정맥 내 미세기포 투여를 이용한 Pulse Inversion Harmonic 심근조영심초음파검사의 관상동맥 협착증 진단 : Tc-99m Sestamibi SPECT와 비교연구

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Assessments of Myocardial Perfusion in Human Using Stress Intravenous PESDA Myocardial Contrast Echocardiography and Pulse Inversion Harmonic Imaging A Comparison Study with Tc-99m Sestamibi SPECT

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ABSTRACT

Objective　　The object of this study was to assess the accuracy of dipyridamole stress intravenous (IV) myocardial contrast echocardiography (MCE) using pulse inversion harmonic imaging and PESDA in the detection of perfusion defect in the patients with coronary artery disease in comparison with dipyridamole stress Tc-99m sestamibi SPECT. **Methods**　　Total 46 patients (29 males, mean age 64 years old) were consecutively enrolled. Patients with prior myocardial infarction were excluded. MCE and Tc-99m sestamibi SPECT were performed at the same day during rest and after 0.56 or 0.84mg/Kg dipyridamole infusion. Continuous IV infusion of PESDA (2- 5 mL/min) was administered while obtaining triggered (1 1) end-systolic apical 2, 4 chamber and long axis views. Tc-99m sestamibi was injected 3 minutes after dipyridamole. Tc-99m sestamibi SPECT images were obtained one hour later. Coronary angiography was followed within two days in all patients. Tc-99m sestamibi SPECT images were matched to the sixteen segments of left ventricle according to American Society of Echocardiography for segmental comparison. Both images were analyzed visually. **Results**　　Using coronary angiography as the standard, MCE showed overall sensitivity of 70.7%, specificity of 95.8%, positive predictive value (PPV) of 87.8% and negative predictive value (NPV) of 88.5% in the detection of coronary atherosclerosis (70% stenosis). Tc-99m sestamibi SPECT showed sensitivity of 75.6%, specificity of 98.9%, PPV of 96.8% and NPV of 90.6%. The overall concordance rate between MCE and Tc-99m sestamibi SPECT for the detection of perfusion defects was 86.9% (Cohen's kappa value 0.63) according

to the coronary territory and 86.8% (Cohen's kappa value 0.55) according to segmental analysis. **Conclusion** Dipyridamole stress IV MCE using pulse inversion harmonic imaging and PESDA is feasible and comparable to Tc-99m sestamibi SPECT in identifying significant coronary stenosis and inducible myocardial perfusion defects in the patients with coronary artery disease. MCE using pulse inversion harmonic imaging seems to be a promising modality for assessing myocardial perfusion in the patients with suspected coronary artery disease. **(Korean Circulation J 2000;30(7)：793-802)**

서　론

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.1) 2)

thallium- 201　　Tc- 99m sestamibi

．

4　6 m

.3- 5)

(spatial distribution image)

6)
.

,7) 8)

perfluorocarbon

.9) 10)

" second harmonic imaging" 10)　　　int-ermittent triggered harmonic imaging　　　9) 4)

.　　　　　pulse inversion harmonic ima-ging　　　second harmonic imaging

pulse

phase　　　　pulse(inverted pulse)

．

(linear response)

(ultrasound si-gnal)

(zero signal)　　　　(nonlinear respon-se)

(harmonic ultrasound signal)

.11)

．

Tc- 99m sestamibi SPECT　　　　　dipy-ridamole　　　　　48

,

pulse inversion harmonic imaging

Tc- 99m sestamibi SPEC　　　．

재 료 및 방법

대 상

1999　1

48

nic) .

((acoustic power) mechanical index

) . 1.1 (gain) .

. (imaging field)

. (depth) ,

2/3

.

PESDA 제조

Perfluoropropane 8 mL 5% dextrose 12 mL, 5% human albumin 4 mL

. 80 (Heat System Inc. LA, California, USA) . (continu-

(sonicator) , ous intravenous infusion) dipyrida-

(maximal out- put 550 W) 25± 3% (mean mole 100

± SD) 124± 15 W mL PESDA 0.05 mL/Kg PESDA

. 0.5- (1 mL/min) .

inch

$98± 11 W/cm^2$. PESDA 3 5 mL/min

PESDA 4.7± 0.2,

$1.3± 0.1× 10^9$ microbubbles/mL .[12] (intermittent triggered imaging)

.

acoustic shadow

심근조영 심초음파와 Tc-99m sestamibi SPECT 영상 PESDA .
의 획득

Fig. 1 4 ,

. 3 , 2 5 8

S- VHS . Dipyridam-

ole 2 . 4 dipyrid-

(HDI- amole(0.56 mg/kg)

5000, ATL, Washington, USA) pulse in-

version harmonic imaging .

P4- 2 1.67 MHz 3.3 MHz(harmo- dipyridamole dipy-
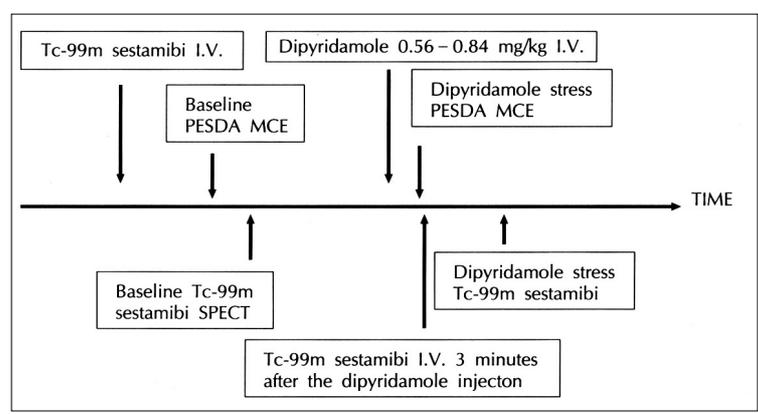
Fig. 1. A single-day protocol of MCE and Tc-99m sestamibi SPECT.

ridamole   0.28 mg/kg   2

.

(Tc- 99m sestamibi SPECT)

Fig. 1   dipyridamole   Tc-
99m sestamibi SPECT   Tc- 99m- sestamibi
7 mCi   60   . Dipyri-
damole   Tc- 99m sestaMIBI   4
dipyridamole   3   25 mCi
60   dipyridamole   Tc-
99m sestamibi SPECT   .

관상동맥 조영술
                                Tc-
99m sestamibi SPECT   48

.
Seldinger

Judkins

Siemens(Mixdorf
Information System AG, Germany)   ANCOR
PCDOH/90PCI
70%

.

영상자료분석
                    American Society of
Echocardiography   16

,   ,   3

.
dipyridamole
dipyridamole
,   dipyrid-
amole
dipyridamole

.
Tc- 99m sestamibi SPECT

. Tc- 99m sestamibi SPECT

결과분석 및 통계처리
                                    (70%
)   (gold standard)
Tc- 99m sestamibi SPECT   ,
,   .

(concordance rate)   ,

.   Kappastatistics
[13]

결   과

대상 환자의 임상적 특성
                    Table 1   .
        46   2

.   29
17   64± 8   .

,
15 ,   13 ,
8
7   .

.

Table 1. Baseline characteristics of enrolled patients

Age (year)	64± 8
Male	29 (63%)
Stable angina	13 (28%)
Unstable angina	15 (33%)
Vasospastic angina	8 (17)
Atypical chest pain	7 (15)
Left ventricular ejection fraction (%)	62± 20
Risk factors	
Diabetes	18 (38%)
Hypertension	23 (50%)
Smoking	26 (56%)
Coronary angiography	
1 VD	12 (26.0%)
2 VD	7 (15.2%)
3 VD	5 (10.8%)
Near normal/Minimal disease	22 (47.8%)

Table 2. Overall accuracy of myocardial contrast echocardiography and Tc-99m sestamibi SPECT in the diagnosis of coronary artery stenosis

	Sensitivity	Specificity	PPV	NPV
MCE	29/41 (70.7%)	93/97 (95.8%)	29/33 (87.8%)	93/105 (88.5%)
SPECT	31/41 (75.6%)	96/97 (98.9%)	31/32 (96.8%)	96/106 (90.6%)

MCE myocardial echocardiography   SPECT Tc-99m sestamibi single photon emission tomography
PPV positive predictive value   NPV negative predictive value

Table 3. Sensitivity and specificity of MCE in the diagnosis of coronary artery stenosis according to the vascular territory

	LAD	LCA	RCA
Sensitivity	15/21 (71.4%)	7/10 (70.0%)	7/10 (70.0%)
Specificity	23/25 (92.0%)	35/36 (97.2%)	35/36 (97.2%)

LAD left anterior descending artery
LCA left circumflex artery
RCA right coronary artery

Table 4. Sensitivity and specificity of Tc-99m sestamibi SPECT in the diagnosis of coronary artery stenosis according to the vascular territory

	LAD	LCA	RCA
Sensitivity	16/20 (80.0%)	7/10 (70.0%)	8/11 (72.7%)
Specificity	26/26 (100%)	24/24 (100%)	33/35 (94.2%)

LAD left anterior descending artery
LCA left circumflex artery
RCA right coronary artery

39

.

12 , 7
5 22

.

관상동맥 영역별 분석

70%

(vascular territory) 138
41 .
29 , 93
70.7%, 95.8% ,
87.8% 88.5% . Tc-99m
sestamibi SPECT 31
, 96 75.6%,
98.9%
96.8% 90.6% (Table 2).

71.4% 92.0%,
70.0% 97.2%, 70%
97.2% (Table 3), Tc-99m sestamibi SPECT
80.0% 100%,
70.0% 100%, 72.7% 94.2%
(Table 4).

23 , 97
86.9% (0.63) (Fig. 2).

Tc-99m sestamibi SPECT			
	Defect	Normal	Total
Defect	23	10	33
Normal	8	97	105
Total	31	107	138

Concordance : 86.9%, κ : 0.63

Fig. 2. Observed agreement on the detection of perfusion defects between two modalities according to the vascular territory. The index of choice for measurement of observed agreement in nominal or existential scale which corrects for agreement expected by chance.

심근분절별 분석

736 149 , Tc-99m sestamibi SPECT 112 ,
82 , 557
86.8% (
0.55) (Fig. 5). Fig. 3
dipyridamole 1 1 triggered harmonic
imaging .
Fig. 4 dipyridamole
amole dipyridamole

. Tc-99m sestamibi
SPECT .
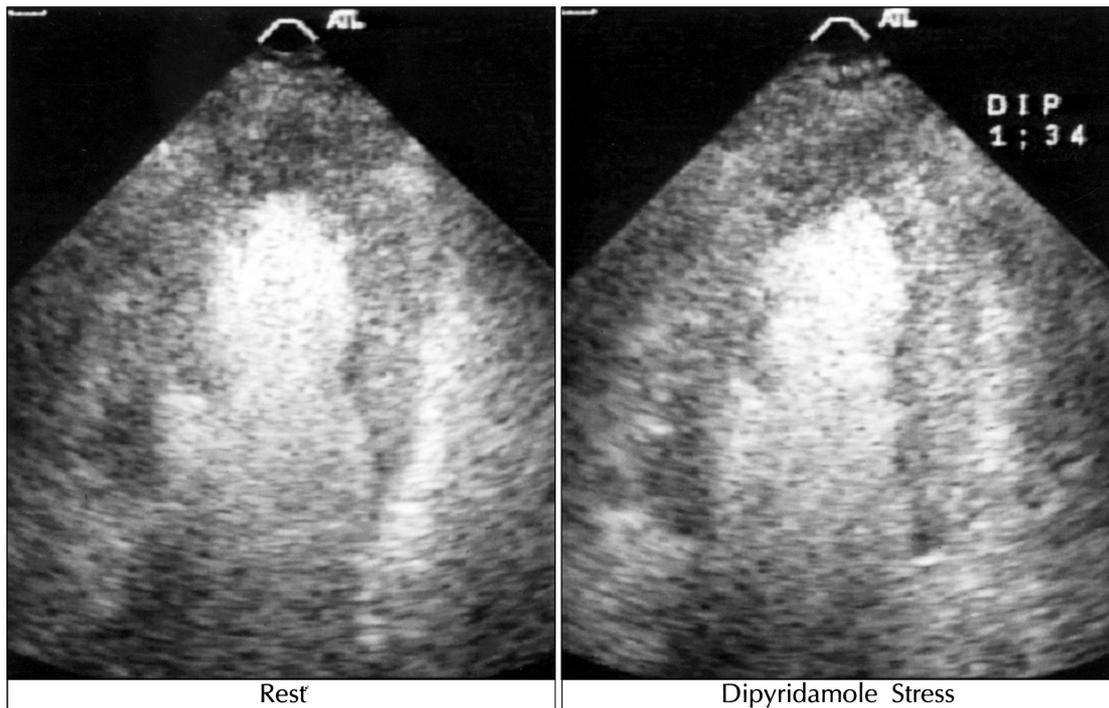
Fig. 3. An example of normal perfusion before and after dipyridamole stress.

환자별 분석

　　　　　　　　　Tc- 99m sestamibi SPECT
　　　　　　　　　　　　16 ，
　　　　　　　22
　　　82.6%(　0.64)　(Fig. 6).

전반적인 정확도

　　　　　　70%

　　　　　　　　　　　70.7%,
　95.8%,　　　　87.8%,　　　88.5%
　, Tc- 99m sestamibi SPECT　　　75.6%,
　　98.9%,　　　　　96.8%,
90.6%　 (Fig. 7).

관찰자간 진단 일치률(interobserver agreement)

　　　　　　　　　97.8%,
　　　　97.6%,
92.6%　 .

검사에 따른 부작용

　PESDA　　　　　　　　　, dipy-
ridamole　　　　　　　12 (26%)
　　　　　　　,
　　　4 ,　　　　　　　1
　　　　　　.
　　　　　　dipyridamole　　　　di-
pyridamole　　　　　　.

고　찰

심근조영 심초음파검사와 Tc-99m sestaMIBI SPECT

　　　　　　　　　　　Tc- 99m sestamibi
SPECT　　　　　　　　.
　　　　　　　　　　.
　　　PESDA
.[14]　　PESDA

| Rest | Dipyridamole Stress |
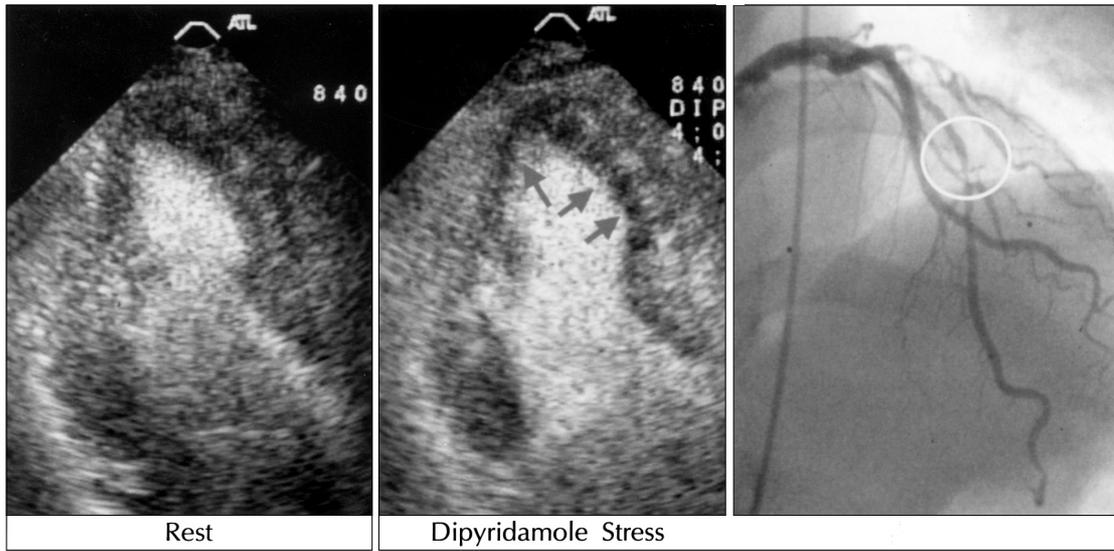
Fig. 4. Note the newly developed perfusion defects atthe territory of the left anterior descending artery after dipyridamole stress (middle) compared to the rest image (left). The simultaneous Tc-99m sestamibi SPECT showed apical and septal perfusion defects that were identical with those of MCE.
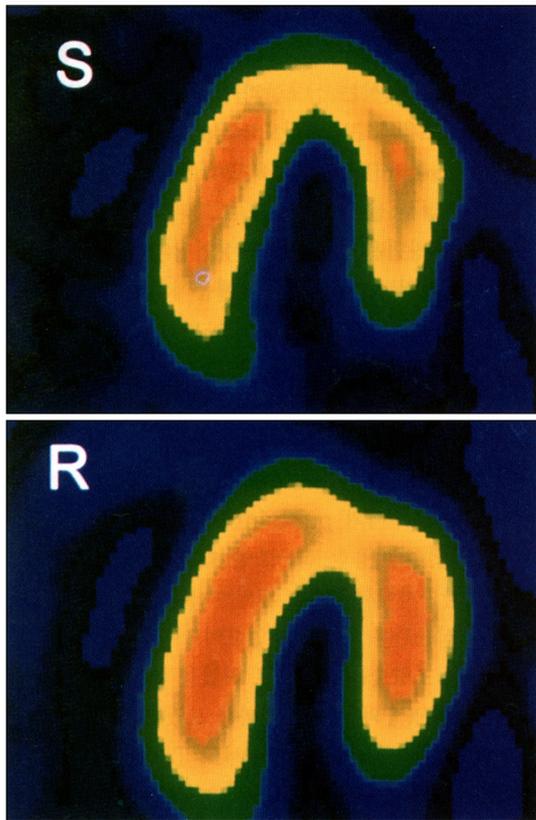
. Tc- 99m ses-

tamibi SPECT   (spatial resolution)

[16]
.

SPECT
[17]
.

(false defect)

.

(atten-

uation)   [18]
,

(gain),

(attenuation),

,
[19]
.

.

,[6] Tc- 99m sestamibi

심근조영 심초음파검사와 Tc-99m sestaMIBI SPECT의
일치율

[15]
.

	Tc-99m sestamibi SPECT		
		Defect	Normal	Total
MCE	Defect	82	67	149
	Normal	30	557	587
	Total	112	624	736
Concordance : 86.8%, κ : 0.55				

Fig. 5. Observed agreement on the detection of perfusion defects between two modalities according to the myocardial segment.

|	Tc-99m sestamibi SPECT		
		Defect	Normal	Total
MCE	Defect	16	4	20
	Normal	4	22	26
	Total	20	26	46
Concordance : 82.6%, κ : 0.64				

Fig. 6. Observed agreement on the detection of perfusion defects between two modalities according to the patient.
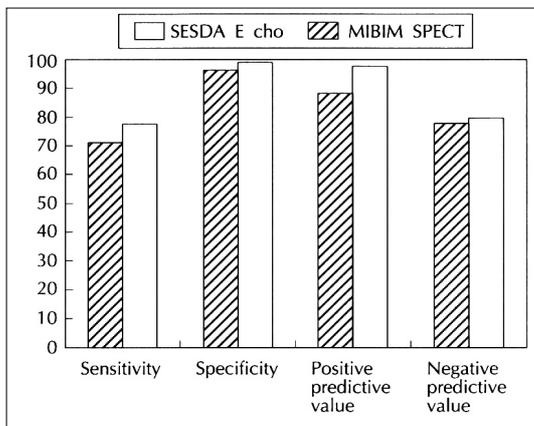
Fig. 7. Overall sensitivity, specificity, positive and negative values of two modalities are depicted.

Tc- 99m sestamibi SPECT

.

41

Tc- 99m sestamibi
SPECT   82%   ,[20]

Tc- 99m sestamibi SPECT

55%,   83%
66%   .[17]

69%,
80%, 92%   .[6,21,22,24]

,   ,

,

.

,

(acoustic power),
(gain control),   (frame rate),

.
[23]

.

Pulse Inversion Harmonic Imaging을 이용한 심근조영 심초음파 검사의 가능성과 진단정확도

(PESDA)
pulse inversion harmonic imaging   48
2   46

Tc- 99m sestamibi SPECT   ,

Tc- 99m sestamibi
SPECT   .   pulse inversion harmonic imaging

,

.

Tc- 99m sestamibi

.

.[24]

본 연구의 제한점

peak in-
tensity ratio   acoustic densitometry
      (quantitative analysis)
           (visual analysis)   .

                                    ,
                                    .

        , Nagueh
        89%   89%,   57%   51%
                                [22]
                                .

        4   (apical 4 chamber view)
        2   (apical 2 chamber view)

        ,

                              .

                              (imaging depth)
  2/3   ,

                              [25]
                              .

요   약

연구목적 :

                                  (70% diameter
stenosis)   perfl-
uorocarbon- exposed sonicated dextrose albumin
(PESDA)   pulse inversion
harmonic imaging   dipyridamole
        (MCE)
    Tc- 99m sestamibi SPECT

              .
방 법 :
                      46 (29 ,
    638   )   PESDA   (2± 5 mL/min)

MCE   Tc- 99m sestamibi SPECT
      , dipyridamole(0.56   0.84 mg/kg)

        48

        .
결   과 :

              Tc- 99m sestamibi SPECT
      70.7%/75.6%,   95.9%/98.9%,
        87.8%/96.8%,   88.5%/90.6%
            .   70%   25
                Tc- 99m sestamibi SPECT
                    16 ,
                    22
(concordance rate)   82.6%(Kappa value   0.64)
          .   (vascular territory)
  138
        23 ,   97
86.9 %(Kappa value   0.63)   .
결   론 :

          PEDSA   pulse inv-
ersion harmonic imaging   dipyridam-
ole   (MCE)   Tc- 99m
sestamibi SPECT   ,

                              .

중심 단어   .   .
              · Pulse inversion harmonic imaging·
PESDA· Tc- 99m sestamibi SPECT.

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