

조영 심초음파

Contrast Echocardiography

134

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Abstract

Contrast echocardiography is an important technique that can be used to examine the cardiac cavity, vascular structure, intracardiac shunt, and myocardial microcirculation. It uses gas - filled microbubbles and various imaging techniques. The properties of microbubbles and their interaction with ultrasound are important in ultrasound - enhanced contrast imaging. This article will describe microbubble physics and new ultrasound techniques that are necessary to understand the basics of contrast echocardiography. The utility of contrast echocardiography in various clinical scenarios will be also described.

Keywords : Contrast echocardiography;

Microbubbles; Myocardium;

Microcirculation

: ; ; ;

agitated saline

. CT MRI

가

(microbubbles)

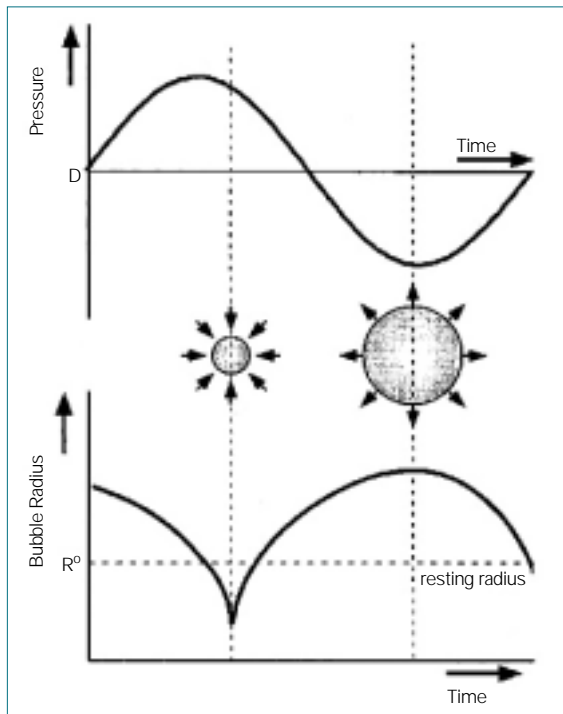
backscatter

(shunt) ,

, Doppler velocity

(1).

가 .



1. nonlinear behavior
echo harmonic
nics (11).

1.

B - mode

가
가
harmonic imaging 가
backscatter , backscatter
frequency
frequency frequency , 가
frequency 가 harmonic
frequency
frequency frequency
frequency frequency
frequency frequency

(1, 2)(2,
3). tissue harmonic 가
harmonic imaging 가
가 .

microbubble (acoustic pressure < 50 kPa)
가 (linearly)

scatter

가 (4, 5). (50 ~ 200 kPa) 가
nonlinear oscillation

harmonics sub - harmonics .

Acoustic pressure가 가 (> 200 kPa)

microbubble (6, 7).

가 shell

gas가 free gas bubble

. free gas bubble oscillation

millisecond shell

harmonics

scatter가

가

(8, 9).

pulse

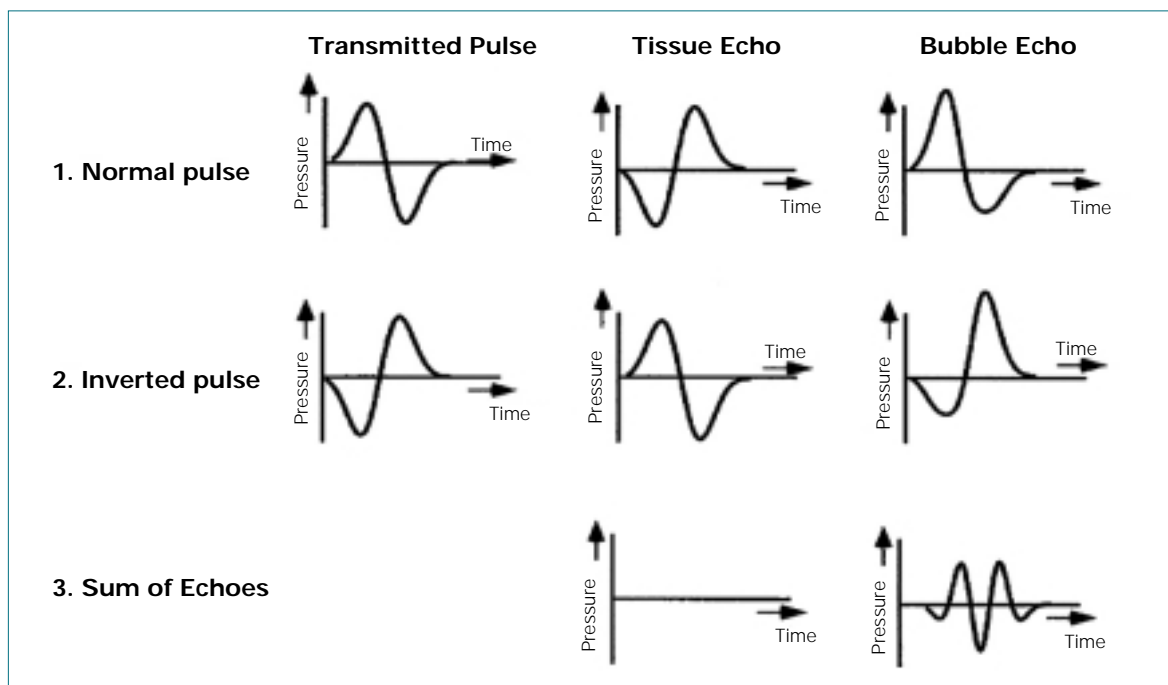
pulse

가

가

(intermittent imaging triggered imaging)

continuous imaging 가



3. Pulse inversion imaging.
echo

pulse
echo

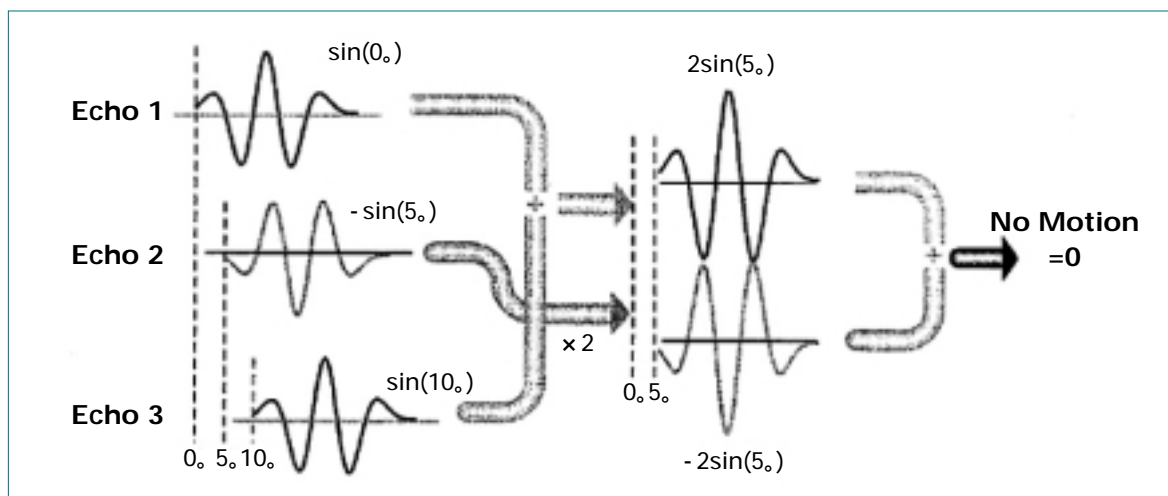
linear echo
nonlinear oscillation

pulse
pulse

pulse polarity
pulse

가

(11).



4. Pulse inversion Doppler(power pulse inversion).

pulse
imaging

pulse

pulse inversion
tissue motion
low mechanical index
pulse

real - time

(11).

1. 가 가 Ultrasound Contrast Agents

Contrast Agent		Gas	Shell Composition	Mean size ((m)
Acusphere (AI - 700)	Acusphere Inc, Cambridge, MA	Decafluorobutane	Synthetic polymer and phospholipid	2.0
Aerosomes (MRX - 115)	IMARx Pharmaceutical, Tucson, AZ	Perfluoropropane	Lipid blayer	2.5
Albunex / Infoscan	Molecular Biosystems, Inc, San Diego, CA	Air	Albumin	3.8
biSphere	POINT Biomedical, San Carlos, CA	Air	Bilayer polymer	4.0
Definity (DMP115)	DuPont Pharmaceuticals Co, North Billerica, MA	Perfluoropropane	Phospholipid	1.5
Imagent (AFO150)	Alliance Pharmaceutical Corp, San Diego, CA	Perfluoropropane vapor and nitrogen	Surfactant/ powder	5.0
Levovist (SHU508)	Schering, Berlin, Germany	Air	Non - bubbles stick to galactose	2~3
Optison (FS069)	Molecular Biosystems, Inc, San Diego, CA	Perfluoropropane	Albumin	3.6
PESDA		Air and perfluoro- carbon	Albumin	4.7
Sonazoid (NC100100)	Nycomed - Amersham, Oslo, Norway	Undisclosed perfluorocarbon	Lipid	3.0
SonoVue (BR1)	Bracco Diagnostics Inc, Switzerland	Sulfur hexafluoride	Phospholipid	2.5

3.

가

1 agitated . 가 fluorocarbon gas albumin, sur-
saline, hydrogen peroxide, indocyanine green dye, factant, lipid polymer shell 3
iodinated contrast

가

(13).

(12).

가

gas shell

2

5% hu-

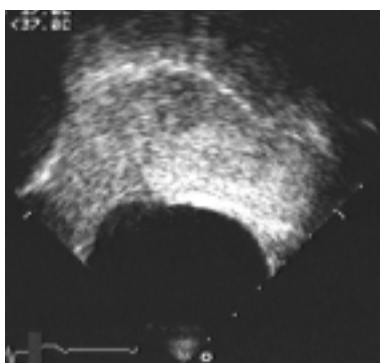
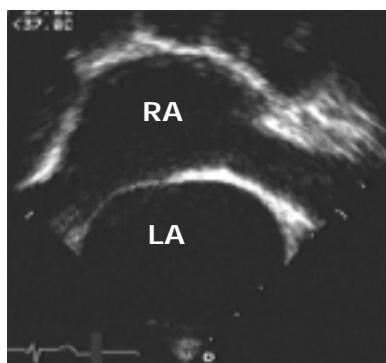
가

man albumin - containing air bubbles

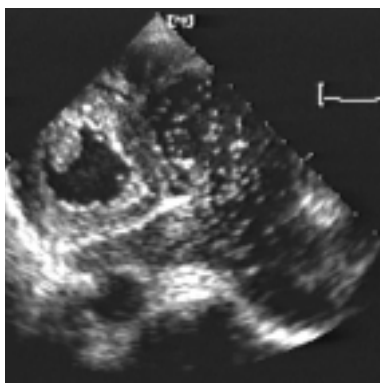
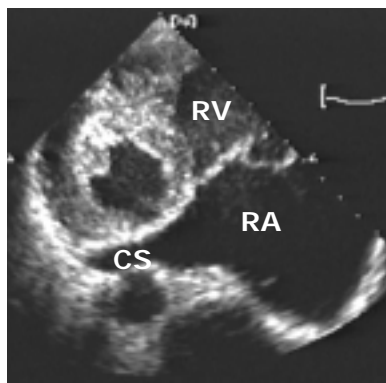
shell

microcirculation

air가



5. 10 mL agitated saline (LA : left atrium, RA : right atrium).



6. agitated saline left - sided superior vena cava, coronary sinus (RV : right ventricle, RA : right atrium, CS : coronary sinus).

가 (5). Agitated saline

가

(arteriovenous fistula)가

(patent foramen ovale) paradoxical embolism

가

(right - to - left shunt)

가 3~5 가

shell rigidity (1)(14).

가

가

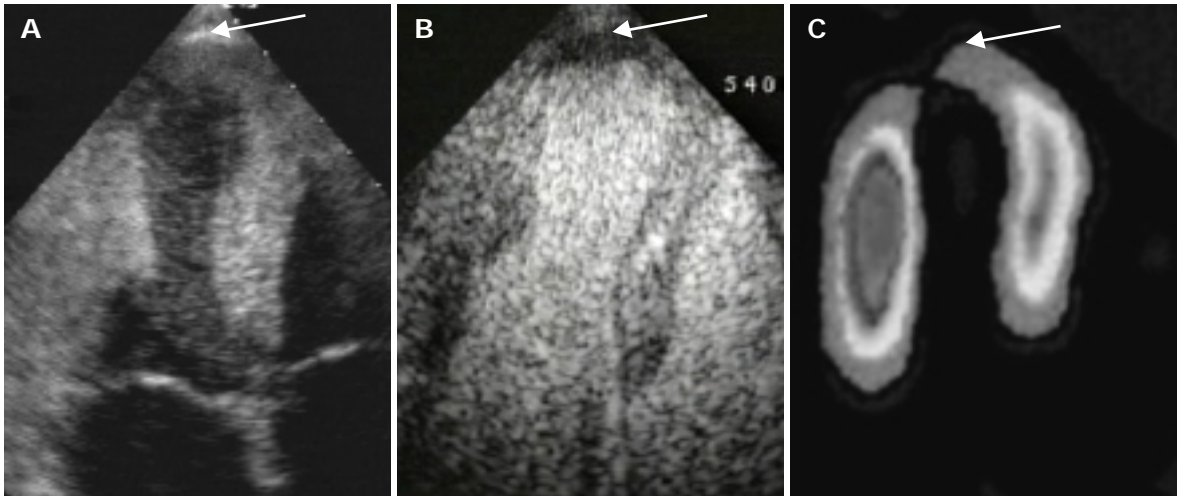
2)

1. (Cardiac Cavity)

1)

가

left - sided superior vena cava(6), azygous vein, innominate vein, anomalous pulmonary venous connection



7.

SPECT (C) (A), ()

(B)

가

3) Doppler Velocity

Doppler velocity 가
(15).

2.

가

가

4)

가

(7).

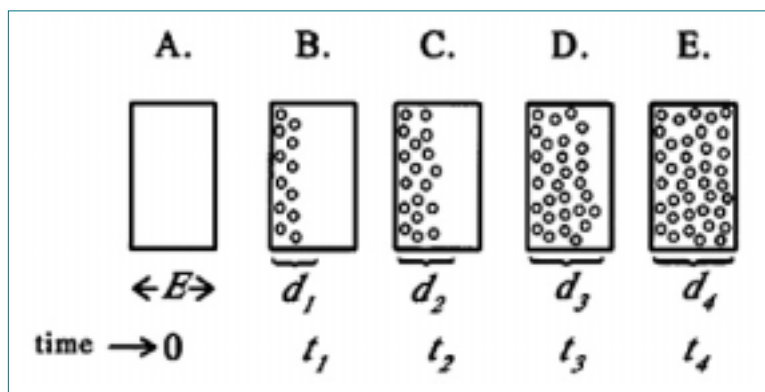
(16, 17).

가 mass

1)

Coronary blood volume

epicardial ves-



8.

E

ultrasound filed

. Time 0(A)

pulse

가

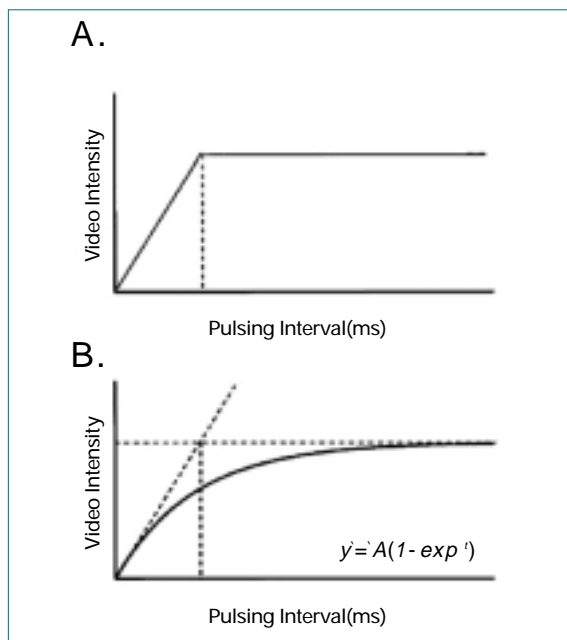
가

B - E

. Microbu-
pulse

bbule
interval(t)

(9).



9.

pulsing interval

videointensity

(A)

curve(B)

A

A

curve
blood volume,
A

RBC

velocity
blood flow

(9).

sel

myocardium

microcircula-

tion

(18~20). Myocar-

dium

myocardial

blood volume

epicardial coro-

nary stenosis

resistance arterio-

le

vasomotion

(21, 22) myocardial

blood volume

coronary artery

가

interstitial space

(23~25) myocardium

myocyte

blood volume

가

가 echogenecity

가

videointensity

blood volume

. Myocardium

microcirculation 90%

capillary

capil-

lary

RBC

(26) myocardium

capillary RBC

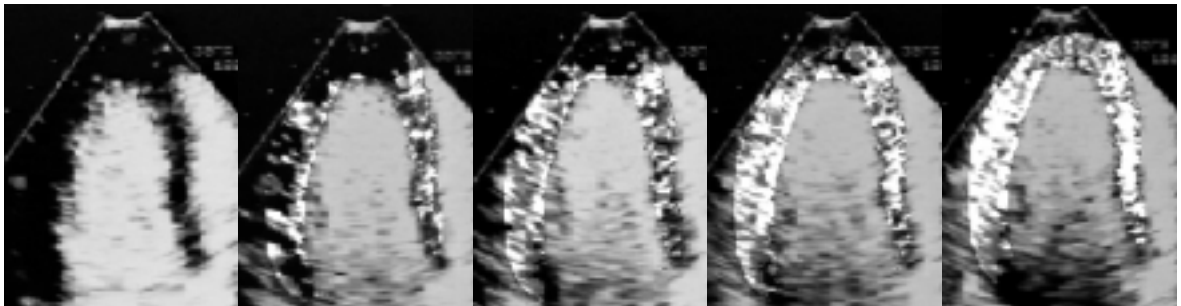
(8~10)(9).

2)

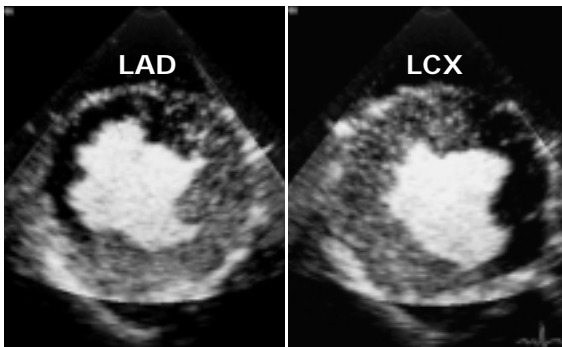
가

가

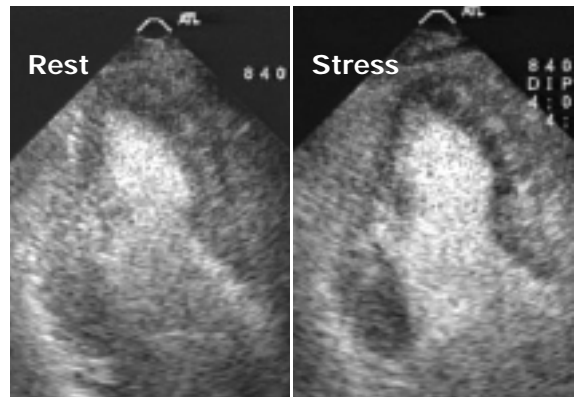
가



10. videointensity가 videointensity가 가 $[y = A(1 - e^{-t})]$
(9).

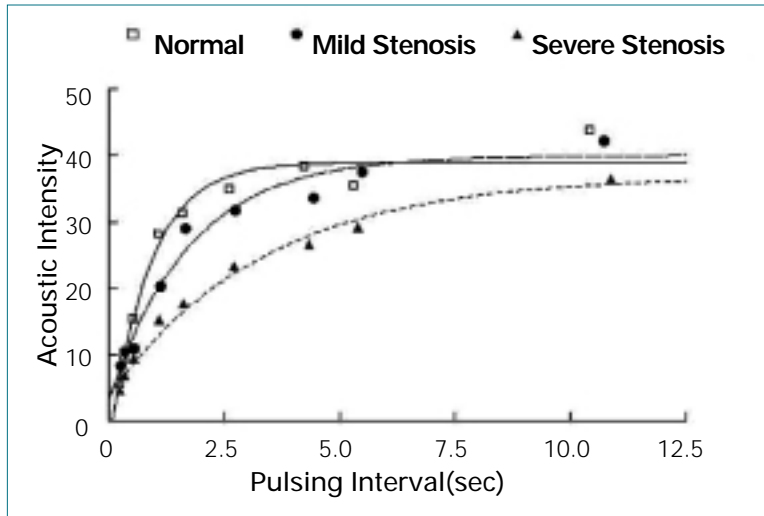


11. (LAD : left anterior descending artery, LCX : left circumflex artery).



12. Stress stress . Dipyridamole

(11). 가가
risk area(27~29)
, 가 'no reflow' . no reflow
risk area . Risk area 가
risk area
가 (30).
가
가 remodel-
ing 가 (31).



13. 3가
intensity curve. hyperemia
sity curve
rate of refilling

time -
time - inten-
가

가

가 stress

가

3.

3)

가

(36,

37).

가

stress 가

(38, 39)

가 . 가

stress flow heterogeneity

(40, 41).

(42).

(12)(32~34).

, pharmacological stress

peak videointensity , myocardial

blood volume (35)

time - intensity curve

(13)(9).

ratio ,
signal - to - noise
가

가



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