Relation between Aortic Stiffness and Left Ventricular Dyssynchrony in Hypertensive Patients with Preserved LV Systolic Function

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Background

- Increasing Aortic stiffness in hypertension
  - Increased systolic and pulse Pressure
  - Induced myocardial structural and functional changes
  - Considered as an important pathophysiology in Heart Failure with preserved Left Ventricular ejection fraction

- Prolonged LV systolic and diastolic dyssynchrony index has been found in hypertensive patients even with preserved LV systolic function, especially in patients with Left ventricular hypertrophy

Tan H, Zheng G, Li L, Wang Z, Gong H, Zhang Y, et al. Impaired left ventricular synchronicity in hypertensive patients with ventricular hypertrophy. J Hypertens 2008; 26:553–559.

- LV dyssynchronicity has been demonstrated in patients with LV dysfunction

Yu C-M, Zhang Q, Yip GWD, Lee P-W, Kum LCC, et al.:
Diastolic and systolic asynchrony in patients with diastolic heart failure.
J Am Coll Cardiol 2007;49:97–105

Aim of study

- To determine the relation of aortic stiffness and LV synchronicity in hypertensive patients with preserved LV systolic function.

Method

- 80 primary hypertensive patients
  - Definition of hypertension (in two seperated visit)
    - Systolic blood pressure>140mmHg
      Diastolic blood pressure>90mmHg
  - Aged from 25 to 77
  - Preserved systolic function (LVEF>50%)
  - QRS duration < 120 msec
- Left ventricular hypertropy
  - Men : LVMI>125g/m^2
  - Women: LVMI>110g/$m^2$3

Ref: 2007 guideline for arterial hypertension by ESC/ESH

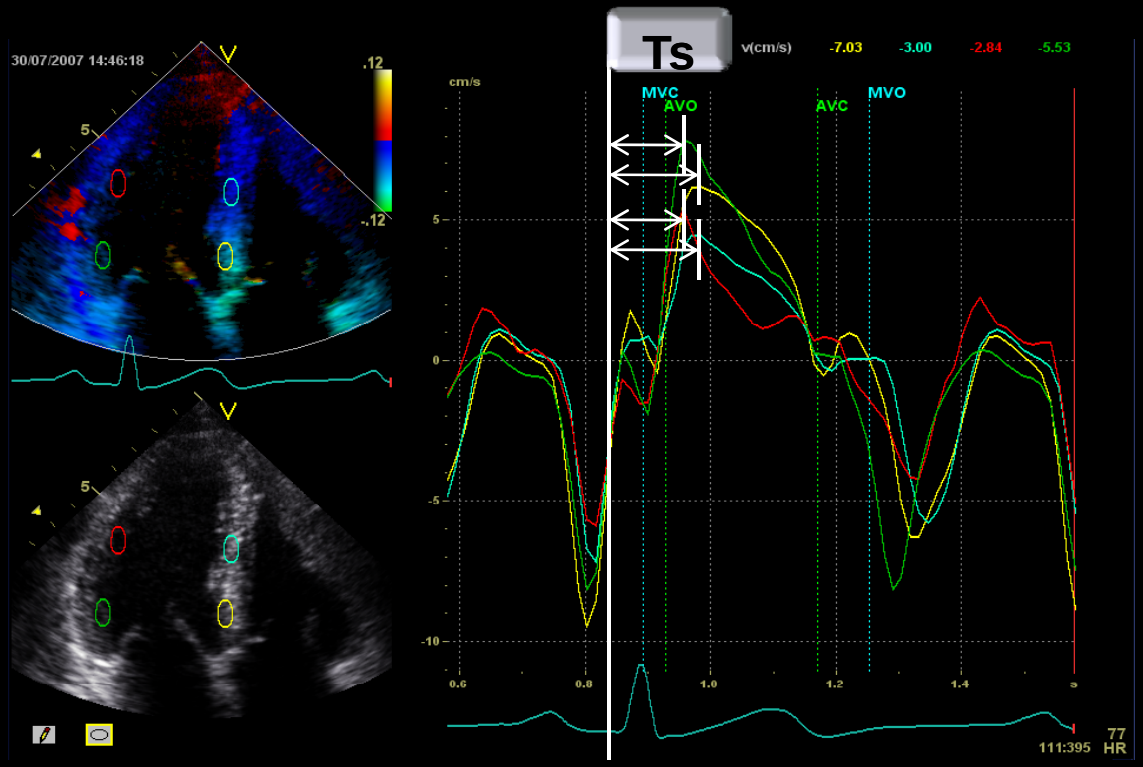
- Conventional echocardiography
  - commercially available equipment (Vivid 7; GE Vingmed Ultrasound AS, Horten,Norway) with 2.5~3.5MHz phased array transducer
  - standard echocardiographic examination:
    - LV systolic and diastolic dimensions, LV end-diastolic wall thicknesses, LV end-systolic volume and end-diastolic volume, LV ejection fraction using the modified biplane Simpson 's method
    - Pulsed-wave Doppler examination of mitral inflow
    - Pulsed-wave Doppler tissue imaging: Systolic (S') and early (E') and late (A') diastolicmitral annular velocities
- Color-coded tissue Doppler imaging
- Image analyzed software package (EchoPAC version 5.0.1; GE Medical Systems, Milwaukee, WI).

- **Exclusion criteria**
  - Evidence of Valvular heart disease
  - Ischemic heart disease
    - History- chest pain, exertional dyspnea
    - Ischemic ECG change: ST change
    - LV wall motion abnormality
  - Arrhythmia
  - congestive heart failure using Framingham criteria
  - chronic renal failure
  - other severe comorbidities that may affect cardiac function

- LV systolic dyssynchrony index

✓ Ts-SD: the standard deviation of time from QRS onset to peak myocardial systolic contraction velocity in 12 segments

✓ Ts-max: maximal differences of time from QRS onset to peak myocardial systolic contraction velocity in 12 segments

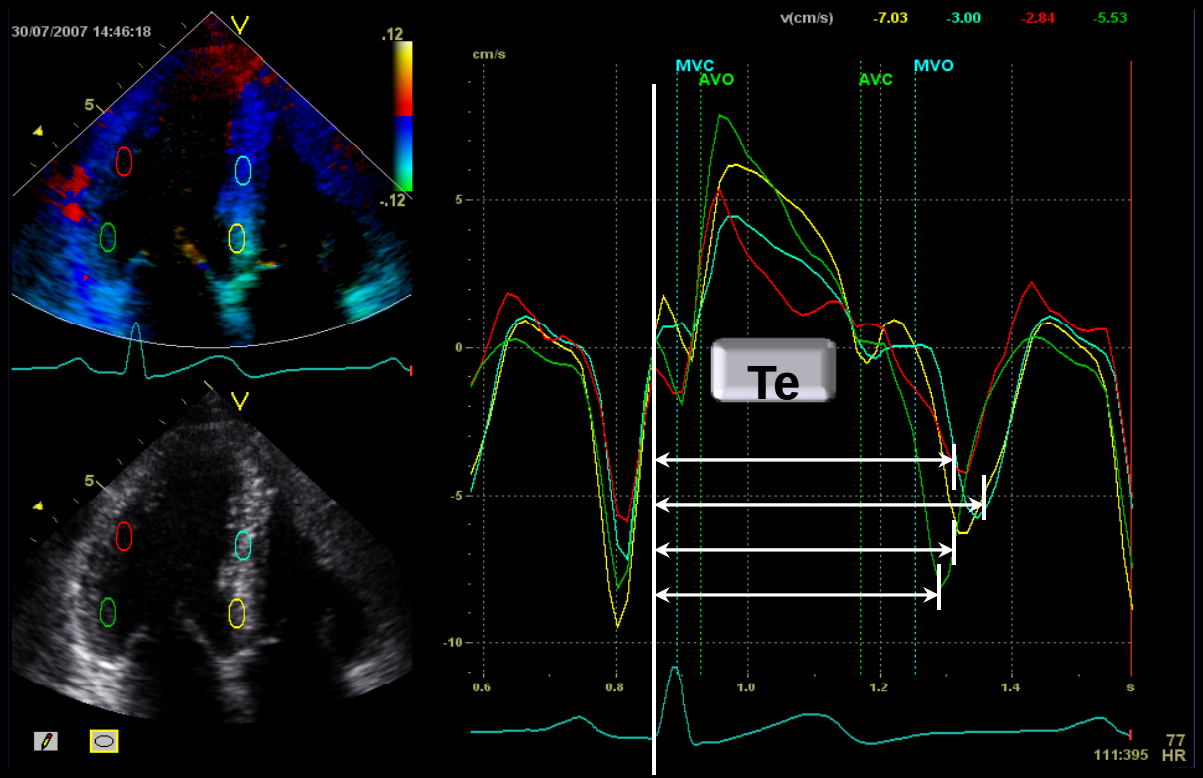


12 segment: Anterior, Anteroseptal, lateral, septal, posterior, inferior segment at basal and mid-level of LV in 3 apical view

- LV diastolic dyssynchrony index

✓ Te-SD: the standard deviation of time from QRS onset to peak myocardial diastolic contraction velocity in 12 segments

✓ Te-max: maximal differences of time from QRS onset to peak myocardial diastolic contraction velocity in 12 segments



12 segment: Anterior, Anteroseptal, lateral, septal, posterior, inferior segment at basal and mid-level of LV in 3 apical view

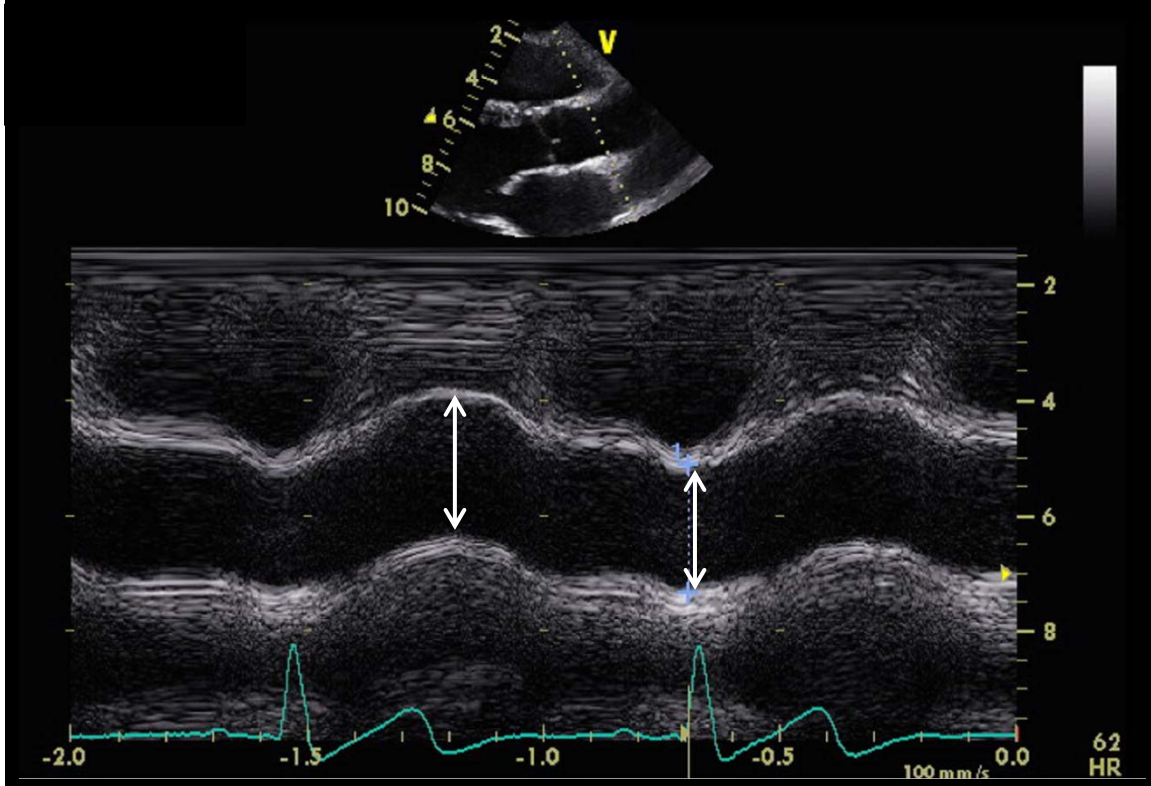
- Aortic stiffness parameters

Aortic strain (%) = (AoS - AoD) *100 / AoD

Aortic root distensibility($10^{-6}cm^2dyn^{-1}$)

$= 2 \times (AoS - AoD)/(SBP - DBP) \times AoD$

Aortic stiffness index = ln (SBP/DBP)/ (AoS– AoD)/AoD



- Aortic systolic diameter (AoS) and diastolic diameter(AoD) were measured at 3cm above aortic valve

Result

- Baseline characteristics

Variable	Nomal (N=11)	Patients with hypertension(N=80)	p-value
Age (yr)	57.7±5.5	55.8±10	0.571
Men	7(60%)	33(41%)	
Diabetes mellitus	2(18%)	11(13.8%)	
Body surface area (m^2)	1.6±0.16	1.7±0.19	0.752
Systolic BP (mm Hg)	115±11.7	140.5±19	<0.001
Diastolic BP (mm Hg)	77±11	87.9±13	0.011
Pulse pressure (mm Hg)	38.7±5.6	52.5±13	<0.001
Hypertension Duration (month)	—	62.9±78.8	0.015
QRS duration (msec)	94.8±19.5	91.8±10	0.812

Antihypertensive treatment	
Antihypertensive medication	72 (90%)
ACEi or ARB	43 (53.8%)
β- blocker	24 (30%)
Calcium channel blocker	47 (58.8%)
Diuretics	18 (22.5%)
Vasodilator (NO)	3 (3.8%)
2 medication combination	34 (42.5%)
3 medication combination	12 (15%)
4 medication combination	1 (1.3%)

2D and M-mode data

Variable	Nomal (N=11)	Patients with hypertension(N=80)	P-value
IVSd (mm)	9.6 ±1.45	10.24 ±1.3	0.535
LVPWd (mm)	9.7 ±1.27	10.1 ±1.1	0.860
LVIDd (mm)	47.2 ±3.0	46.4 ±4.1	0.212
LVISd (mm)	26.4±2.9	26.8 ±5.3	0.465
LA (mm)	31±10.5	35 ±5.1	0.243
LV mass index (g/m²)	95.7 ±13.6	123.1 ±22.4	<0.001
LVEF (%)	64.8 ±6	57.9 ±2.8	<0.001
E (m/s)	59.5 ±12.2	60.8 ±16.2	0.961
A (m/s)	63.9±18	66.3 ±15.4	0.45
DT (m/s)	210 ±38.2	227 ±46	0.197
E/A ratio	0.98 ±0.29	0.96 ±0.3	0.697
E′ (m/s)	6.8±1.5	5.9±1.8	0.090
A′ (m/s)	9±2.2	8.2 ±1.5	0.237
E/E′	8.6 ±2.2	10.7 ±3.7	0.046

Dyssynchrony index			
Variable	Nomal (N=11)	Patients with hypertension(N=80)	P-value
Ts - SD	27.2 ± 22.7	31.9 ± 18.3	0.037
Ts - Max	72.6 ± 54.2	89.8 ± 51	0.030
Te - SD	16.7 ± 4.5	21.3 ± 11.3	0.041
Te - Max	54.7 ± 14.9	67.9 ± 33.7	0.076

Aortic stiffness parameter			
Variable	Nomal (N=11)	Patients with hypertension(N=80)	P-value
Aortic strain	9.5± 4.2	8.1± 4.9	0.091
Aortic distensibility	4.9± 2	3.3± 2.3	0.003
Aortic stiffness index	5.2± 2.4	8.2± 6.3	0.022

- LV systolic dyssynchrony index and age, 2-D echocardiographic parameters, diastolic dyssyncrony index, aortic stiffness paramenter

Systolic synchrony indexes (n=91)			
	Variable	R	P-value
Ts- SD	Age	0.289	0.006
	Te-SD	0.075	0.478
	Te-Max	0.143	0.177
	E	0.242	0.021
	A	0.281	0.007
	E/A	-0.37	0.729
	E/E'	0.447	<0.00
	E'	-0.233	0.026
	A'	-0.178	0.091
	DT	0.058	0.585
	LVMI	0.259	0.014
	Aortic strain	-0.154	0.146
	Aortic distensibility	-0.162	0.125
	Aortic stiffness index	0.033	0.757

Systolic synchrony indexes (n=91)			
	Variable	R	P-value
Ts-Max	Age	0.303	0.004
	Te-SD	0.127	0.232
	Te-Max	0.196	0.062
	E	0.208	0.048
	A	0.268	0.01
	E/A	-0.5	0.642
	E/E'	0.426	<0.00
	E'	-0.256	0.014
	A'	-0.149	0.158
	DT	0.05	0.639
	LVMI	0.266	0.011
	Aortic strain	-0.178	0.092
	Aortic distensibility	-0.188	0.075
	Aortic stiffness index	0.067	0.523

- LV diastolic dyssynchrony index and age, 2-D echocardiographic parameters, systolic dyssyncrony index, aortic stiffness paramenter

Diastolic synchrony indexes (n=91)			
	Variable	R	P-value
Te- SD	Age	0.219	0.037
	Ts-SD	0.075	0.478
	Ts-Max	0.127	0.232
	E	-0.345	0.001
	A	0.167	0.114
	E/A	-0.4.2	<0.00
	E/E'	0.106	0.318
	E'	-0.396	<0.00
	A'	0.064	0.257
	DT	0.431	<0.00
	LVMI	0.319	0.004
	Aortic strain	-0.253	0.015
	Aortic distensibility	-0.219	0.037
	Aortic stiffness index	0.245	0.019

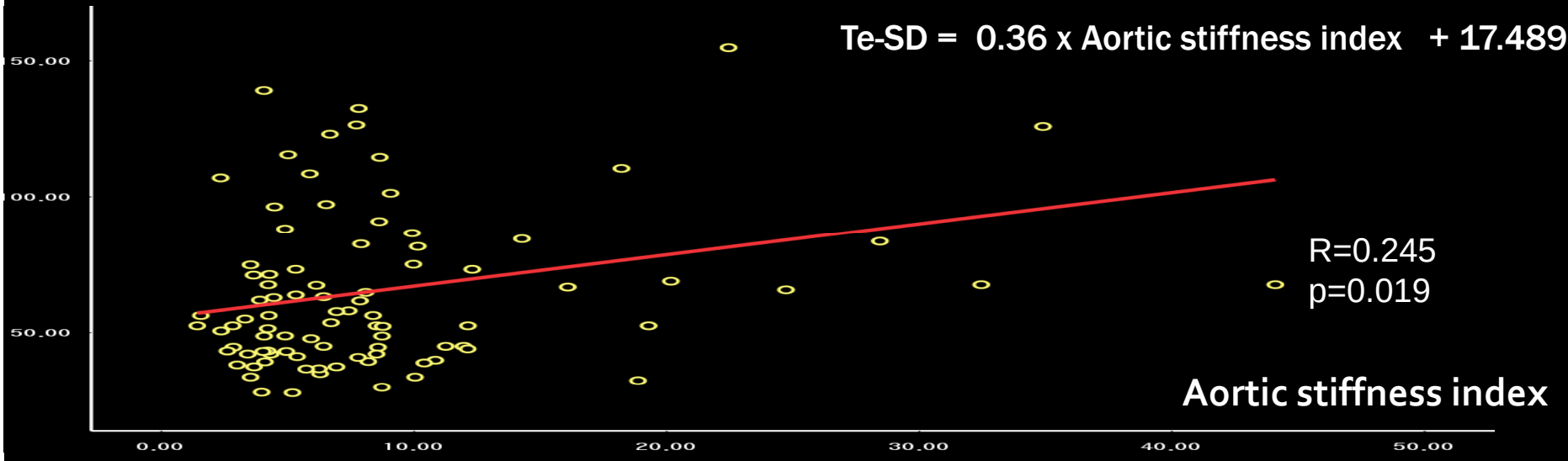
Diastolic synchrony indexes (n=91)			
	Variable	R	P-value
Te-Max	Age	0.254	0.015
	Ts-SD	0.143	0.177
	Ts-Max	0.196	0.062
	E	-0.323	0.002
	A	0.222	0.034
	E/A	-0.45	<0.00
	E/E'	0.176	0.095
	E'	-0.414	<0.00
	A'	0.079	0.454
	DT	0.392	<0.00
	LVMI	0.368	0.001
	Aortic strain	-0.270	0.010
	Aortic distensibility	-0.233	0.026
	Aortic stiffness index	0.264	0.012

Aortic stiffness index relation (n=91)

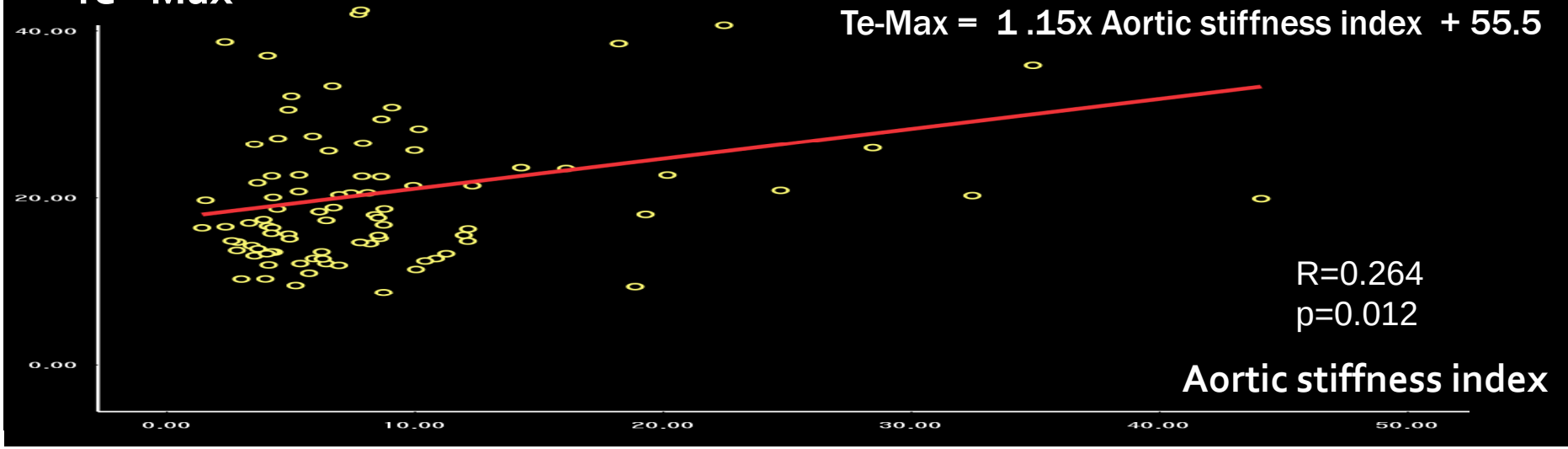
	Variable	R	P-value
Aortic Stiffness index	Age	0.153	0.149
	Hypertension duration	-0.019	0.867
	Pulse Pressure	0.448	<0.001
	Ts-SD	0.033	0.757
	Ts-Max	0.067	0.528
	Te -SD	0.245	0.019
	Te-Max	0.264	0.012
	E	-0.172	0.103
	A	0.109	0.302
	E/A	-0.24	0.023
	E/E′	0.132	0.212
	E′	-0.285	0.006
	A′	-0.058	0.588
	DT	-0.054	0.61
	LVMI	0.193	0.068

- Relation of diastolic dyssynchrony index and aortic stiffness

Te - SD



Te - Max



- Age, 2-D echocardiographic parameters between LVH group and Non-LVH group

	Normal (n=11)	NLVH group (n=34)	LVH group (n=46)	P-value
Age (yr)	57.7±5.6	52.5±10	58±10	0.03
SBP (mmHg)	115.5±11.7	137±19.2	142±19.8	<0.001
DBP (mmHg)	77±10.9	88±13	87±13.3	0.032
Ejection fraction (%)	64.1±6.9	57.8±2.7	58±2.9	<0.001
LVMI (g/m2)	95.7±13.6	105±11.7	136±19	<0.001
E (cm/s)	59.5±12.2	62.5±16.6	59.6±15.9	0.694
A (cm/s)	63.9±18	61.6±16	69±14	0.62
DT (ms)	210±38.2	215.3±47.8	236.9±43.3	0.053
E/E′	8.6±2.2	10.3±2.5	11±4.4	0.153

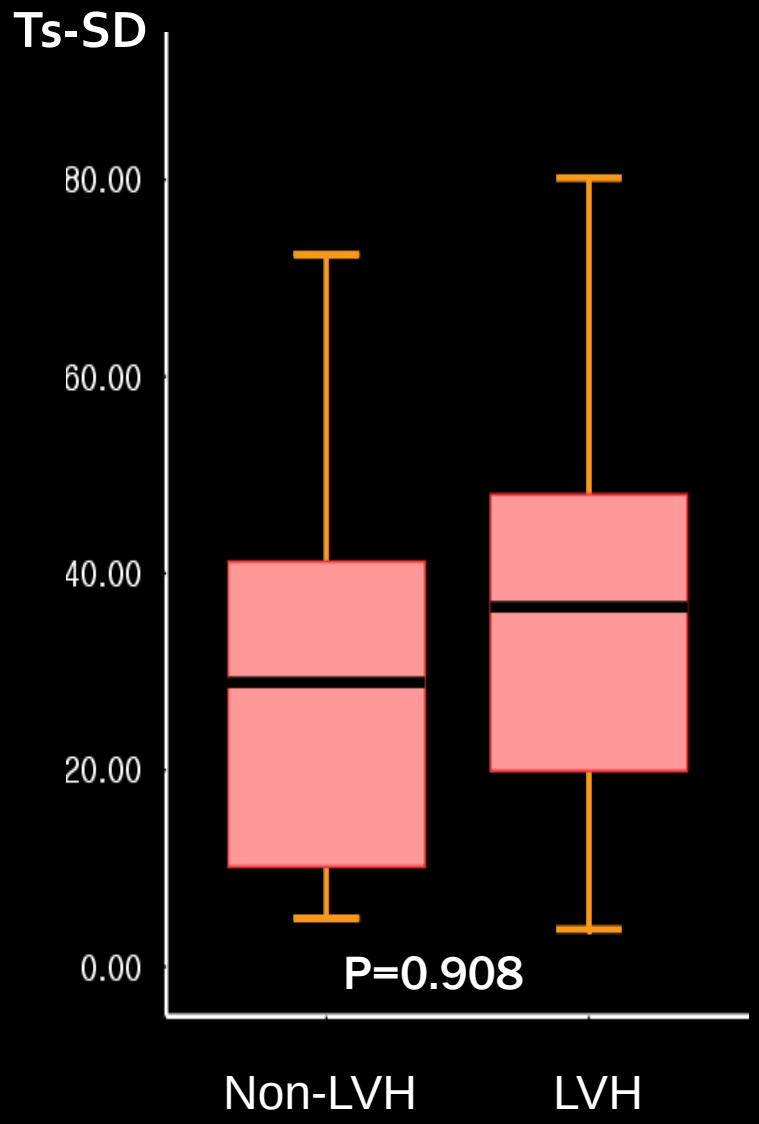
- Dyssynchrony index between LVH group and Non-LVH group

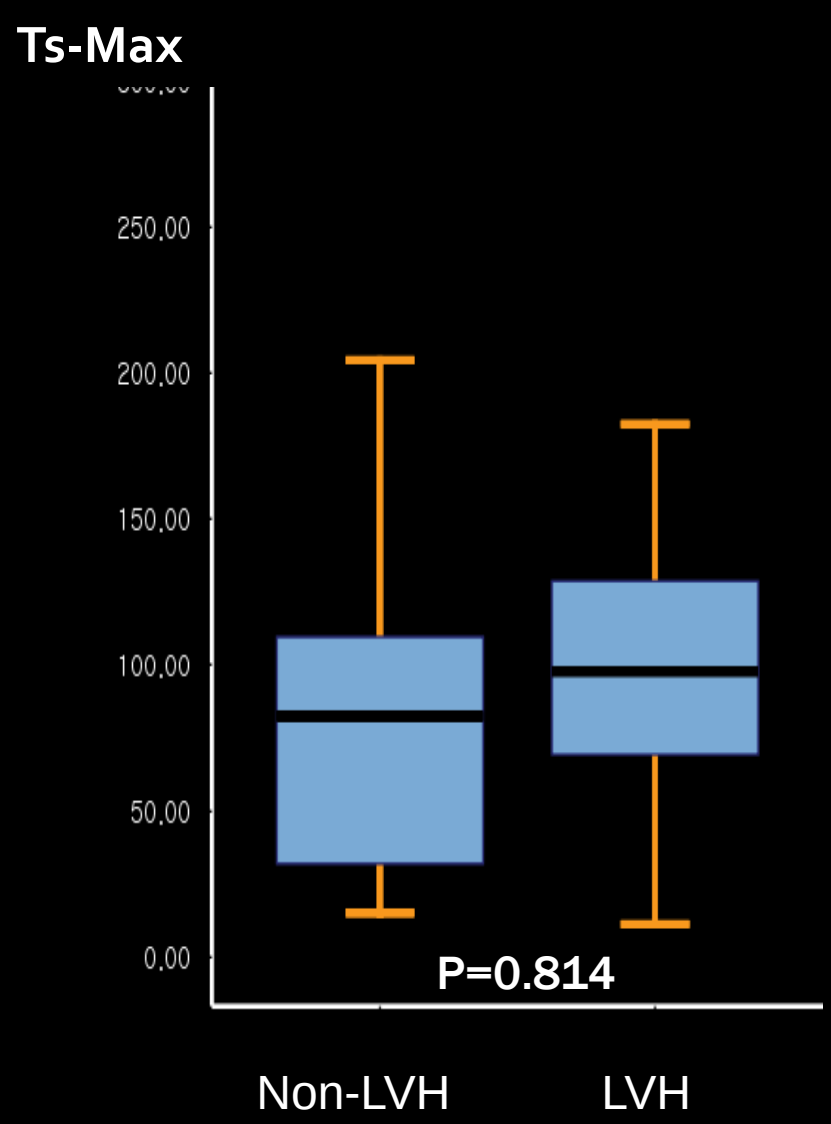
	Normal (n=11)	NLVH group (n=34)	LVH group (n=46)	P-value
Ts-SD (msec)	19.7±15.18	28.3±17.9	34.5±18.3	0.036
Ts_max (msec)	55.9±38.4	79±46.7	97.8±53.1	0.028
Te-SD (msec)	15.5±4.32	17.9±6.7	23.8±13.3	0.012
Te max (msec)	49.1±10.7	56.8±24	76.1±37	0.005

- Aortic stiffness parameter between LVH and Non-LVH group

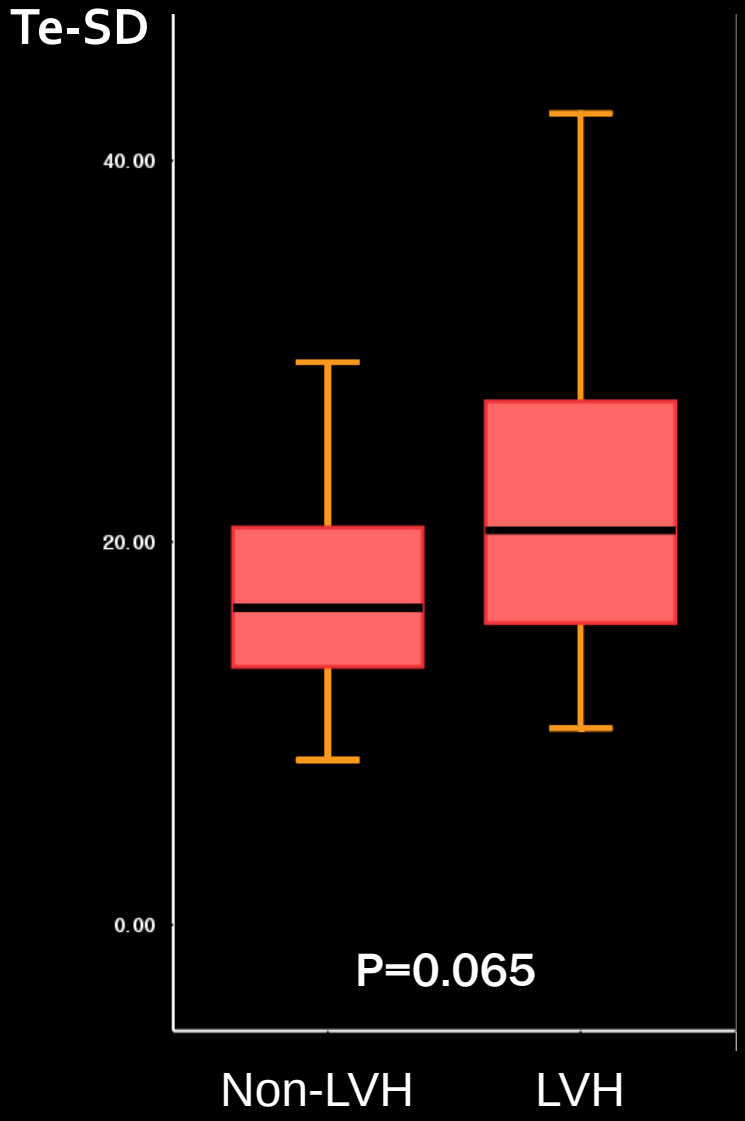
	Normal (n=11)	NLVH group (n=34)	LVH group (n=46)	P-value
Aortic strain	9.8±4.8	9.1±5.3	6.1±3.1	0.002
Aortic distansibility	5.0±2.2	4.0±2.5	2.4±1.5	>0.000
Aortic stiffness index	5.2±2.6	6.4±4.9	11.4±8.7	0.002

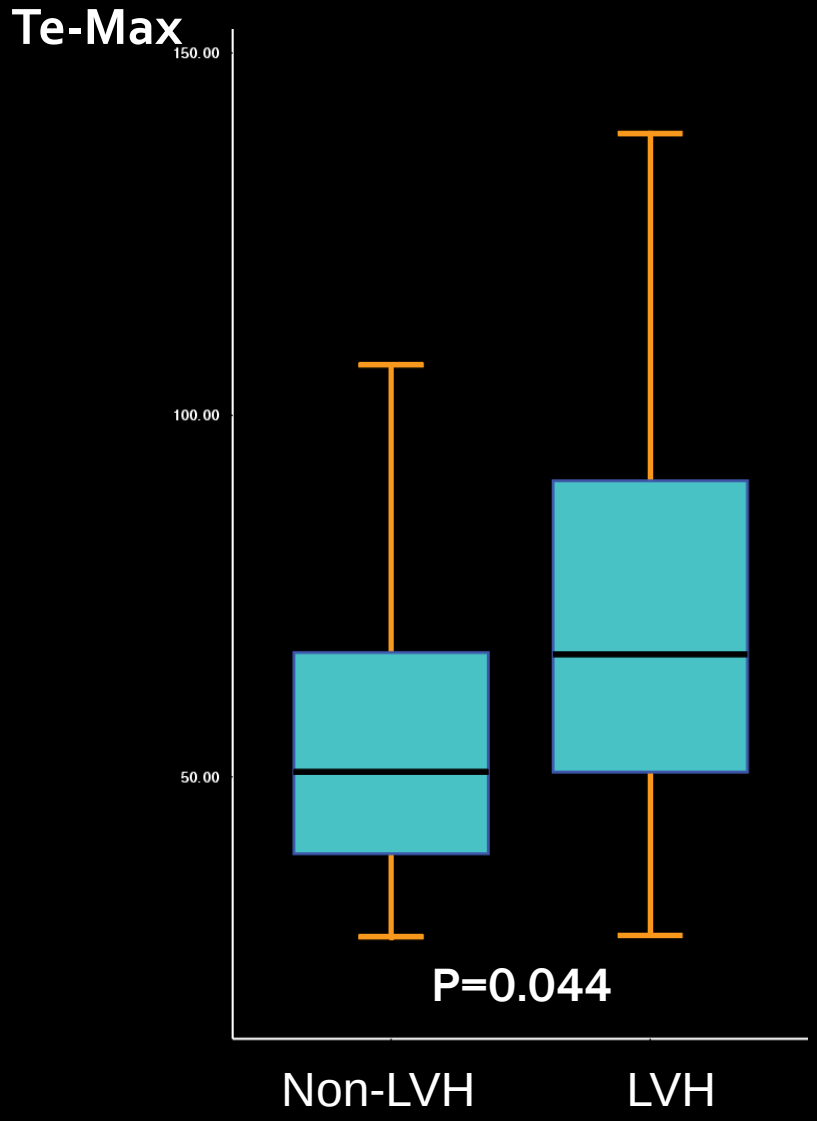
- Comparison of LVH and non- LVH group



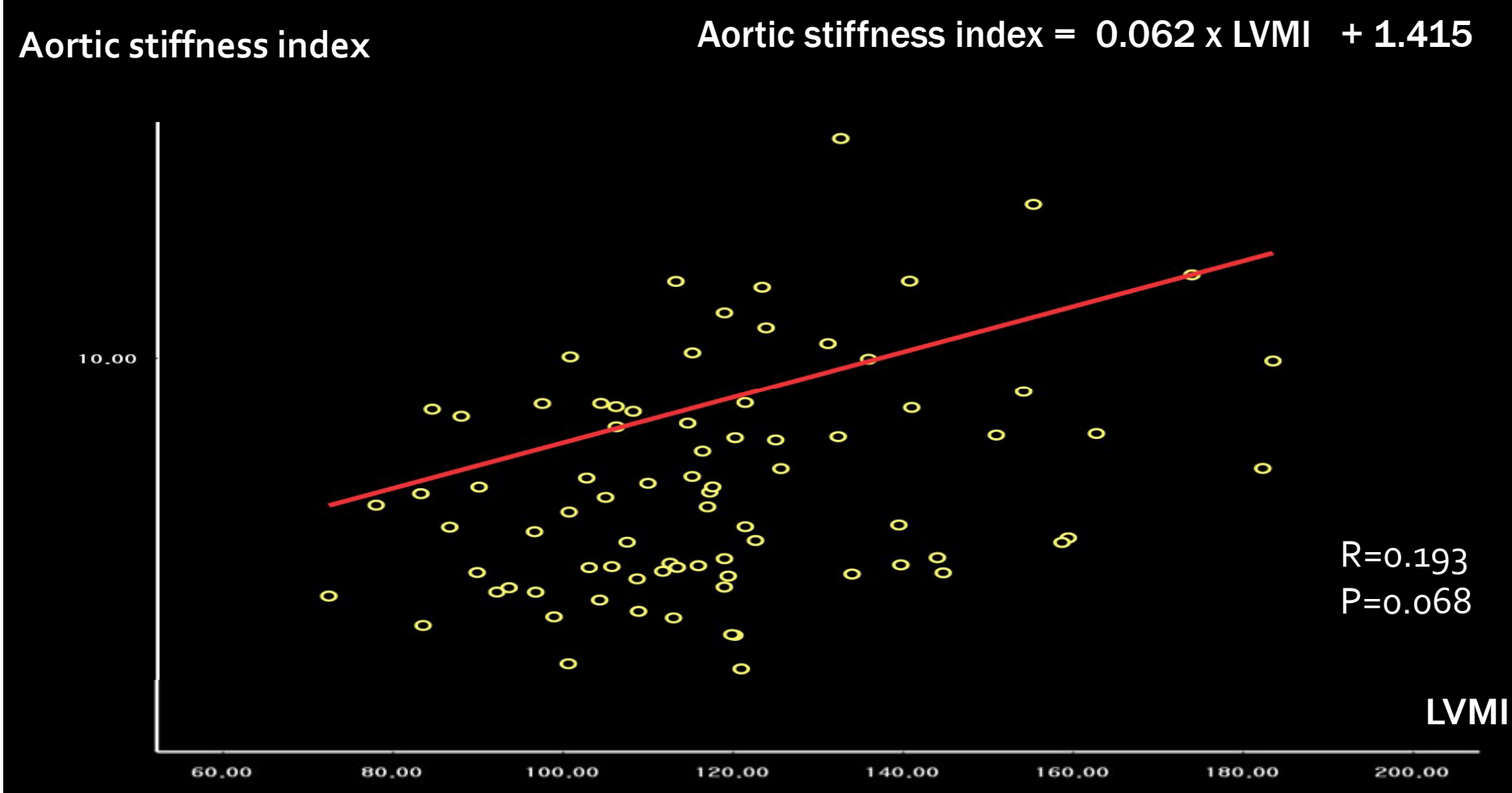


- Comparison of LVH and non- LVH group





- Relation of Aortic stiffness and LVMI



Summary

- Systolic and diastolic dyssynchrony index was greater and in hypertensive patient than that of control

- Aortic stiffness index was higher in hypertensive patients than that of control

- Diastolic dyssynchrony index was associated E’ , E/A, Deceleration time, LVMI
- Aortic stiffness index was associated E’ , E/A and tend to related LVMI
- Aortic stiffness index was related to LV diastolic dyssynchrony index, but not related to LV systolic dyssynchrony index

- In hypertensive patients, aortic stiffness index and LV diastolic dyssynchrony index was higher in patients with LVH

- In hypertensive Patient without LVH, aortic stiffness parameter was higher than that of control

Conclusion

- LV dyssynchronous change and diastolic dysfunction may be caused by increased LV mass and Arterial stiffness