Echocardiographic Correlates of Pulmonary Artery Systolic Pressure

The Role of Left Ventricular Diastolic Function

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Conflicts of Interest

None (all co-authors)

Background

- LV diastolic dysfunction – associated with pulmonary artery systolic pressure (PASP) ↑
  - This association – previously described in specific patient populations
    - LV systolic dysfunction ± MR[1]
    - HF with preserved LVEF[2]
    - General population (community-based study)[3]
  - Not examined in large patient populations in *routine clinical practice*
- Weak association between LVEF ↓ ↔ PASP ↑
  - Association – independent of LV diastolic function ?

[1]Enriquez-Sarano M – *JACC* 1997;29:153-9
[2]Lam CS – *JACC* 2009;53:1119-26
[3]Lam CS – *Circulation* 2009;119:2663-70

Objectives

- To describe the distribution of PASP in a large population of subjects undergoing echocardiography in a tertiary medical center in routine clinical practice
- To define the echocardiographic parameters associated with PASP ↑
  - LVEF
  - LV diastolic function
- To examine effect of LVEF on the relation between LV diastolic function & PASP

Methods
Patient Population

- Echocardiography laboratory computerized database (2011)
  - Selection of pts fulfilling inclusion criteria
  - Data abstracting
- Inclusion criteria
  - TTE
  - Sinus rhythm
  - No MS, mitral prosthesis / repair, significant (> moderate) MR
  - Sufficient diastolic assessment – *at least* measurements of:
    - E/A ratio
    - E/e' (septal) ratio
  - Measurable PASP

n = 2317 pts

Statistical Analysis

- Linear regression (multivariate)

  Independent variables

  - Age, gender
  - LVEF

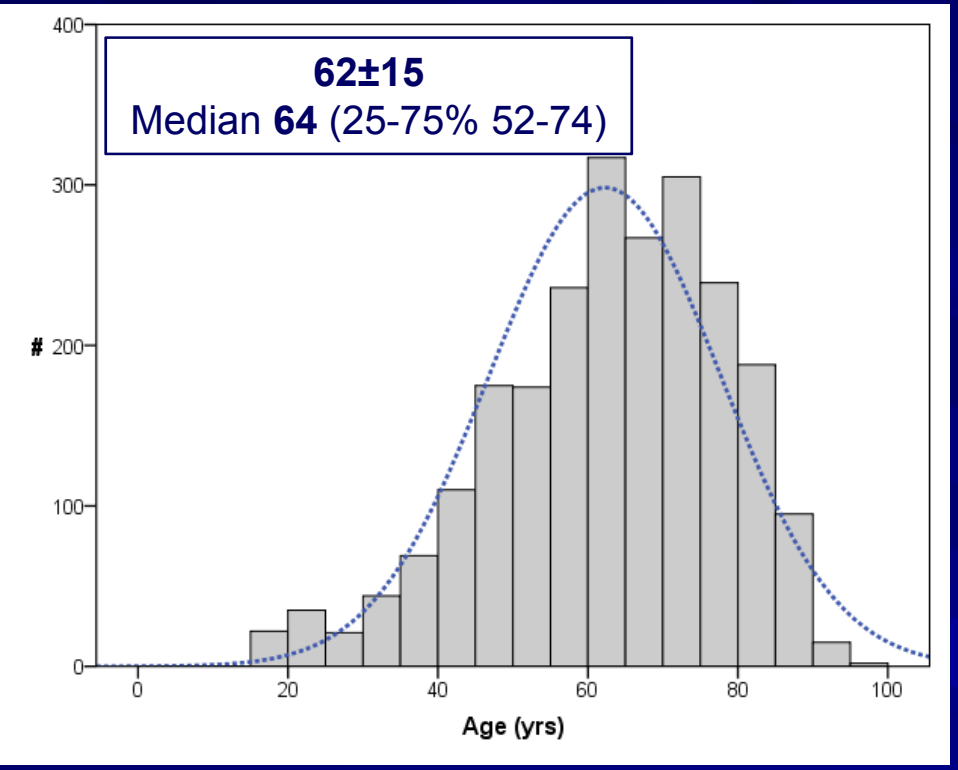
  } Entered *a prior* into models

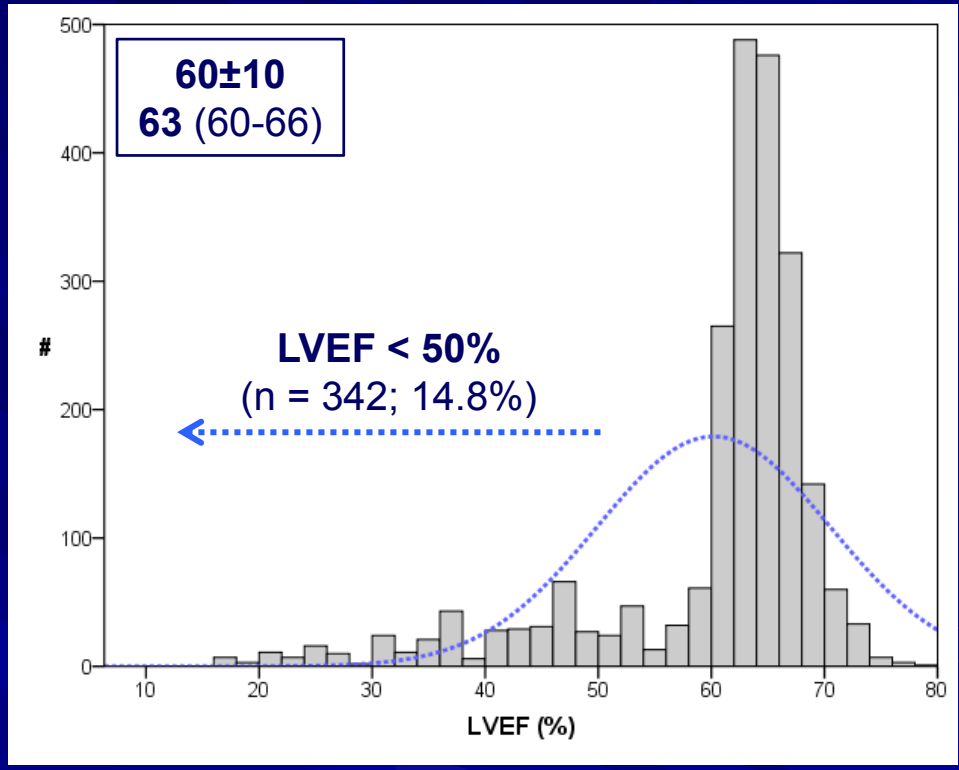
  - BMI
  - LV size / wall thickness / remodeling / mass
  - LA size
  - LV diastolic parameters + HR
  - Moderate MR (> moderate MR excluded)

PASP (*dependent* variable)

- Logistic regression (multivariate)
  - Predictors of “pulmonary hypertension” – PASP ≥ 50 / ≥ 35 mmHg

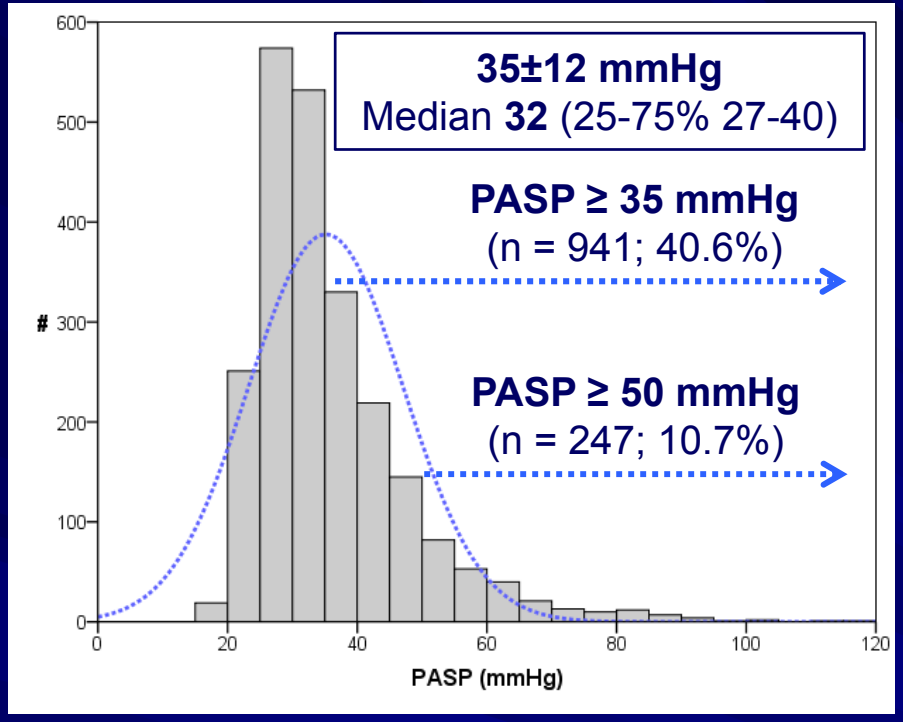
Patient Characteristics (n = 2317)

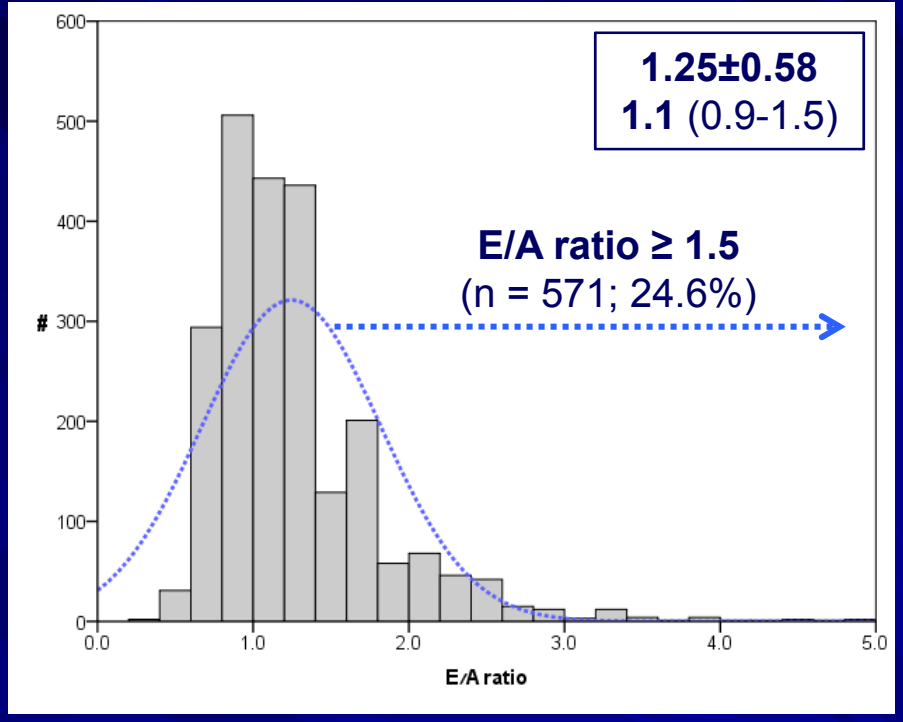


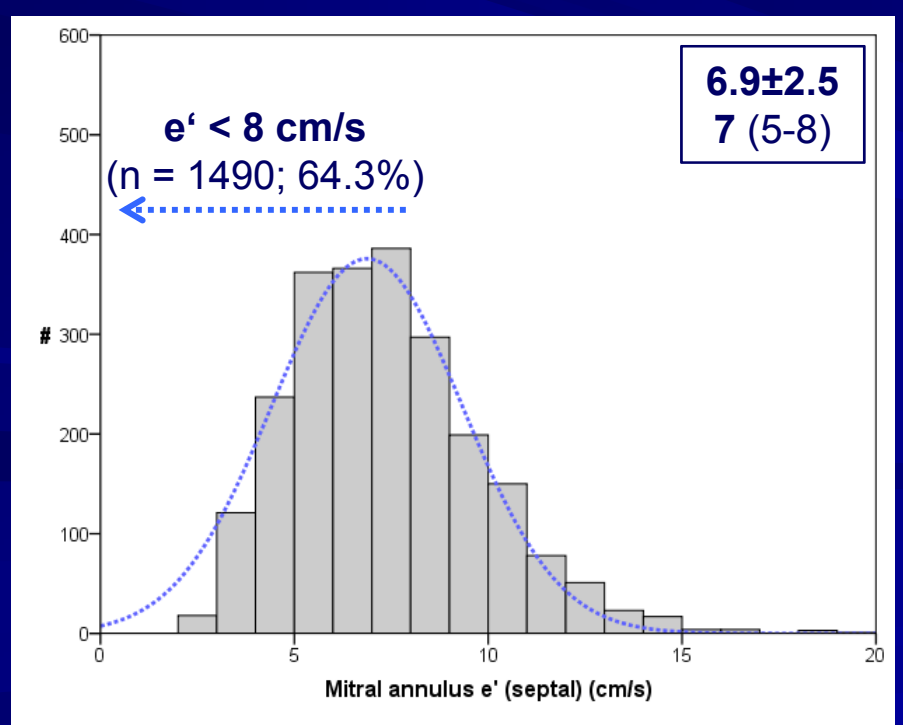


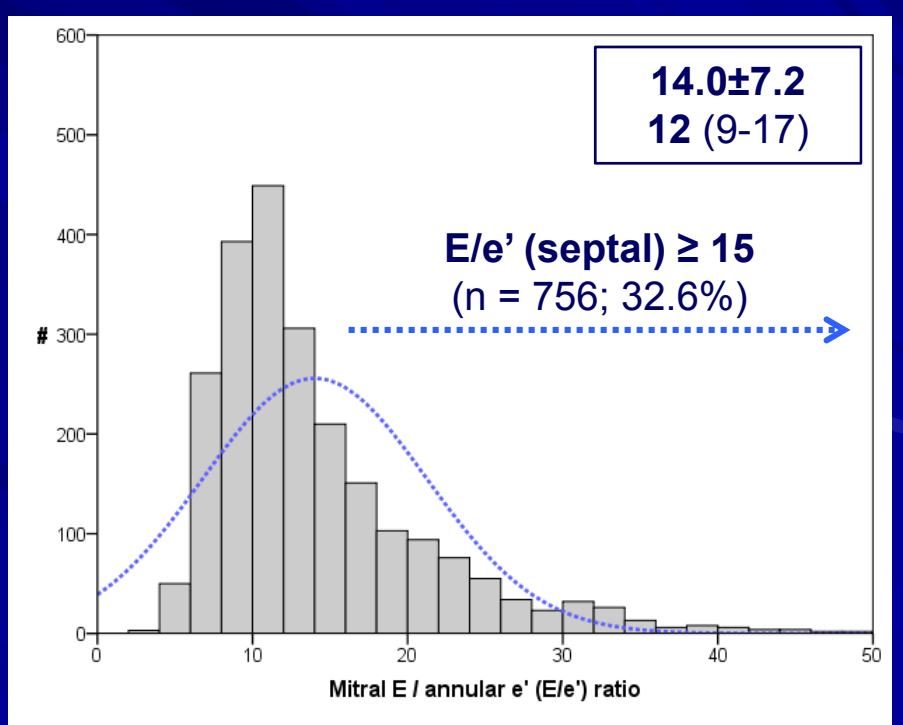
• Male gender, %	52	LVEDd, cm	5.0±0.6
• BMI, kg/m^2	28±5	LV wall thickness (mean), cm	0.9±0.1
• Heart rate, min^{-1}	67±11	Relative wall thickness	0.38±0.08
• LA diameter, cm	4.1±0.6	LV mass, g	171±54
• Moderate MR, %	5	LVH*	19%

* Any degree (qualitative)


35±12 mmHg
Median 32 (25-75% 27-40)
PASP ≥ 35 mmHg
(n = 941; 40.6%)
PASP ≥ 50 mmHg
(n = 247; 10.7%)
#
PASP (mmHg)


1.25±0.58
1.1 (0.9-1.5)
E/A ratio ≥ 1.5
(n = 571; 24.6%)
#
E/A ratio


6.9±2.5
7 (5-8)
e‘ < 8 cm/s
(n = 1490; 64.3%)
#
Mitral annulus e' (septal) (cm/s)


14.0±7.2
12 (9-17)
E/e’ (septal) ≥ 15
(n = 756; 32.6%)
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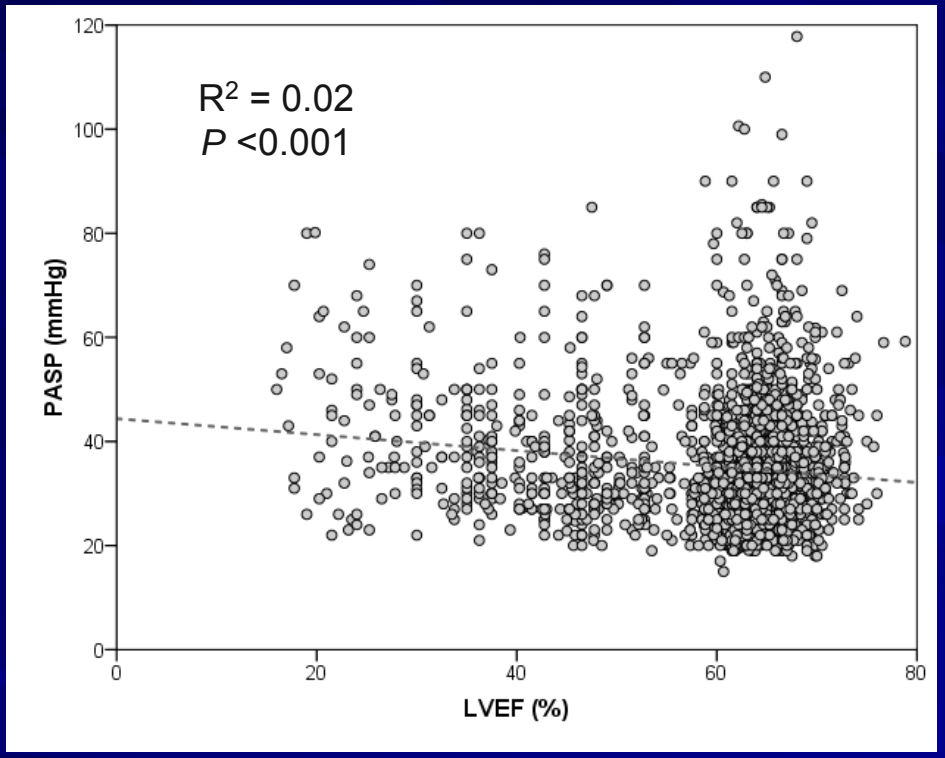
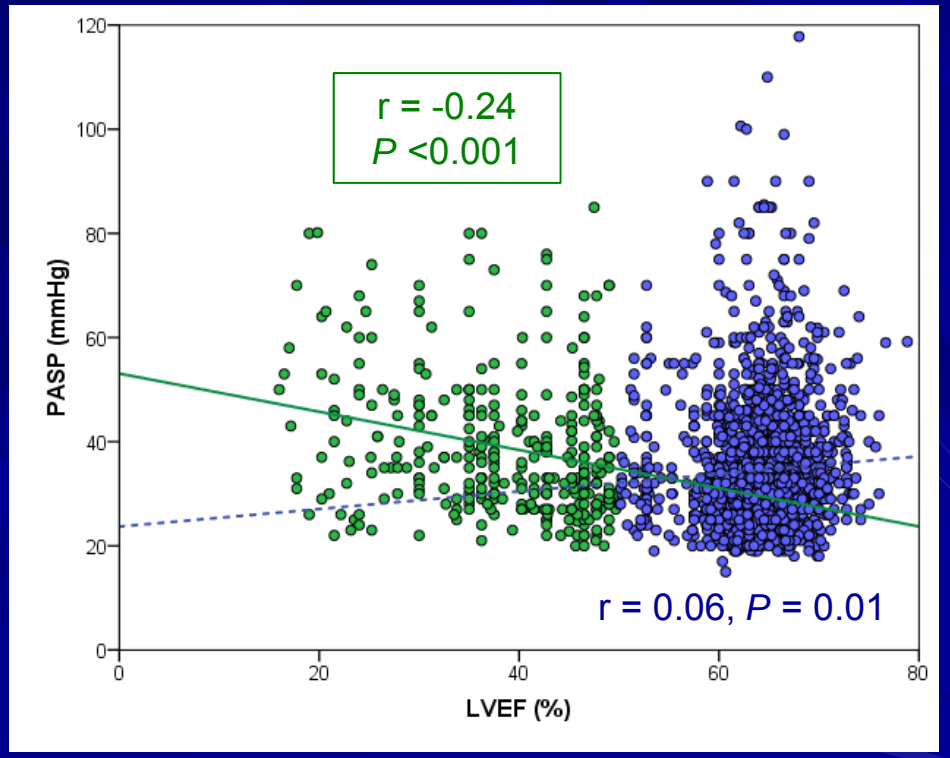
Mitral E / annular e' (E/e') ratio

Correlations – LVEF ↔ PASP

All subjects



LVEF 50% cutoff



	LVEF < 50%	≥ 50%
PASP (mmHg)	39±13	34±12
	36 (30-45)	32 (27-39)
	P <0.001	

Predictors of PASP

Multivariate Linear Regression*

Variable	B (95% CI)	β	*P*
Age, per 10 yrs	2.5 (2.1,2.9)	0.34	<0.001
Male	-2.1 (-3.1,-1.0)	-0.09	<0.001
LVEF < 50%	-0.6 (-2.1,1.0)	-0.02	0.48
LV mass, per 10 g	0.2 (0.1,0.3)	0.08	0.004
LA diameter, per 1 cm	3.1 (1.9,4.2)	0.15	<0.001
Mitral E wave, per 10 cm/s	1.1 (0.8,1.4)	0.21	<0.001
Mitral E/A ratio, per 0.1 units	0.4 (0.3,0.5)	0.21	<0.001
Mitral E / annular e' (septal) ratio	0.1 (0,0.2)	0.07	0.03
Heart rate, per 10 min^{-1}	1.5 (1.1,2.0)	0.15	<0.001
Moderate MR	3.2 (0.7,5.8)	0.06	0.01

* Adjusted for age, male gender, LVEF – forced into model
BMI – not significantly associated with PASP

Model $R^2 = 0.41$

Secondary Analyses
Multiple LVEF Expressions

LVEF		*P* *
LVEF < 50% (final model)	n = 342	0.48
LVEF < 40%	n = 161	0.89
LVEF < 30%	n = 56	0.42
LVEF (continuous variable)		0.15
Square root [LVEF] – more normally distributed		0.21

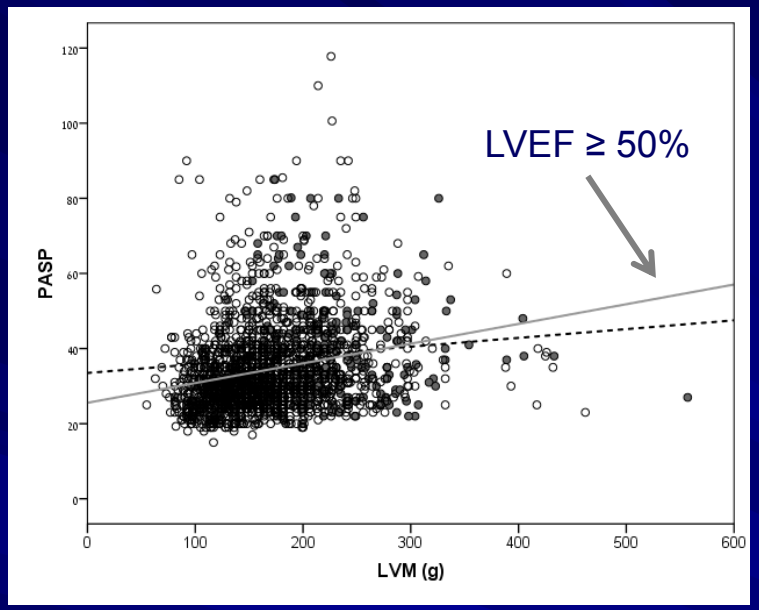
* Adjusted for all parameters in full model

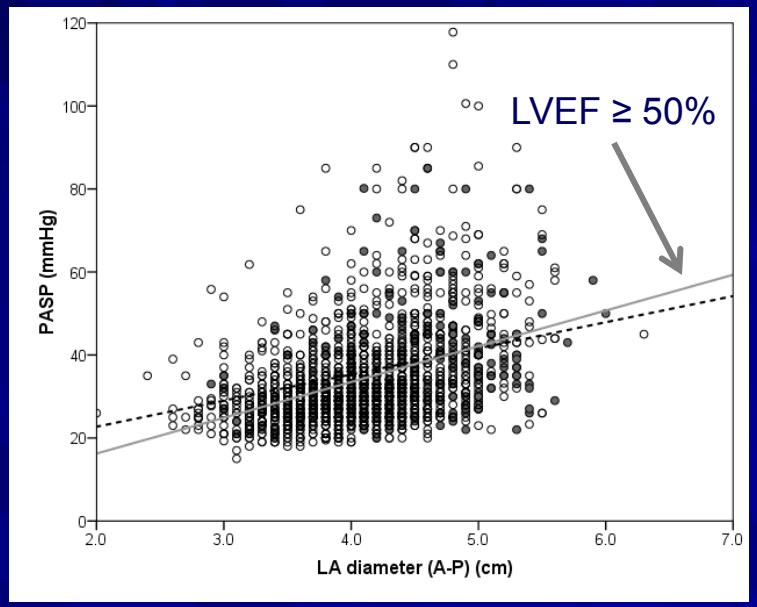
LVEF ↓ → Diastolic Parameters ↔ PASP

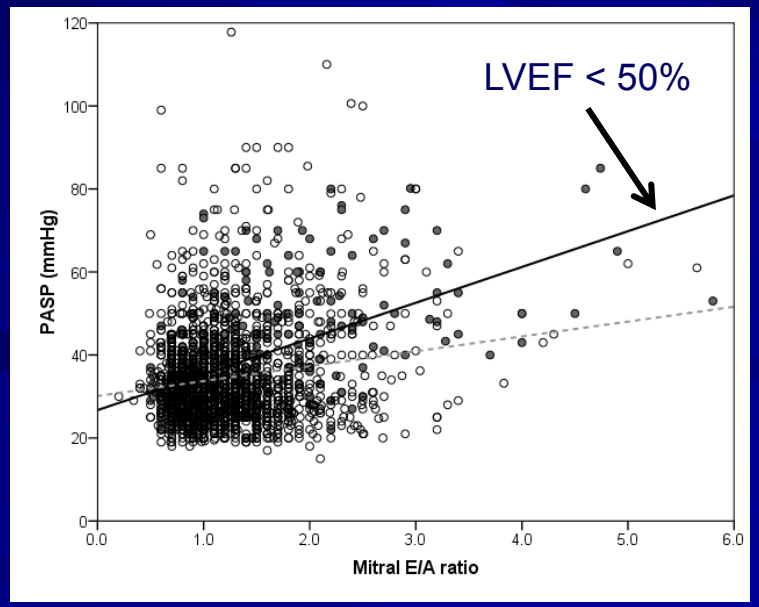
○ LVEF ≥ 50%
● LVEF < 50%

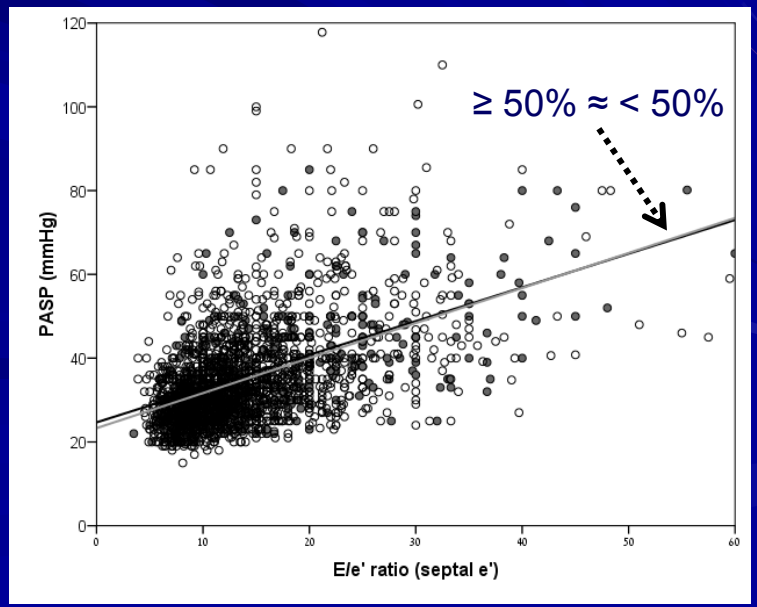
P for interaction (linear regression)

- LVM 0.02
- LA diam 0.06
- E/A <0.001
- E/e' 0.65









Linear Regression

Separate Models by LVEF ≥ 50% / < 50%

	LVEF ≥ 50%		LVEF < 50%	
Variable	**B (95% CI)**	***P***	**B (95% CI)**	***P***
Age, per 10 yrs	2.6 (2.2,3.0)	<0.001	1.6 (0.6,2.6)	<0.02
Male	-2.0 (-3.1,-0.9)	0.001	-3.0 (-6.0,-0.1)	0.046
LVEF, per 10%	1.3 (0.1,2.6)	0.04	-1.1 (-2.7,0.5)	0.16
LV mass, per 10 g	0.3 (0.1,0.4)	<0.001		
LA diameter, per 1 cm	3.4 (2.2,4.7)	<0.001		
Mitral E wave, per 10 cm/s	1.4 (1.1,1.7)	<0.001		
Mitral E/A ratio, per 0.1 units	0.4 (0.2,0.5)	<0.001	0.8 (0.6,1.0)	<0.001
Mitral E / annular e' (septal) ratio			0.3 (0.04,0.4)	0.02
Heart rate, per 10 min^{-1}	0.2 (0.1,0.2)	<0.001	1.3 (0.2,2.5)	0.02
Moderate MR	3.1 (0.1,6.1)	0.045		
Model R^2	**0.40**		**0.50**	

Predictors of PASP ≥ 50 / ≥ 35 mmHg

Multivariate *Logistic* Regression

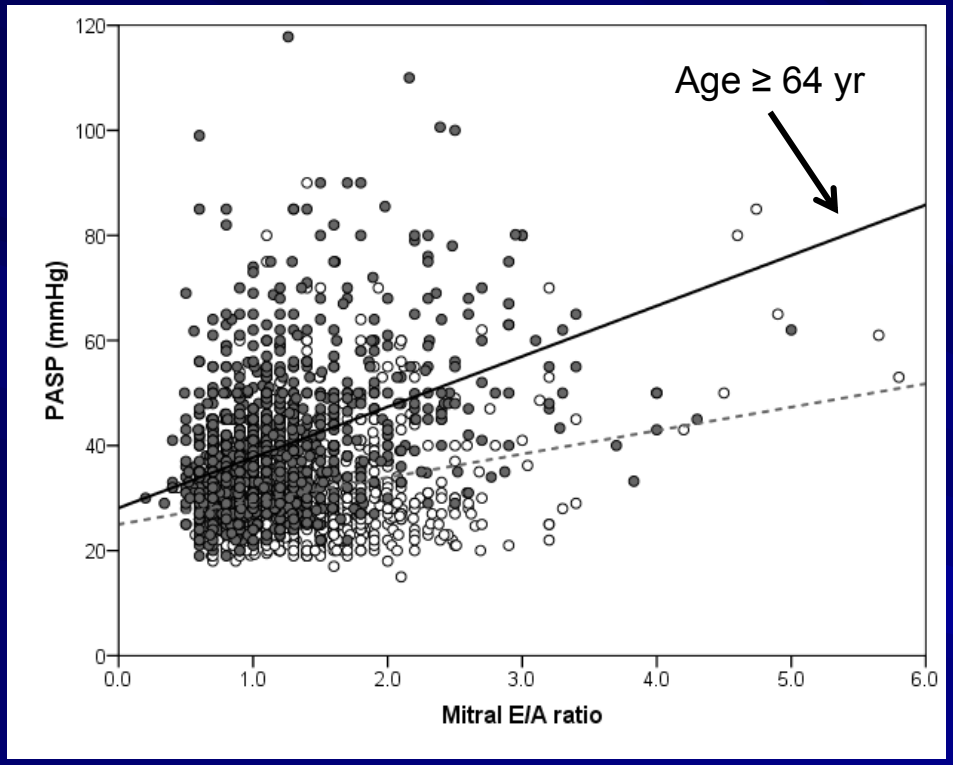
	PASP ≥ 50 mmHg		PASP ≥ 35 mmHg	
Variable	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***
Age, per 10 yrs	1.7 (1.4,2.1)	<0.001	2.0 (1.7,2.2)	<0.001
Male	0.5 (0.3,0.7)	0.002	0.6 (0.4,0.8)	0.001
LVEF < 50%	0.6 (0.3,1.3)	0.21	1.1 (0.7,1.7)	0.60
LV mass, per 10 g			1.1 (1.0,1.1)	<0.001
LA diameter, per 1 cm	2.8 (1.7,4.7)	<0.001	1.4 (1.0,2.0)	0.04
Mitral E wave, per 10 cm/s	1.3 (1.2,1.5)	<0.001	1.4 (1.3,1.5)	<0.001
Mitral E/A ratio, per 0.1 units	1.1 (1.1,1.2)	<0.001	1.1 (1.0,1.1)	0.002
Mitral E / annular e' (septal) ratio	NS			
Heart rate, per 10 min^{-1}			1.3 (1.2,1.5)	<0.001
Moderate MR	2.1 (1.0,4.2)	0.04		

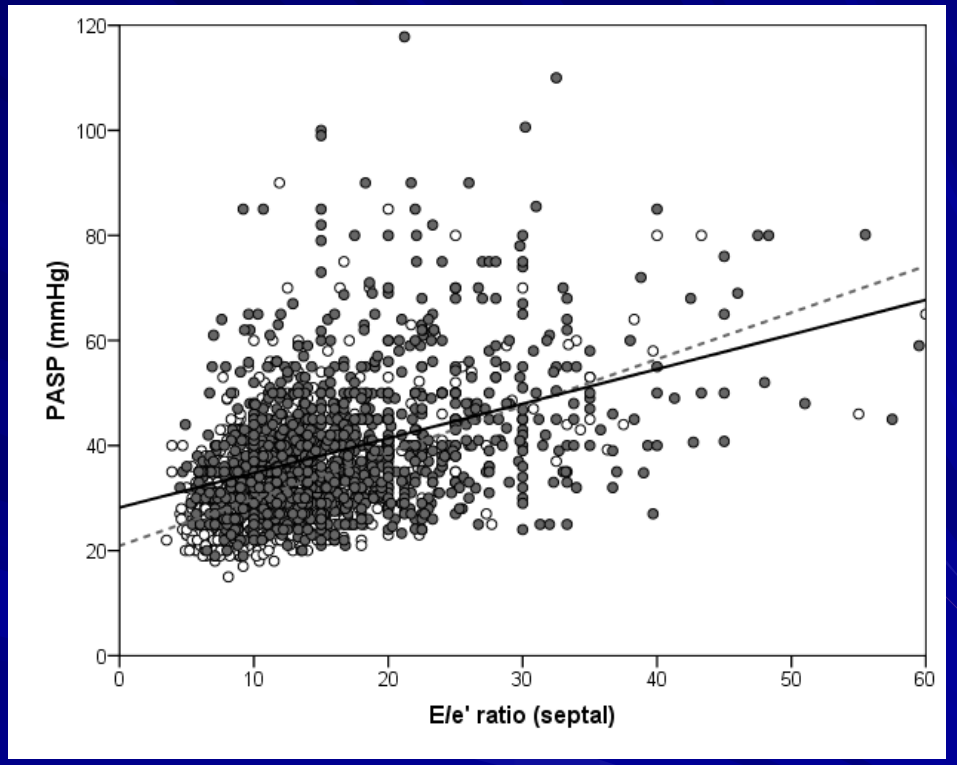
PASP ≥ 50: n = 247 (10.7%); PASP ≥ 35: n = 941 (40.6%)

Conclusions

- Multiple LV diastolic parameters are strongly associated with PASP
- LVEF
  - Not a independently associated with PASP
    - Adjusting for age, gender, *LV diastolic parameters*
  - Modifies the relations between LV diastolic parameters & PASP

Age / Diastolic Function Interactions





Age < 64 yr
Age ≥ 64 yr

Univariate Predictors of PASP

Variable	β	R^2	*P*
Age, yrs	0.39	0.15	
Male	- 0.09	0.01	
BMI, kg/m^2	0.15	0.02	
LVEF, %	- 0.13	0.02	
LVEDd, cm	0.11	0.01	
LV mass, g	0.23	0.05	
LA diameter, cm	0.41	0.17	
Moderate MR	0.22	0.05	**<0.001**
Mitral E wave, cm/s	0.41	0.17	
E/A ratio	0.26	0.07	
E wave deceleration time, ms	- 0.09	0.01	
Annular e' (septal), cm/s	- 0.32	0.10	
Annular e' (lateral), cm/s	- 0.27	0.07	
E/e' ratio (septal)	0.51	0.26	
E/e' ratio (lateral)	0.47	0.22	