

## 한국인에서의 정상 심초음파 검사치의 확립에 관한 다기관연구

박 승 우

## Multicenter Trial for Estimation of Normal Values of Echocardiographic Indices in Korea

Seung Woo Park, MD

Echocardiography Council of the Korean Society of Circulation, Cardiac and Vascular Center, Samsung Medical Center, Department of Medicine, SungKyunKwan University School of Medicine, Seoul, Korea

## ABSTRACT

**Background and Objectives :** There has been much need for standard normal values of echocardiographic indices in Korea. Echocardiography Council of the Korean Society of Circulation performed multicenter trial for estimation of normal values of echocardiographic indices. **Methods :** In 19 university or general hospitals, echocardiographic specialists measured frequently used echocardiographic indices with the same method in healthy people. The measured indices were 36 items which involved M-mode, 2-dimensional and Doppler echocardiographic parameters. All the results were recorded on video tapes and reviewed by the review committee. The results were included for analysis only if the review committee accepted them. **Results :** Total 371 healthy people were included. There were 189 women. Their age ranged from 3rd decades to 8th decades. Complete measurement of all the indices was done in 225 people. Left ventricular wall thickness, aorta size, left atrial size and left ventricular mass in M-mode echocardiographic measurement changed significantly with the increase of age ( $p < 0.005$ ). In 2-dimensional echocardiographic examination, sinotubular junction diameter of the aorta, anteroposterior & superoinferior diameters of left atrium, both ventricular outflow tract diameter and main pulmonary artery diameter changed with the increase of age ( $p < 0.01$ ). Diastolic dysfunction became prominent with the increase of age in Doppler examination. **Conclusions :** We conclude that these data could be used as the standard criteria for echocardiographic examination in Korea. However, age factor should be considered when they are applied because many echocardiographic indices change significantly with the increase of age. (Korean Circulation J 2000;30(3):373-382)

**KEY WORDS :** Echocardiographic index · Normal value · Multicenter trial.

## 서 론

: , 135 - 710 50  
: (02) 3410 - 3419 · : (02) 3410 - 3417  
E - mail : swpark@yurim.skku.ac.kr

1-4) 가

가

W =

(multicenter trial) , 가 1989 “Recommendations for Quantitation of the Left Ventricle by Two-Dimensional Echocardiography”<sup>16)</sup>

(가 ). , 가 가

가 12 mm , 8 mm (  $\pm 4$  mm) 가 , 95% (  $=0.05$ ),

$N = 4 \times 1.96^2 \times 12^2 / 8^2 = 34.5744$  ( 35 )

10% sample 40

가 . 20 60 10

40  $40 \times 5 = 200$  .

가

, 20 60 , 10 2

20 , 380

, 가

371 , 70 3

#### 심초음파 검사

, 3

,

내용 및 방법

대상군의 설정

19 가 6

3

2

(20 , 30 , ...) M

M

,

$N = 4 \times z( )^2 \times S^2 / W^2$

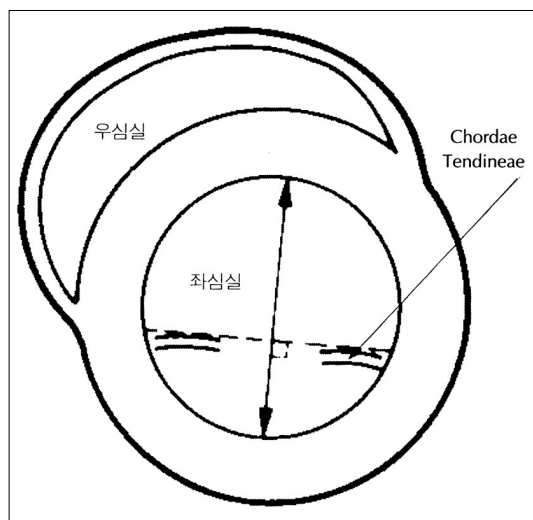
N = M

$z( ) =$  (significance level)

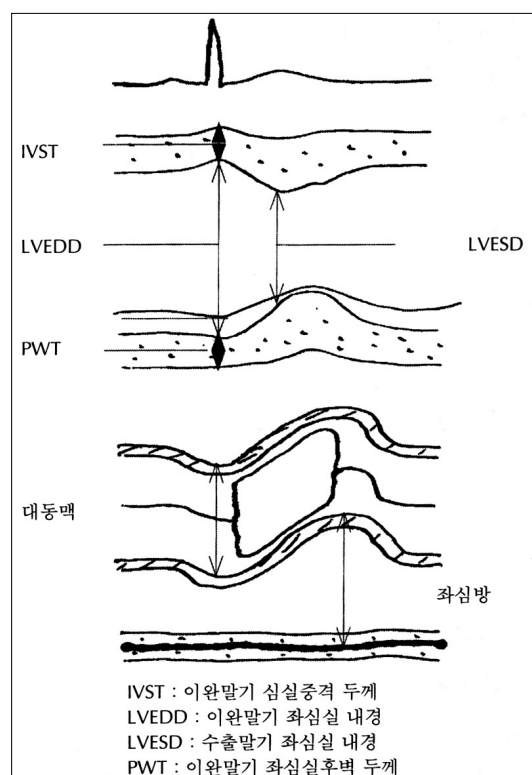
S =

art 100 mm/sec , 가 strip ch-tracing

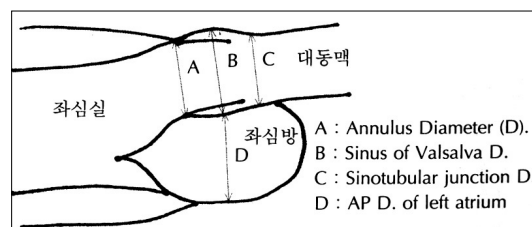
onscreen . 가 le -  
 ading edge leading edge (Fig. 2).  
 가  
 가 , trail edge  
 leading edge  
 leading edge trail edge ,  
 leading edge leading edge .  
 가  
 (parasternal short axis view) ,  
 chordae ten -  
 dineae  
 (Fig. 1).  
 M  
 leading edge leading edge  
 가  
 가 가



**Fig. 1.** Two-dimensional echocardiographic guidance for M-mode measurement.



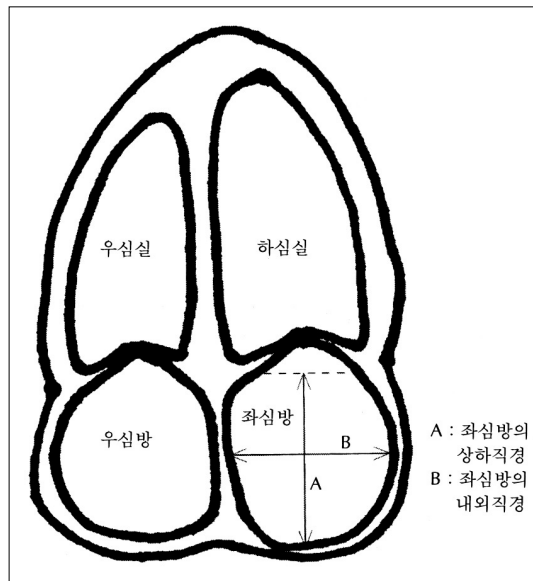
**Fig. 2.** M-mode echocardiographic measurement.



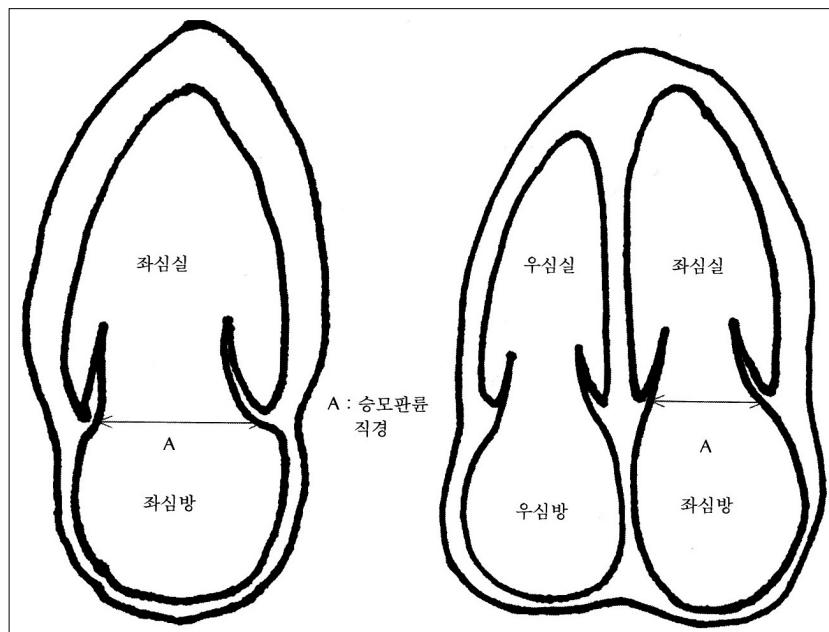
**Fig. 3.** Two-dimensional echocardiographic measurement of aorta and anteroposterior left atrial diameters at parasternal long axis view.

가 (parasternal long axis view) (Anteroposterior : AP diameter) (Fig. 3), (Superior : SI diameter) (Mediolateral : ML diameter) Fig. 4 (apical 4 chamber view) 2 (apical 2 chamber view) (Fig. 5).

(Aortic annulus), (Sinus of Valsalva) 가 (Sino-tubular junction) (Fig. 3).



**Fig. 4.** Two-dimensional echocardiographic measurement of superiorinferior and mediolateral diameters of left atrium at apical 4 chamber view.



**Fig. 5.** Mitral annulus diameter at apical 2 (left) and 4 (right) chamber views.

axis view) (parasternal short tracing 가 tr -

acing 20% ,

4 , sample volume disc가 가

0.5 1.0 cm 가 M -

(Atrial reversal flow) (D<sup>3</sup> formula)<sup>6)</sup> (modi -

fied D<sup>3</sup> formula)<sup>7)</sup> ,

(tip) sample vo - (left ventricular mass index)

(E velocity)

(A velocity) (E/A

ratio) (Deceleration time)

modal velocity

(Isovolumic relaxation time)

$$= 1.05 \times \frac{4}{3} \times \left\{ \left( \frac{LVEDD + PWT + IVST}{2} \right)^3 - \left( \frac{LVEDD}{2} \right)^3 \right\}$$

sample volume

$$= 1.04 \times \{ (LVEDD + PWT + IVST)^3 - LVEDD^3 \} - 13.6$$

2

LVEDD :

PWT (Posterior wall thickness) :

IVST (Interventricular septal thickness) :

100 mm/sec strip chart

on - screen 가

통계학적 측정방법

Oneway

ANOVA test , 가

, Post Hoc test Bonferroni test

가 p<0.05

가

±

foreshortening 가(unde -

restimation) , 4 가

가

결 과

가 371 ,

가 225 .

frame frame , 가 182 , 가 189 , 44

frame ( : 20 72 ), 60.7 kg(

가 frame : 40 kg 90 kg ), 163.4 cm(

method : 142 cm 183 cm ) .

of discs(modified Simpson's rule) <sup>5)</sup> ( ± ).

M형 심초음파 검사(단위 : mm)

- 1) IVST :  $8.8 \pm 1.73$ , 2) LVEDD :  $48.9 \pm 4.07$
- 3) PWT :  $8.4 \pm 1.54$ , 4) LVESD :  $31.1 \pm 3.85$
- 5) Aorta Diameter :  $29.0 \pm 3.70$
- 6) LA(left atrium) Diameter :  $35.5 \pm 4.68$
- 7) :  $151 \pm 40.9$  g( ),  $183 \pm 50.5$  g( )
- 8) :  $91 \pm 22.6$  g/M<sup>2</sup>( ),  $110 \pm 28.0$  g/M<sup>2</sup>( )

이면성 심초음파 검사(단위 : mm)

- 9) Aorta annulus Diameter :  $20.7 \pm 2.26$
- 10) Sinus of Valsalva Diameter :  $30.1 \pm 3.23$
- 11) Sinotubular Junction Diameter :  $25.4 \pm 3.32$
- 12) Anteroposterior(AP) Diameter of LA :  $29.1 \pm 5.44$
- 13) RV outflow tract(RVOT) Diameter :  $21.3 \pm 3.07$
- 14) Main pulmonary artery(PA) Diameter :  $21.6 \pm 3.31$
- 15) Superoinferior(SI) Diameter of LA :  $44.7 \pm 5.49$
- 16) Mediolateral(ML) Diameter of LA :  $37.9 \pm 5.27$
- 17) LV Volume(Diastole) :  $84.7 \pm 23.64$  mL
- 18) LV Volume(Systole) :  $35.2 \pm 13.99$  mL
- 19) Mitral Annulus(4 chamber) Diameter :  $27.9 \pm 4.39$
- 20) Mitral Annulus(2 chamber) Diameter :  $27.4 \pm 3.97$

도플러 심초음파 검사

- A. :  $99 \pm 21.7$  cm/sec  
(TVI) :  $20 \pm 4.4$  cm
- B. :  $73 \pm 17.1$  cm/sec
- C. :

	E velocity (cm/s)	A velocity (cm/s)	E/A ratio	IVRT (ms)	DT (ms)
	$75 \pm 16.0$	$55 \pm 18.1$	$1.5 \pm 0.52$	$92 \pm 21.8$	$183 \pm 38.1$
	$52 \pm 13.1$	$34 \pm 10.4$	$1.6 \pm 0.49$		$203 \pm 51.8$

- D. :

(cm/s)	$53 \pm 13.9$	$46 \pm 11.6$	$23 \pm 5.1$

연령에 따른 변화

가 , 가 , 가 ,  
가 , IVST, PWT, ,  
가 ,  
, LVEDD LVESD 가  
(Table 1).

가 , (AP diame -

**Table 1.** Change of M-mode echocardiographic indices with age group

Age (year)	20 - 29	30 - 39	40 - 49	50 - 59	60 -	Total
Index						
IVST (mm)*	$8.3 \pm 1.69$	$8.4 \pm 1.34$	$8.4 \pm 1.76$	$9.4 \pm 1.65^\dagger$	$9.7 \pm 1.70^\dagger$	$8.8 \pm 1.73$
PWT (mm)*	$8.0 \pm 1.61$	$8.0 \pm 1.33$	$8.2 \pm 1.62$	$8.9 \pm 1.31^\dagger$	$9.1 \pm 1.55^\dagger$	$8.4 \pm 1.54$
Aorta diameter (mm)*	$27.2 \pm 3.00$	$28.5 \pm 3.41$	$28.6 \pm 4.06$	$30.0 \pm 3.47$	$30.7 \pm 3.49^\dagger$	$29.0 \pm 3.70$
Left atrial diameter (mm)*	$32.9 \pm 3.43$	$34.3 \pm 3.67$	$34.5 \pm 4.34$	$37.3 \pm 4.36^\dagger$	$38.7 \pm 5.14^\dagger$	$35.5 \pm 4.68$
LVESD (mm)	$31.9 \pm 3.69$	$31.4 \pm 3.45$	$30.5 \pm 3.75$	$30.9 \pm 4.01$	$30.9 \pm 4.25$	$31.1 \pm 3.85$
LVEDD (mm)	$48.2 \pm 3.88$	$48.5 \pm 3.30$	$48.7 \pm 3.72$	$49.7 \pm 3.87$	$49.3 \pm 5.39$	$48.9 \pm 4.07$
LVM (g)*	$138 \pm 42.2$	$139 \pm 32.2$	$143 \pm 39.7$	$165 \pm 38.8^\dagger$	$169 \pm 39.9^\dagger$	$151 \pm 40.9$
LVMI (g/M <sup>2</sup> )*	$83 \pm 21.8$	$83 \pm 16.6$	$86 \pm 20.4$	$100 \pm 21.5^\dagger$	$105 \pm 23.1^\dagger$	$91 \pm 22.6$

\*Indices showed significant difference according to age group ( $p < 0.005$ ).

<sup>†</sup> Age group showed significant difference from at least 3 other age groups by Post Hoc test (Bonferroni Test) ( $p < 0.005$ ).

IVST : interventricular septal thickness, PWT : left ventricular posterior wall thickness, LVESD : left ventricular end systolic dimension, LVEDD : left ventricular end diastolic dimension, LVM : left ventricular mass by D<sup>3</sup> formula, LVMI : left ventricular mass index by D<sup>4</sup> formula

ter), (SI diameter),  
(Sinus of Valsalva diameter), Sinotubular  
junction , ,  
가 가 (Table 2).  
  
가 가 ,  
, 가 ,  
, E/A  
ratio (Table 3).  
가 ,  
가 (Table 3).  
  
고 찰  
  
가 1 - 4)  
가  
가  
19  
  
M  
  
가  
Feigenbaum 8) (St -  
andard convention)  
  
6)  
(Penn convention)  
가  
7)  
leading edge to trail  
edge , leading edge to leading

**Table 2.** Change of 2-dimensional echocardiographic indices with age group

Index	Age (year)						Total
	20 - 29	30 - 39	40 - 49	50 - 59	60 -		
Aortic annulus diameter (mm)	20.6 ± 2.44 <sup>†</sup>	20.7 ± 2.19	20.6 ± 2.33	20.7 ± 1.76	20.6 ± 2.59	20.7 ± 2.26	
Sinus of Valsalva diameter (mm)*	28.3 ± 3.09 <sup>†</sup>	29.5 ± 2.90	30.1 ± 3.21	31.2 ± 2.75	31.3 ± 3.23	30.1 ± 3.23	
Sinotubular junction diameter (mm)*	23.2 ± 2.62 <sup>†</sup>	25.1 ± 3.63 <sup>†</sup>	25.5 ± 3.16	26.6 ± 2.69	27.0 ± 3.11 <sup>†</sup>	25.4 ± 3.32	
Anteroposterior left atrial diameter (mm)*	26.3 ± 4.46	28.1 ± 5.07	28.6 ± 5.46	31.0 ± 5.13 <sup>†</sup>	31.7 ± 5.40 <sup>†</sup>	29.1 ± 5.44	
Mediolateral left atrial diameter (mm)	37.4 ± 5.14	37.3 ± 5.16	38.1 ± 5.69	37.9 ± 5.15	38.8 ± 5.16	37.9 ± 5.27	
Superoinferior left atrial diameter (mm)*	42.4 ± 5.08	44.4 ± 4.96	44.5 ± 5.47	46.3 ± 5.23	46.2 ± 5.91	44.7 ± 5.49	
Right ventricular outflow diameter (mm)*	20.3 ± 2.96	21.0 ± 2.90	21.7 ± 3.37	21.6 ± 3.09	22.1 ± 2.75	21.3 ± 3.07	
Main pulmonary artery diameter (mm)*	20.5 ± 2.86	21.3 ± 3.16	21.7 ± 3.23	21.9 ± 3.50	22.5 ± 3.53	21.6 ± 3.31	
Mitral annulus diameter in apical 4 chamber view (mm)	27.6 ± 4.70	27.6 ± 4.11	27.8 ± 4.83	27.9 ± 4.24	28.6 ± 4.05	27.9 ± 4.39	
Mitral annulus diameter in apical 2 chamber view (mm)	27.2 ± 4.34	27.1 ± 3.86	27.3 ± 4.20	27.3 ± 3.91	28.0 ± 3.47	27.3 ± 3.97	
Left ventricular end systolic volume (mL)	38.4 ± 19.70	36.2 ± 12.48	34.0 ± 10.98	34.2 ± 12.62	33.1 ± 11.42	35.2 ± 13.99	
Left ventricular end diastolic volume (mL)	81.7 ± 23.06	84.9 ± 23.58	84.0 ± 22.50	88.2 ± 24.57	84.6 ± 24.70	84.7 ± 23.64	

\*Indices showed significant difference according to age group (p<0.01).

<sup>†</sup> Age group showed significant difference from at least 3 other age groups by Post Hoc test (Bonferroni Test) (p<0.01).

**Table 3.** Change of Doppler echocardiographic indices with age group

Age (year)	Index	20 - 29	30 - 39	40 - 49	50 - 59	60 -	Total
Left ventricular outflow tract							
Vmax (cm/s)		98 ± 20.4	98 ± 20.3	101 ± 19.4	98 ± 23.5	101 ± 24.9	99 ± 21.7
VTI (cm)		19 ± 4.5	20 ± 4.3	20 ± 4.0	20 ± 4.1	21 ± 5.1	20 ± 4.4
Right ventricular outflow tract v <sub>max</sub> (cm/s)		78 ± 17.8	73 ± 15.3	74 ± 17.0	70 ± 16.5	72 ± 17.9	73 ± 17.1
Mitral valve							
E velocity (cm/s)*		82 ± 15.2 <sup>†</sup>	77 ± 16.4	75 ± 15.6	71 ± 14.7	69 ± 15.2	75 ± 16.0
A velocity (cm/s)*		43 ± 9.7	46 ± 9.6 <sup>†</sup>	55 ± 13.0 <sup>†</sup>	63 ± 19.2 <sup>†</sup>	72 ± 18.9 <sup>†</sup>	55 ± 18.1
E/A ratio*		2.0 ± 0.44 <sup>†</sup>	1.7 ± 0.46 <sup>†</sup>	1.4 ± 0.33 <sup>†</sup>	1.2 ± 0.33 <sup>†</sup>	1.0 ± 0.25 <sup>†</sup>	1.5 ± 0.52
IVRT (ms)*		80 ± 15.8 <sup>†</sup>	87 ± 21.0 <sup>†</sup>	92 ± 18.9 <sup>†</sup>	100 ± 23.6 <sup>†</sup>	105 ± 20.1 <sup>†</sup>	92 ± 21.8
DT (ms)*		165 ± 33.8 <sup>†</sup>	176 ± 38.6	178 ± 31.7	192 ± 34.4	205 ± 40.6 <sup>†</sup>	183 ± 38.1
Tricuspid valve							
E velocity (cm/s)*		58 ± 13.6 <sup>†</sup>	55 ± 13.6*	51 ± 12.0	48 ± 11.4	48 ± 12.0	52 ± 13.1
A velocity (cm/s)*		30 ± 10.5 <sup>†</sup>	33 ± 8.5	35 ± 9.7	35 ± 11.73	8 ± 10.2	34 ± 10.4
E/A ratio*		2.0 ± 0.50 <sup>†</sup>	1.7 ± 0.52 <sup>†</sup>	1.5 ± 0.36 <sup>†</sup>	1.4 ± 0.40 <sup>†</sup>	1.3 ± 0.34 <sup>†</sup>	1.6 ± 0.49
DT (ms)*		184 ± 38.7 <sup>†</sup>	188 ± 44.7	201 ± 57.4	212 ± 55.7	229 ± 47.7 <sup>†</sup>	203 ± 51.8
Pulmonary vein							
Systolic v <sub>max</sub> (cm/s)*		48 ± 12.7 <sup>†</sup>	49 ± 11.3 <sup>†</sup>	54 ± 13.6 <sup>†</sup>	56 ± 11.5 <sup>†</sup>	61 ± 12.2 <sup>†</sup>	53 ± 13.0
Diastolic v <sub>max</sub> (cm/s)*		53 ± 11.4 <sup>†</sup>	48 ± 11.5 <sup>†</sup>	44 ± 9.8	43 ± 10.8 <sup>†</sup>	42 ± 11.2 <sup>†</sup>	46 ± 11.6
Atrial reversal v <sub>max</sub> (cm/s)*		21 ± 5.4	22 ± 4.8	23 ± 5.4	24 ± 4.5	25 ± 4.9	23 ± 5.1

\*Indices showed significant difference according to age group (p&lt;0.005)

<sup>†</sup>Age group showed significant difference from at least 2 other age groups by Post Hoc test (Bonferroni Test) (p<0.05), V<sub>max</sub> : peak velocity, VTI : velocity-time integral, IVRT : isovolumic relaxation time, DT : deceleration time



edge  
trail edge to leading edge  
가

## 결 론

M in  
vitro leading edge to leading edge  
M - 가  
(ASE convention),<sup>9)</sup> 가<sup>10)</sup>  
leading edge to trail edge  
leading edge to leading edge

ASE convention

중심 단어 :

감사문

1997

가

,<sup>11)</sup>

가<sup>9)</sup>

12)

가

가

가

9)13)

가

가

14)

가

가

가

## REFERENCES

- 1) Park CH, Nam SH, Sohn RJ, Park YK, Lee BH, Lee CK, et al. Echocardiographic study in normal Korean. *Korean Circulation J* 1981;11:173-82.
- 2) Park JC, Hong KP, Rim CY, Koh YB, Lee Y. Echocardiographic evaluation of cardiac functions in normal Korean adults. *Korean Circulation J* 1989;17:265-71.
- 3) Ryu WS, Kim TH, Lee HJ, Kwon KI, Kang CS, Ryoo UH. The effect of aging on the left ventricular mass. *Korean Circulation J* 1989;19:405-12.
- 4) Lim SH, Kim SY, Kim AN, Lim YS, Kim YK, Park SH. A comparative study on the methods of echocardiographic measurement of left ventricular mass in normal subjects: M-mode, 2-dimensional area-length method and method using Simpson's rule. *Korean Circulation J* 1993; 23:341-9.
- 5) Schiller NB, Shah PM, Crawford M, DeMaria A, Devereux R, Feigenbaum H, et al. Recommendations for quantitation of the left ventricle by two-dimensional echocardiography. *J Am Soc Echocardiogr* 1989;2:358-67.
- 6) Troy BL, Pombo J, Rackley CE. Measurement of left ventricular wall thickness and mass by echocardiography. *Circulation* 1972;45:602-11.
- 7) Devereux RB, Reichek N. Echocardiographic determination of left ventricular mass in man: anatomic validation of the method. *Circulation* 1977;55:613-8.

- 8) Feigenbaum H, Popp RL, Chip JN, Haine CL. *Left ventricular wall thickness measured by ultrasound. Arch Int Med* 1968;121:391-5.
- 9) Sahn DJ, DeMaria A, Kisslo J, Weyman A. *Recommendations regarding quantitation in M-mode echocardiography: Results of a survey of echocardiographic measurements. Circulation* 1978;58:1072-83.
- 10) Wyatt HL, Haendchen RV, Meerbaum S, Corday E. *Assessment of quantitative methods for two dimensional echocardiography. Am J Cardiol* 1983;52:396-401.
- 11) Savage DD, Levy D, Dannenberg AL, Garrison RJ, Castelli WP. *Association of echocardiographic left ventricular mass with body size, blood pressure and physical activity. Am J Cardiol* 1990;65:371-6.
- 12) Nishimura RA, Tajik AJ. *Evaluation of diastolic filling of left ventricle in health and disease: Doppler echocardiography is the clinician's Rosetta stone. J Am Coll Cardiol* 1977;30:8-18.
- 13) Spirito P, Maron JB. *Influence of aging on Doppler echocardiographic indices of left ventricular diastolic function. Br Heart J* 1988;59:672-9.
- 14) Lee SC, Park SW, Choe SY, Gwon HC, Kim JS, Kim DK, et al. *Age-Associated Changes in Parameters of Mitral Annular Dynamics Assessed by Pulsed Doppler Myocardial Imaging. JACC Suppl. A, 2000;35:492.*