

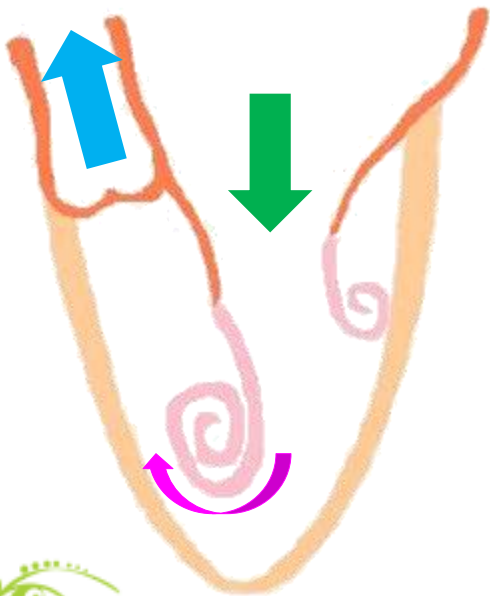
Change of Vortex Flow Characteristics with Aging in Normal Population

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Jong-Min Song, Duk-Hyun Kang, Jae-Kwan Song

**Asan Medical Center
University of Ulsan College of Medicine**

Background

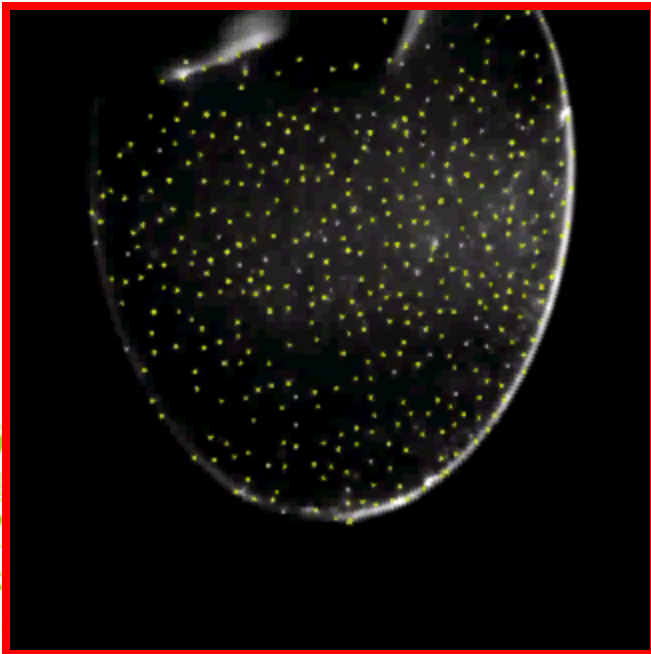
Intraventricular Flow



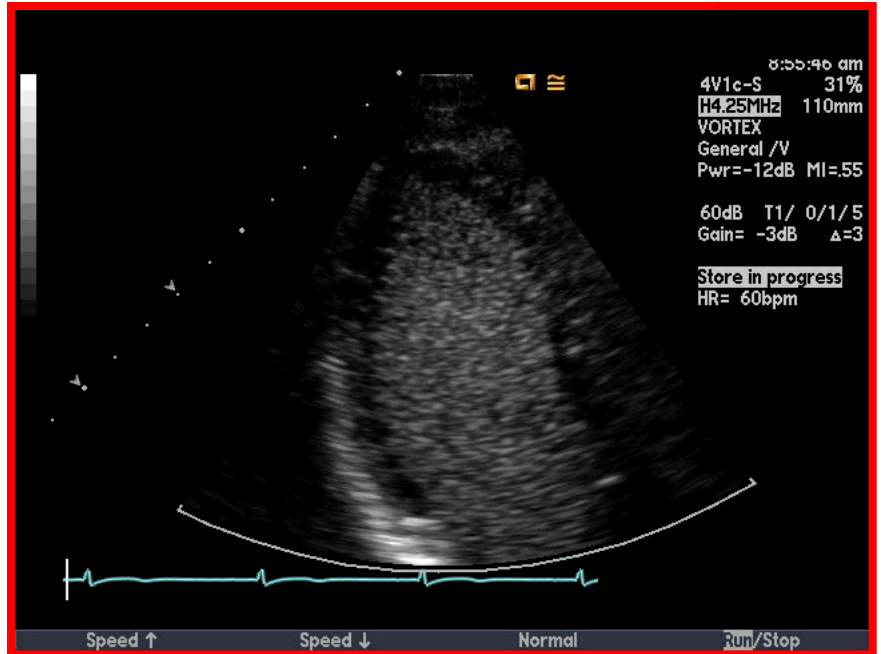
- Transmitral flow produce an intraventricular vortex ring
- Vortex supports more efficient fluid transport compared with a straight jet alone

Visualization of Vortex

Particle Imaging Velocimetry

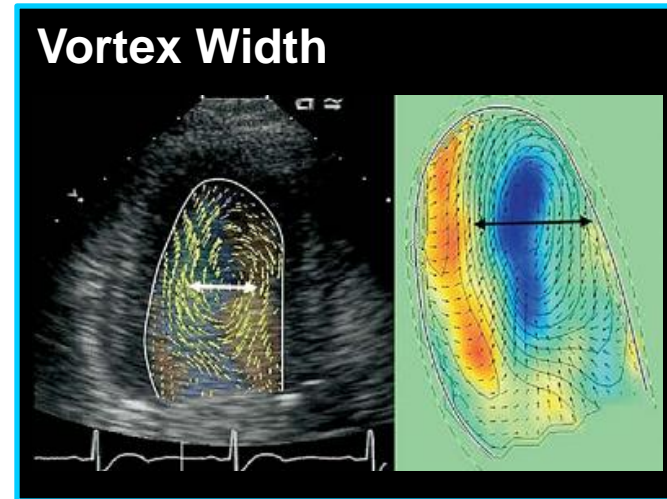
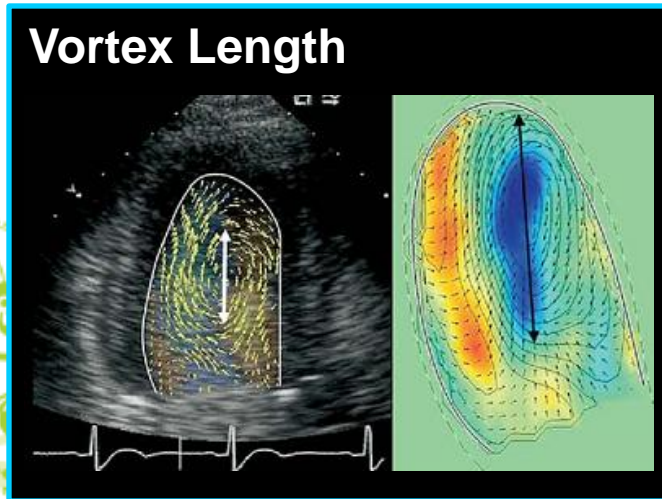
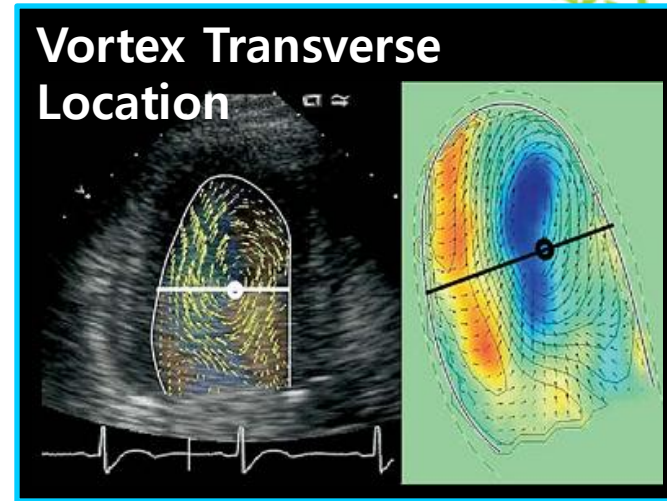
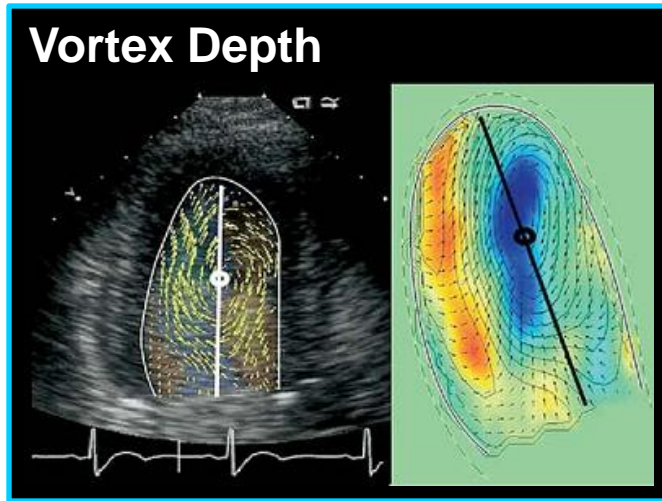


Contrast Echocardiography



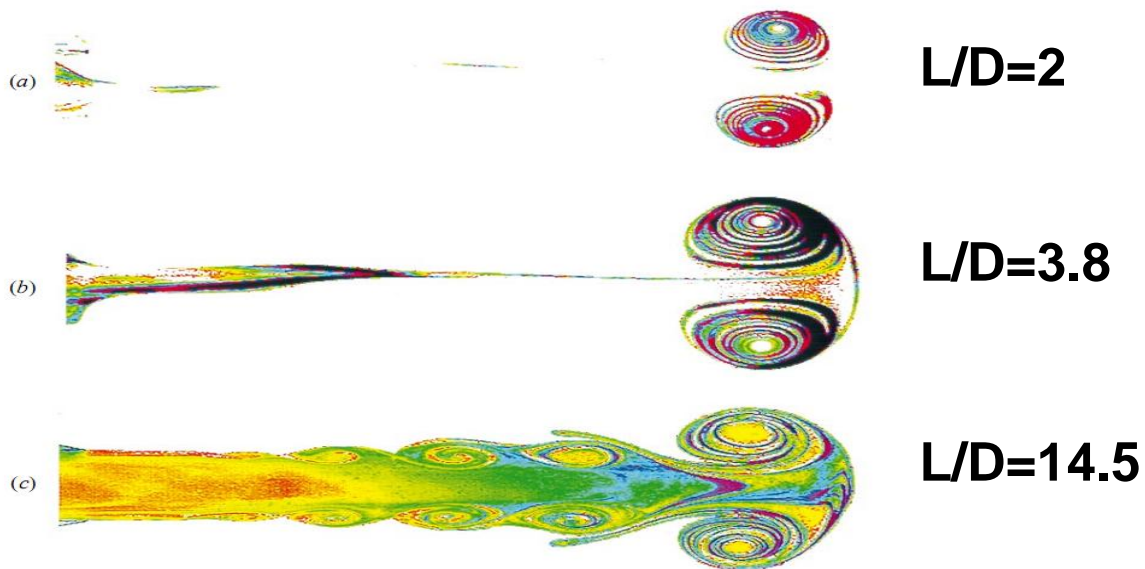
courtesy G. Querzoli, A. Cenedese
(Univs. Cagliari & Rome, Italy)

Quantification of Vortex



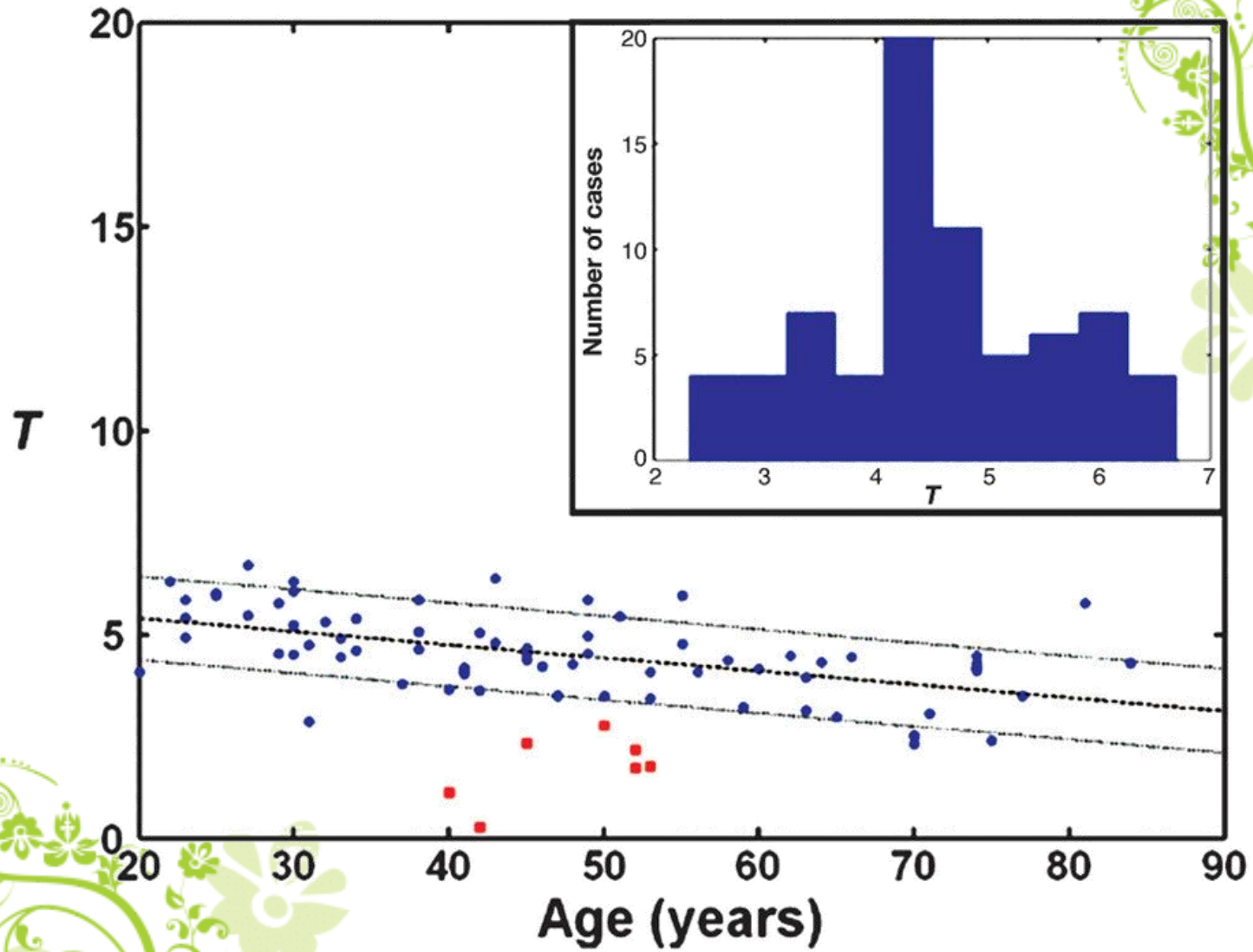
Index of the Optimal Vortex Formation

- Vortex formation time (VFT)



❖ An indicator of cardiac health

Gharib et al. Proc Natl Acad Sci USA 2006;103:6305-8



Objective

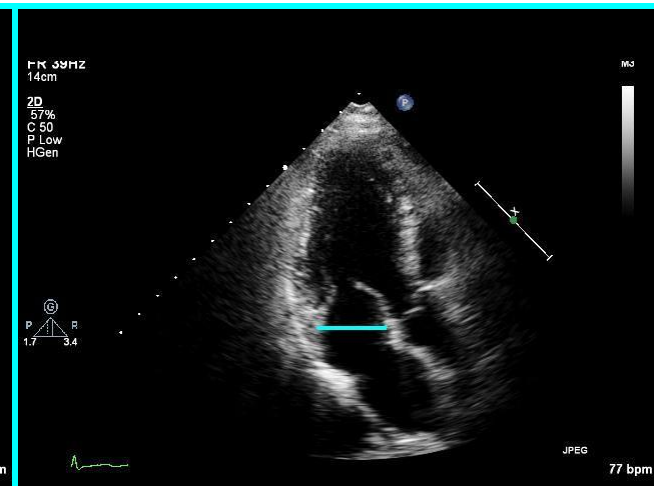
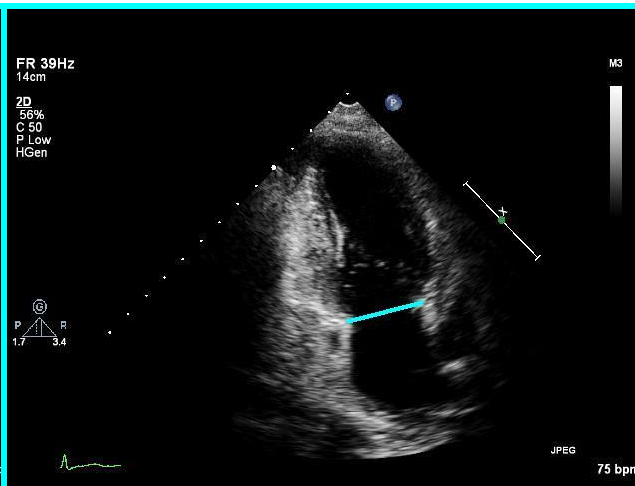
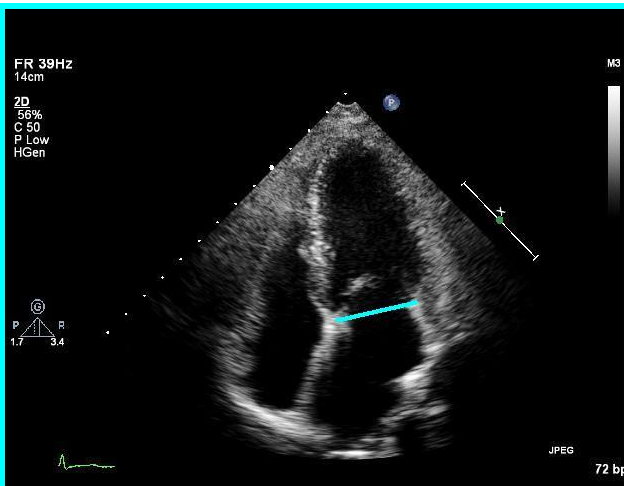
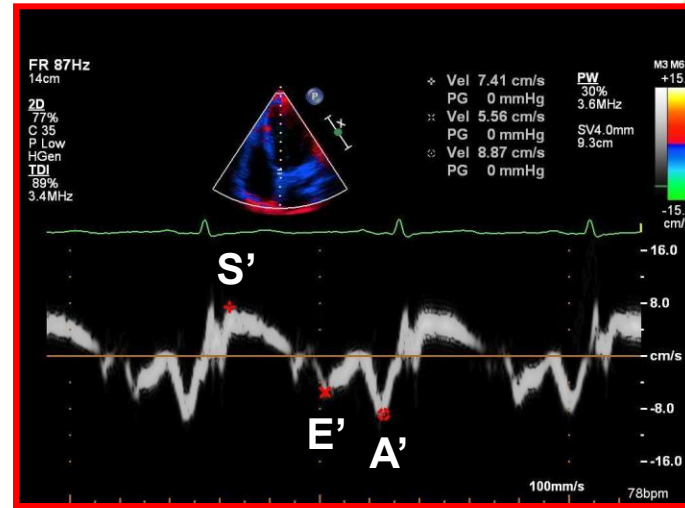
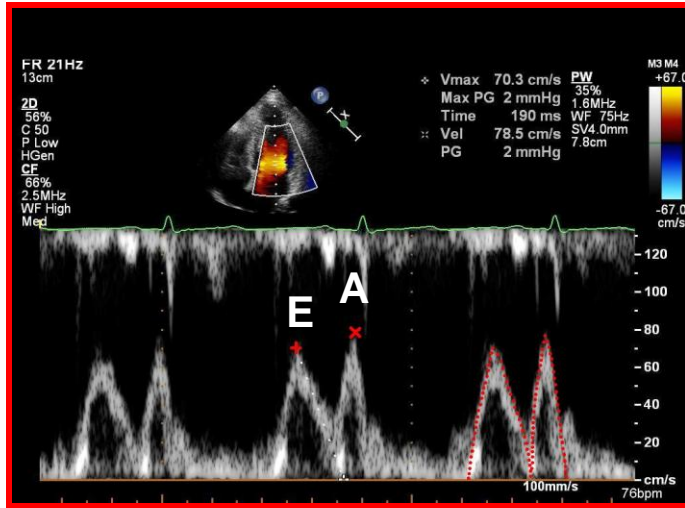
- To define the normal physiologic change of vortex characteristics with aging
- To clarify the relationship between characteristics of vortex and other Doppler indices

Study Population



- One hundred-forty normal populations (48.5 ± 14.6 years, 47 males) were included
- Exclusion criteria
 - Medical history of hypertension, diabetes or ischemic heart disease
 - LV ejection fraction < 50%
 - Significant arrhythmia
 - Significant valvular disease
 - Inability to obtain adequate echocardiographic examination

Echocardiography Examination



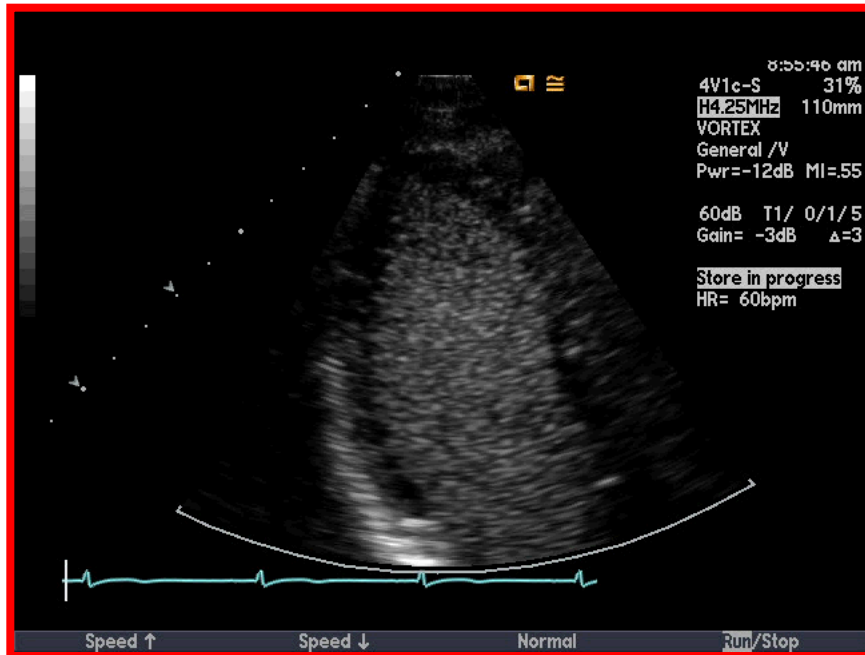
eas Index

$$E'/(A' \times S')$$

- Combined index of diastolic & systolic performance
- Powerful & independent predictor of death

Circulation 2009;119:2679-2685

Contrast Echocardiography



- ❖ Contrast agent
 - : Home-made perfluorocarbon exposed sonicated dextrose albumin (PESDA)
- ❖ System settings
 - ✓ Mechanical index:0.4-0.6
 - ✓ High frame rate (minimum 60 Hz)
 - ✓ Minimum 3 beats acoustic capture
- ❖ Apical long axis view

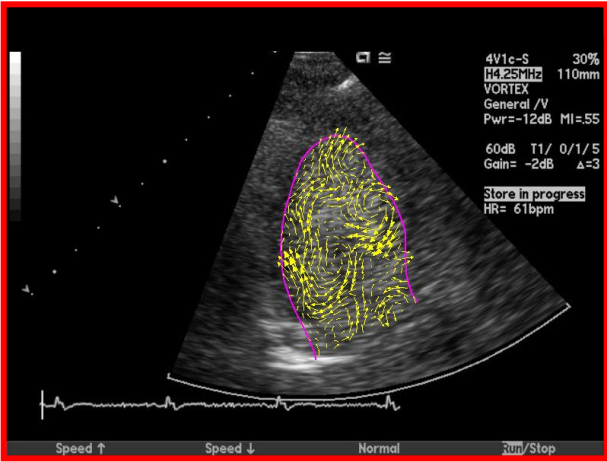
Vortex Flow Analysis

- Quantitative parameter by Omega Flow
 - ❖ Vortex length (VL), vortex width (VW), sphericity index (SI, VL/VW)
- Vortex Formation Index
 - ❖ $VFT = 4(1-\beta)/\pi D^3 \times SV$
 - ✓ β : fraction of SV contributed from the atrial component of LV filling
 - ✓ D: mitral orifice diameters
 - ✓ SV: stroke volume

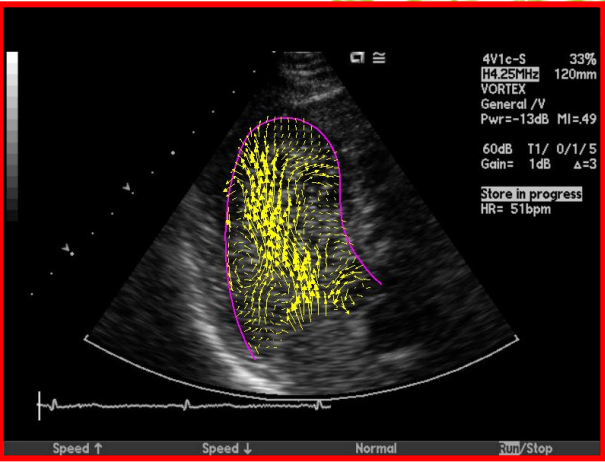
Change of Intraventricular Flow by Aging



28-year

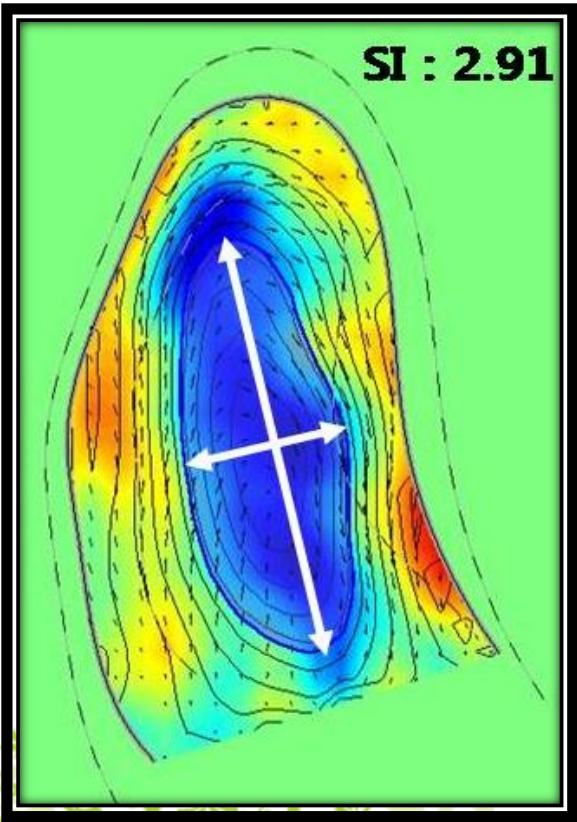


53-year

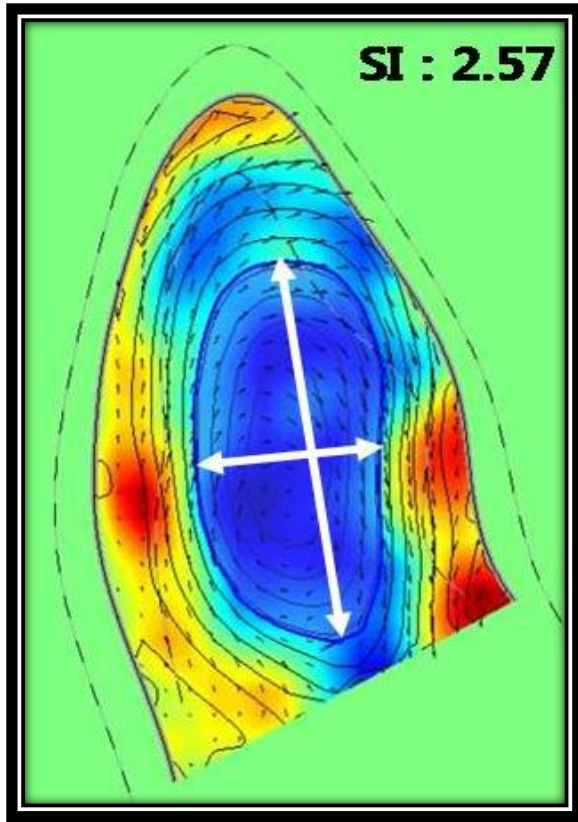


65-year

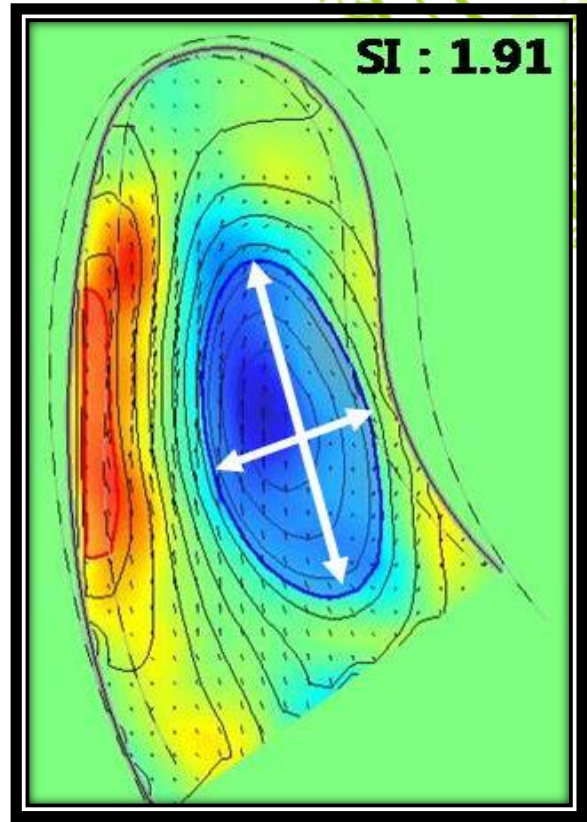
Change of Intraventricular Flow by Aging



28-year



53-year

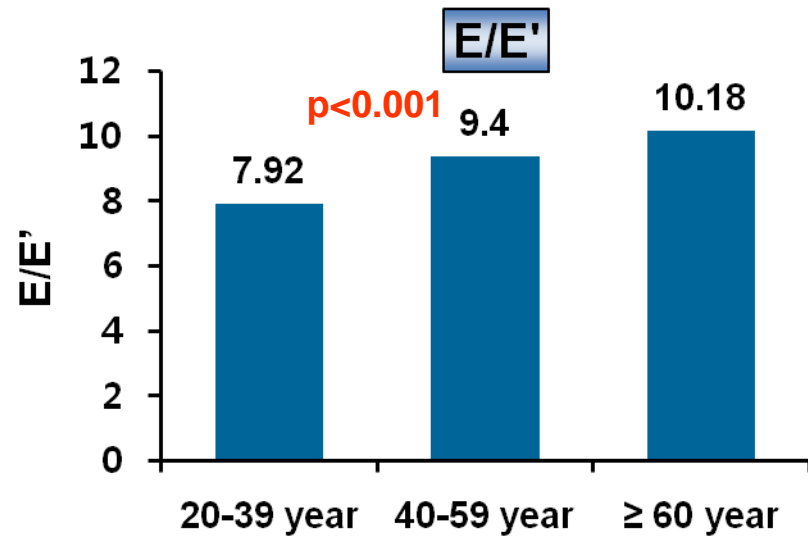
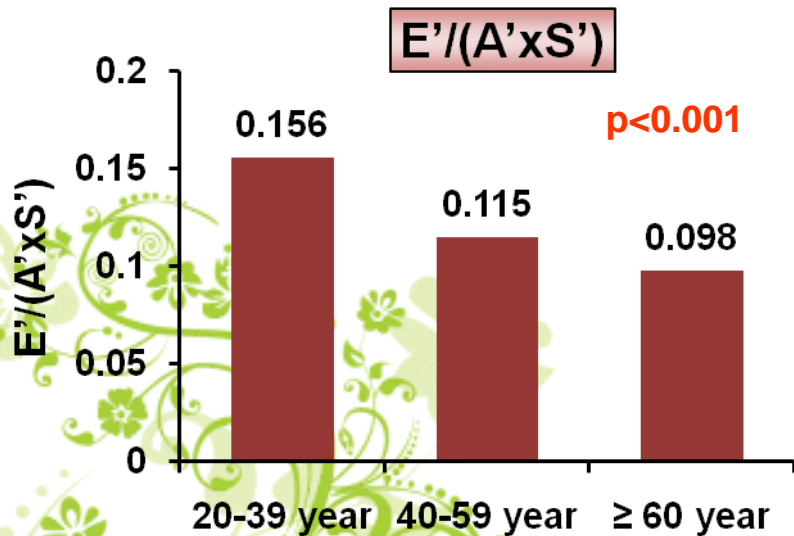
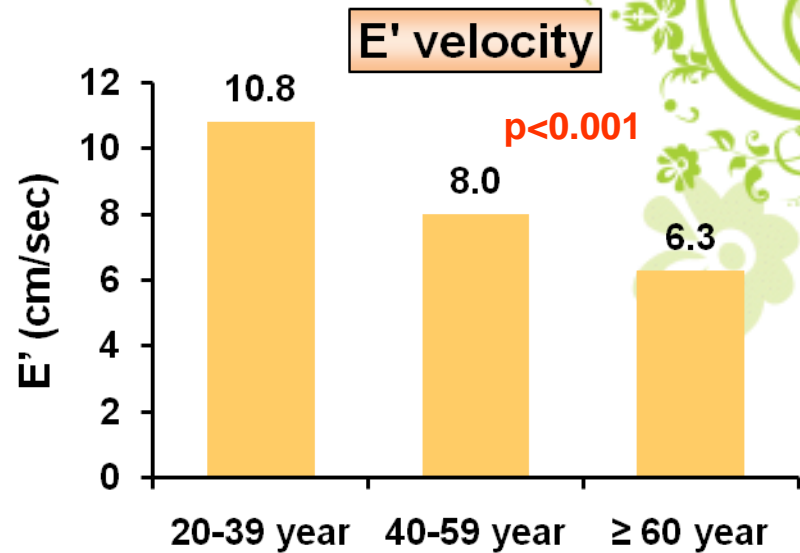
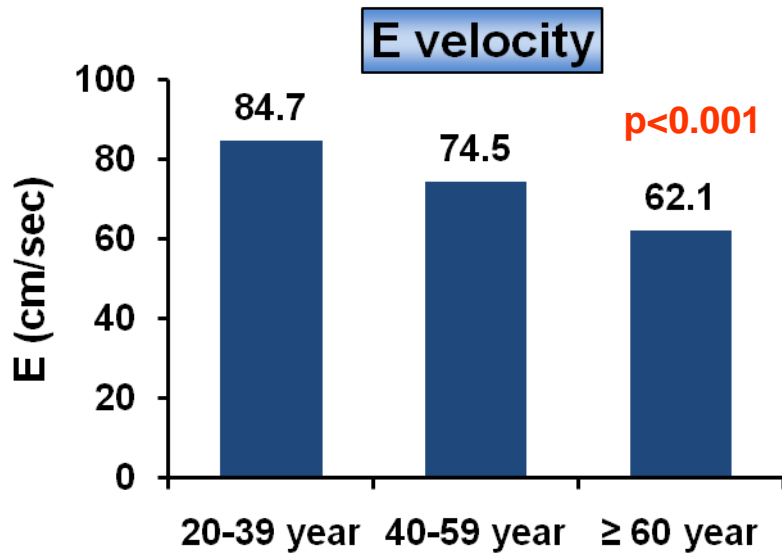


65-year

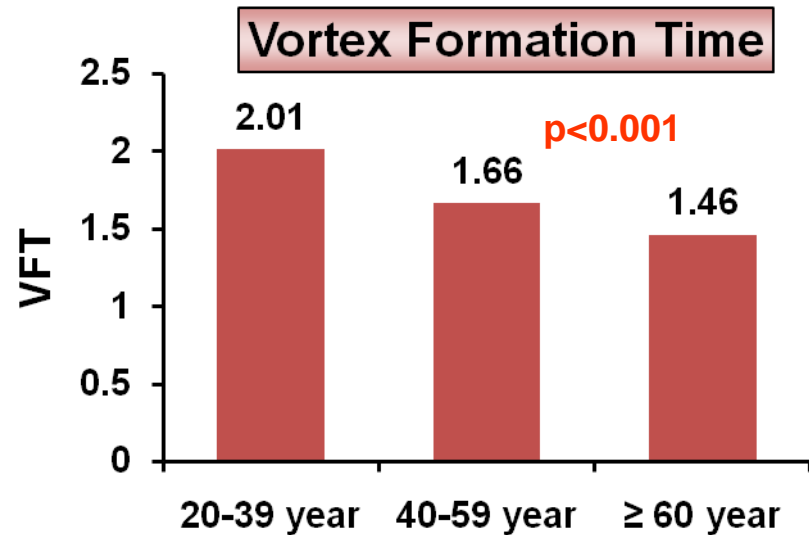
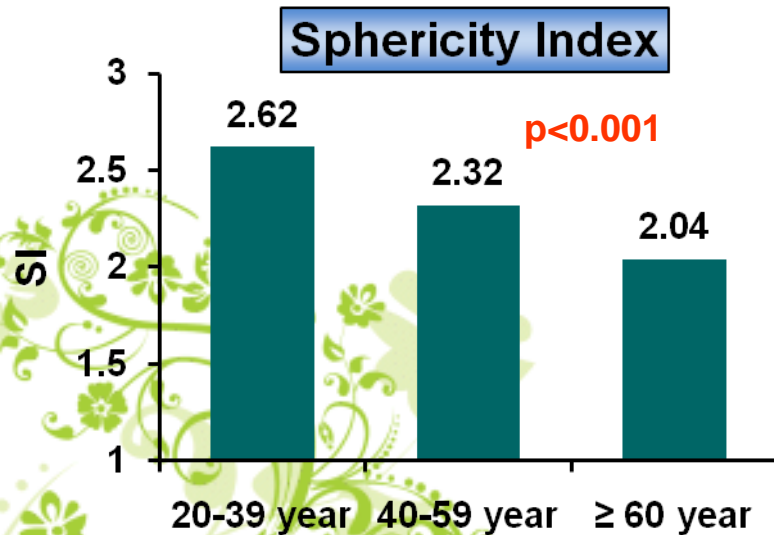
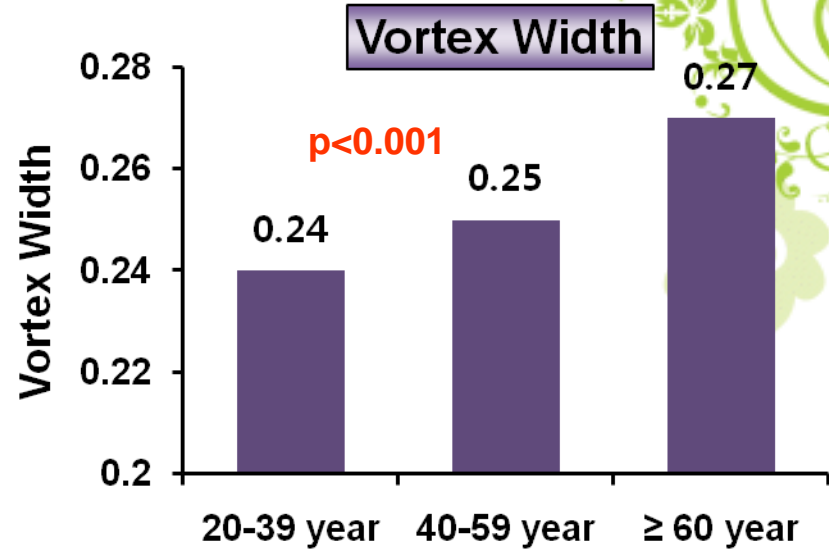
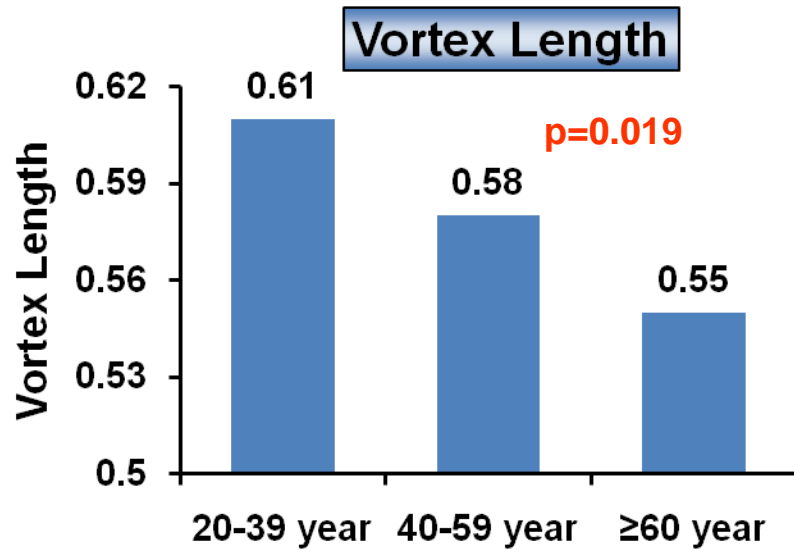
Comparison of LV Geometry

	20-39 years (n=50)	40-59 years (n=46)	≥ 60 years (n=44)	P-value
Age, years	31.6±5.0	51.4±5.7	64.8±3.8	<0.001
Male, n(%)	13 (26.0)	14 (30.4)	20 (45.5)	0.124
BSA, m ²	1.6±0.2	1.7±0.2	1.6±0.2	0.743
LV ESD, mm	30.4±2.8	30.0±3.7	29.5±3.8	0.456
LV EDD, mm	48.2±3.3	49.1±4.8	48.7±4.7	0.572
LV ESV, ml	35.7±8.6	33.6±9.6	32.4±9.3	0.200
LV EDV, ml	92.0±20.2	88.6±21.0	86.4±22.1	0.431
LV EF, %	61.2±3.3	62.2±3.9	62.6±3.5	0.165

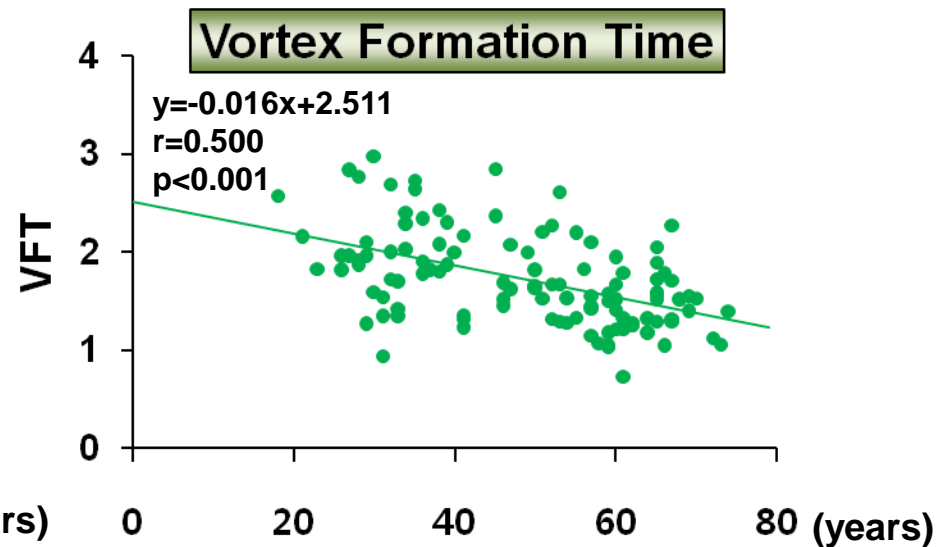
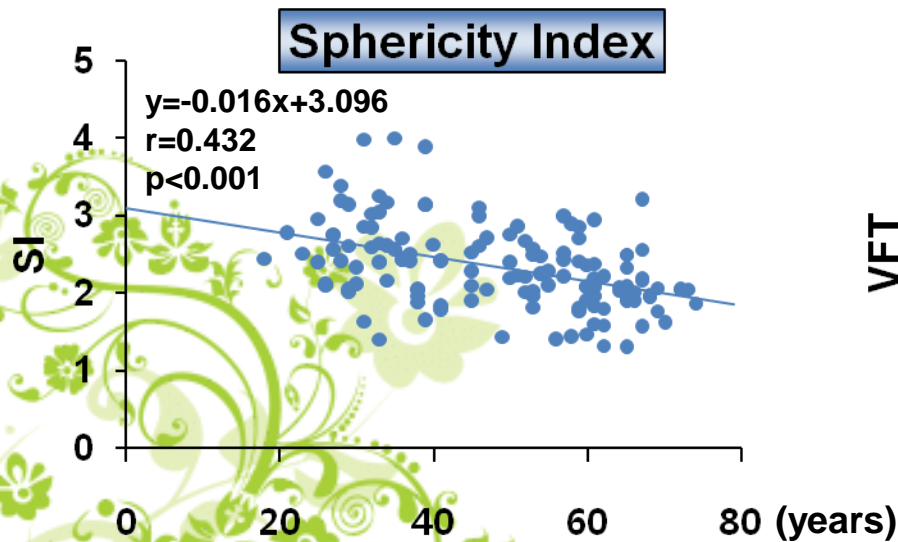
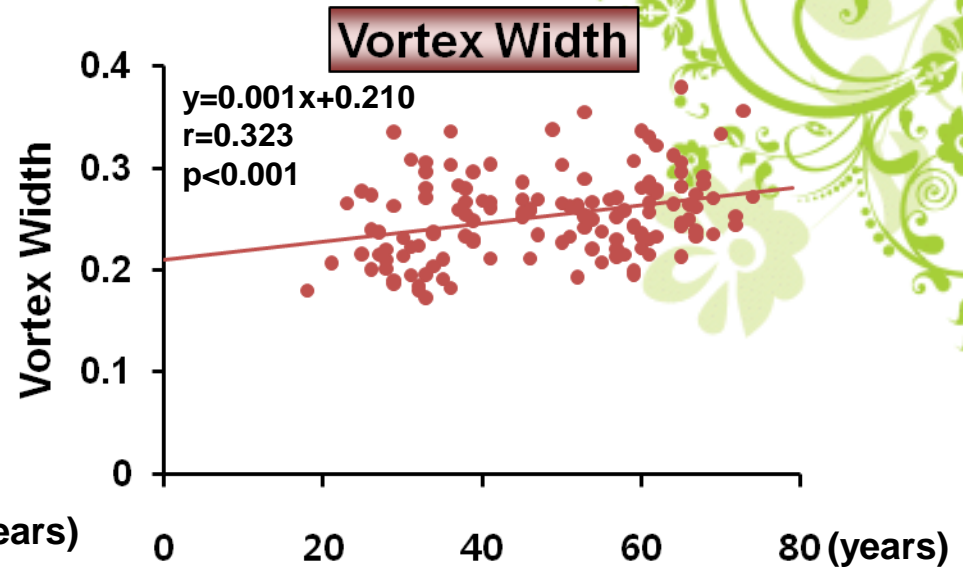
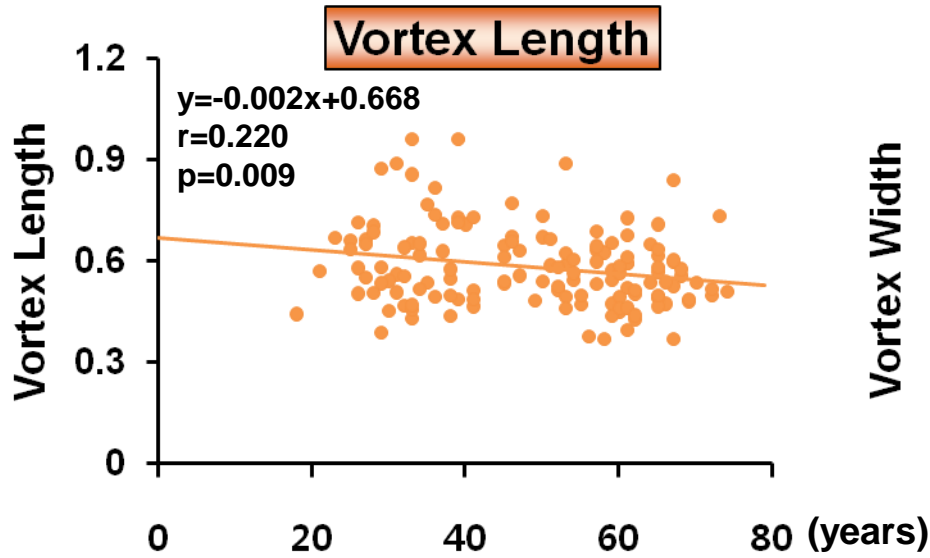
Comparison of Doppler Index



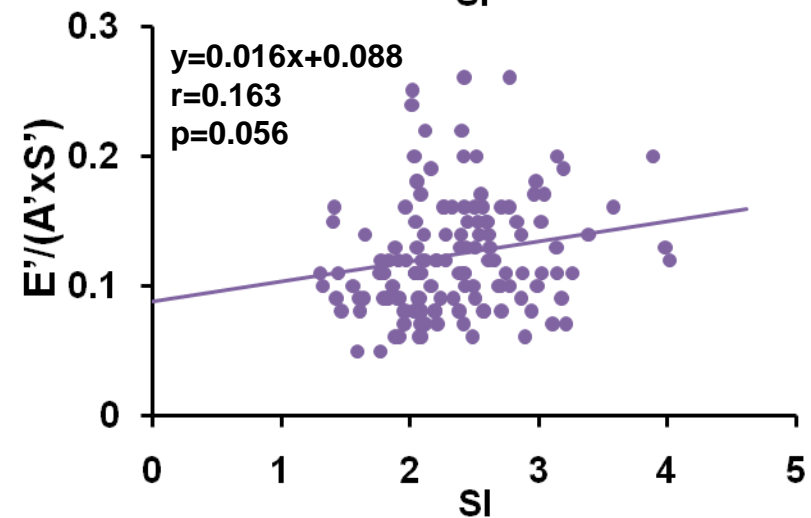
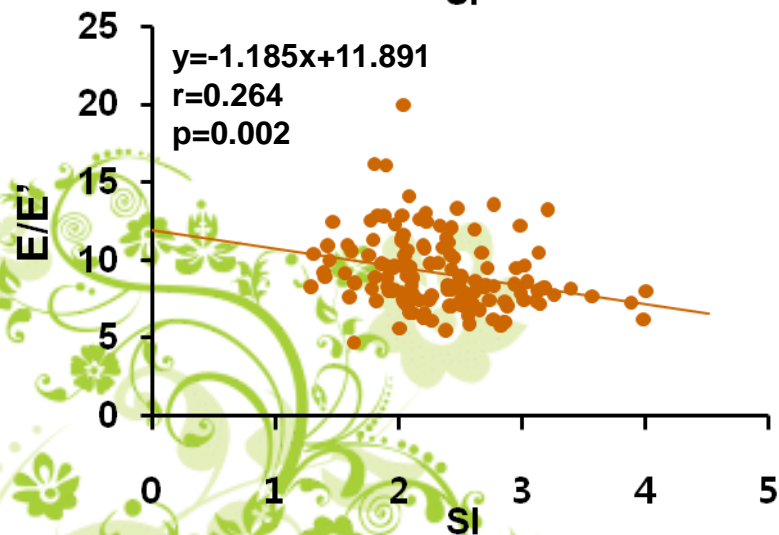
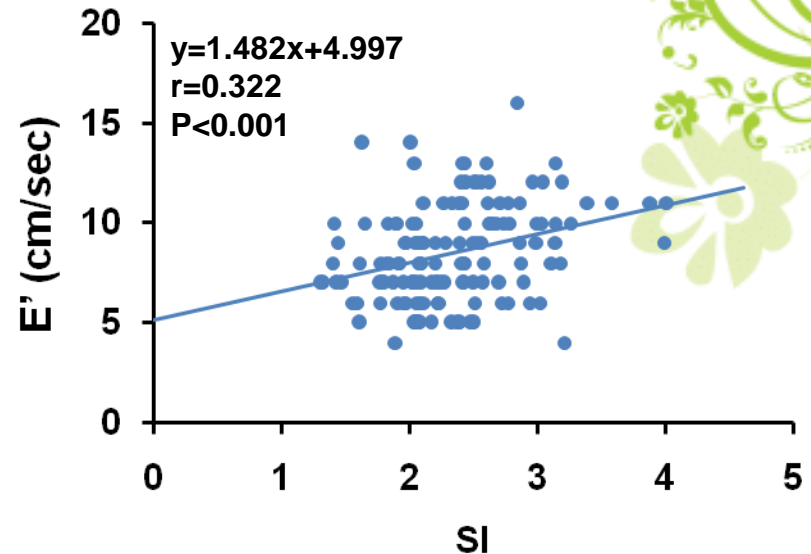
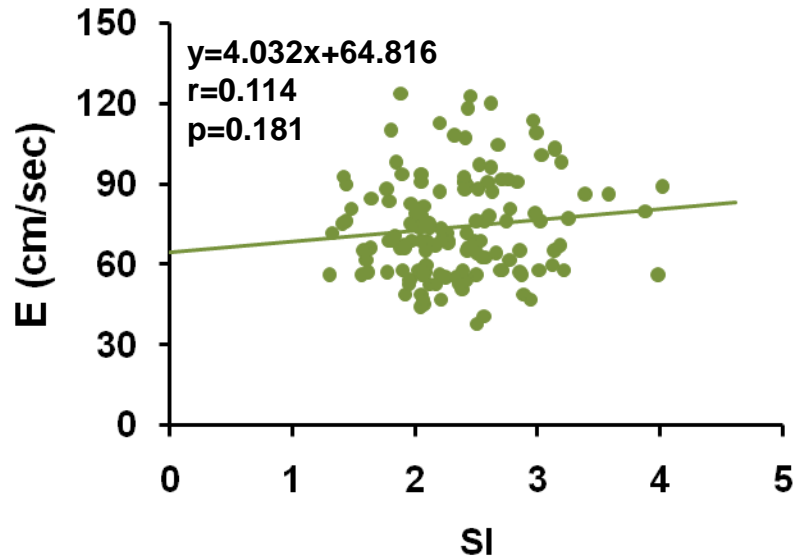
Comparison of LV Vortex



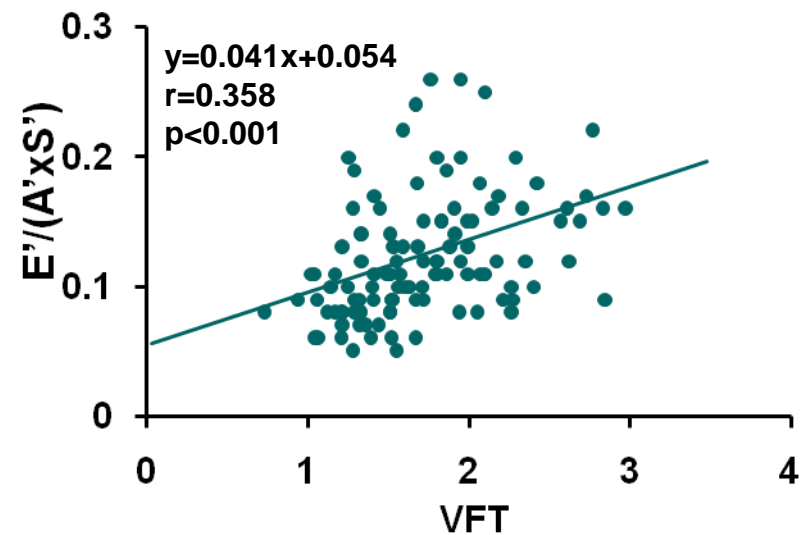
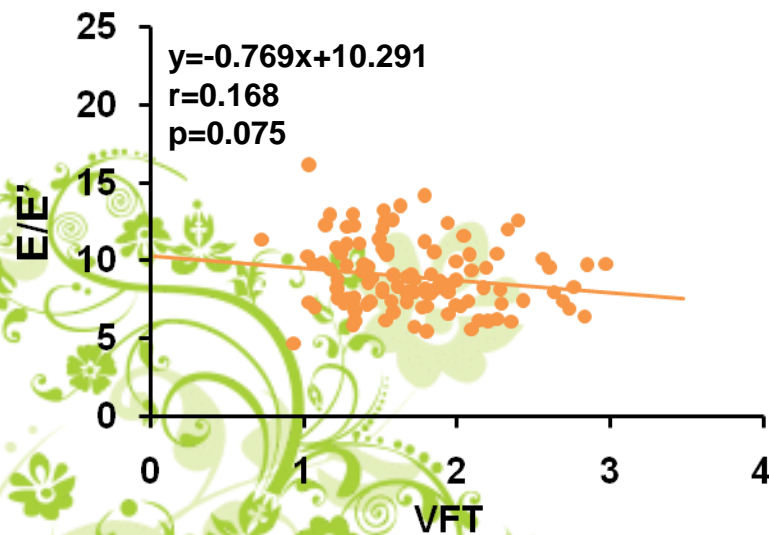
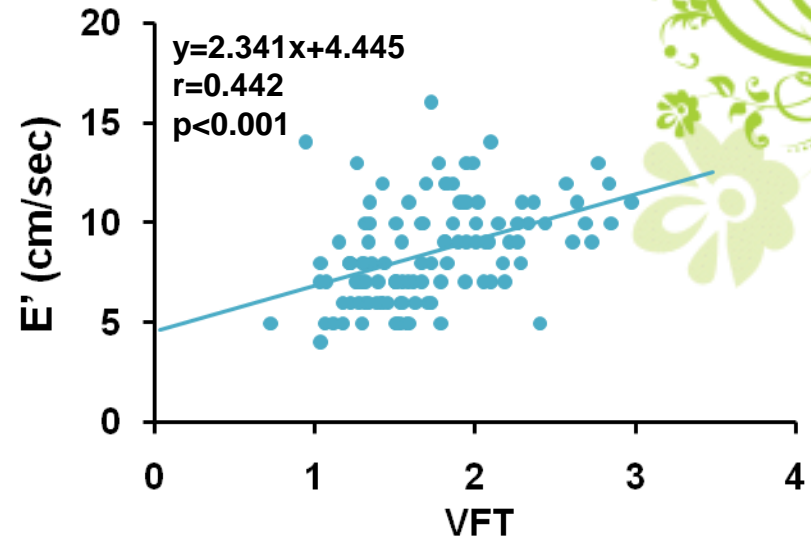
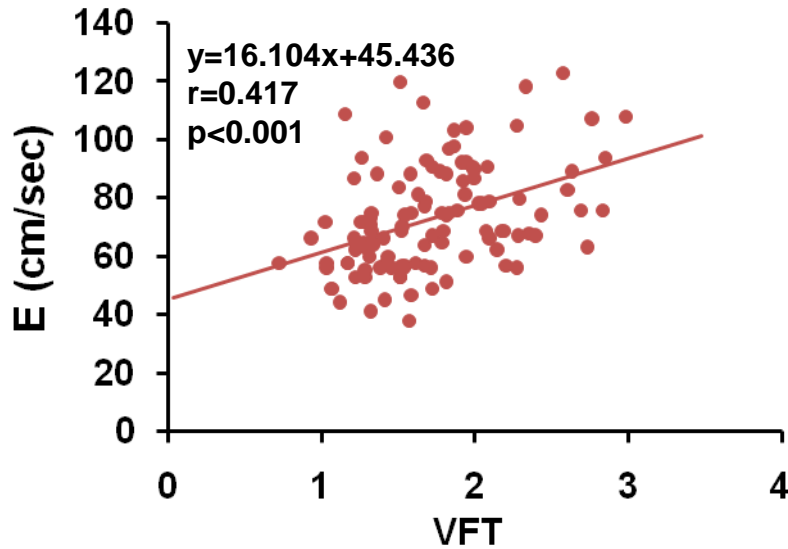
Vortex & Age



Vortex Sphericity Index & Doppler Index



Vortex Formation Time & Doppler index



Summary

1

Shape of LV vortex becomes more spherical with aging

2

Vortex formation time decreased with aging

3

**Weak positive association between SI and E'
Weak negative association between SI and E/E'**

4

**Moderate positive association between VFT
and E, E' and E'/(A'xS')**

Conclusion

Echocardiographic PIV can contribute to a better understanding of the change of LV vorticity with aging.

Hemodynamic significance of age-dependent change of LV vorticity remains to be elucidated in future studies.