

Fundamental 2DE
(seven days after PCI)

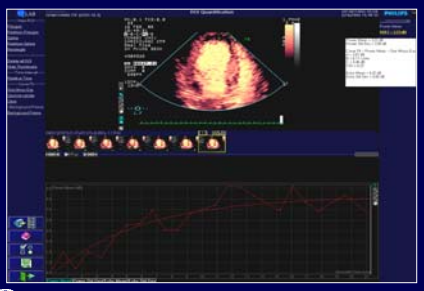
Akinesia of apical segments

MCE
(seven days after PCI)

Low MI (0.1), real-time power modulation mode

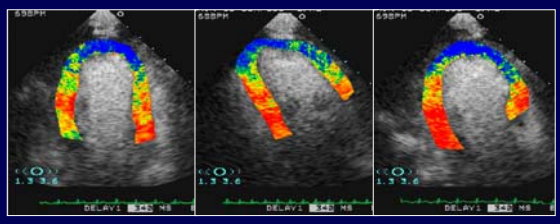
High MI (1.5) ultraharmonic mode

Measurement of MBF index (Axβ, dB/sec) using Q-Lab program

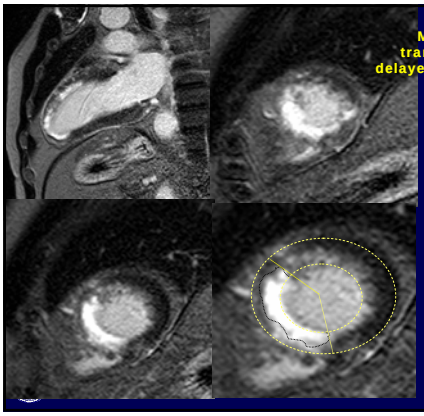


A=3.67dB
β=0.17 s^{-1}
Axβ=0.624 dB/sec

Measurement of relative CI and MBVF (ml/100g myocardium) using Volu-Map program



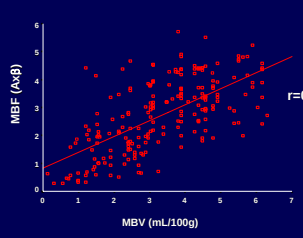
Septal apex relative CI = -26.3
Calculated MBVF=0.234 ml



Measurement of transmural extent of delayed hyperenhancement

75% transmural DE at septal apex

Calibrated transmural MBV (mL/100g) was significantly correlated with MBF (Axβ)



r=0.650, p<0.001

Segments : subdivided into three groups

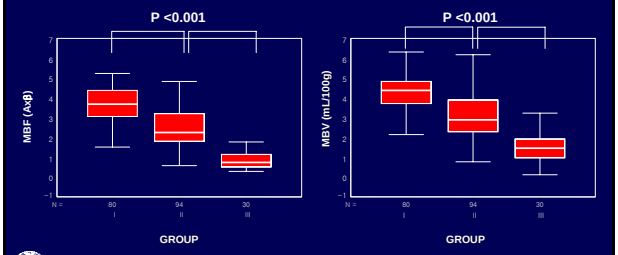
- Group I : normokinetic without DE (n=80)
- Group II : 0-50% DE (n=94)
- Group III :51-100% DE (n=30).

Comparison between groups

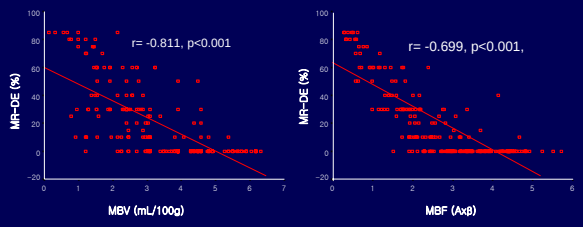
	Group I (n=80)	Group II (n=94)	Group III (n=30)
% MR-DE	0	18.83±15.68*	70.83±10.51**
CCI (dB)	-13.9±1.3	-15.6±2.0 *	-18.9±3.0 **
MBV (mg/100g)	4.30±1.11	3.05±1.24 *	1.54±0.80 **
A	9.73±1.01	8.87±2.32 *	5.87±2.02 **
β	0.37±0.07	0.28±0.92 *	0.13±0.04 **
Axβ	3.63±0.79	2.54±1.07 *	0.86±0.50 **

DE : delayed hyperenhamcement
CCI : calibrated contrast intensity

Comparison between groups

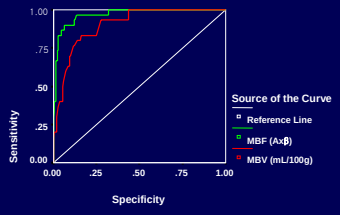


Mean transmural MBF and MBV were negatively correlated with %DE



Optimal cutoff values for predicting 50% MR-DE

MBV :1.64 ml (sensitivity 63%, specificity 91%)
MBF :1.26 (sensitivity 83%, specificity 97%)



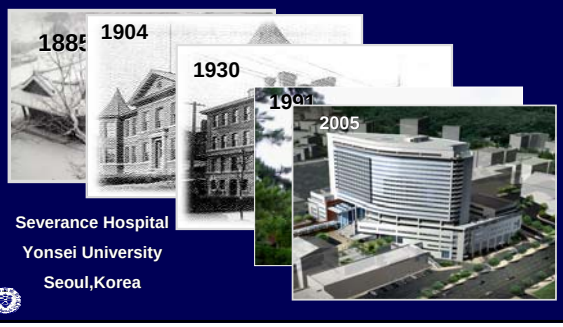
Future wall motion recovery and parameters of ceMRI and MCE

Segments in Risk Area (n=143)			
	Persistent dysfunctional (n=110)	Recovered (n=33)	p
% DE	69.2 ± 21.6	25.9 ± 23.7	<0.01
Relative CI (dB)	–18.9 ± 3.8	–16.6 ± 2.9	<0.01
MBVF (ml/100g)	1.41 ± 1.53	2.67 ± 1.68	<0.01
Axβ (dB/sec)	1.19 ± 0.84	2.41 ± 1.25	<0.01

Conclusion

- MCE-derived transmural MBVF can be an effective predictor of transmural extent of infarct and future contractile improvement in the reperfused myocardial infarction.

Thanks for Your Attention



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