Impact of Pressure Recovery on Quantitative Assessment of Aortic Valve Stenosis in Real Clinical World

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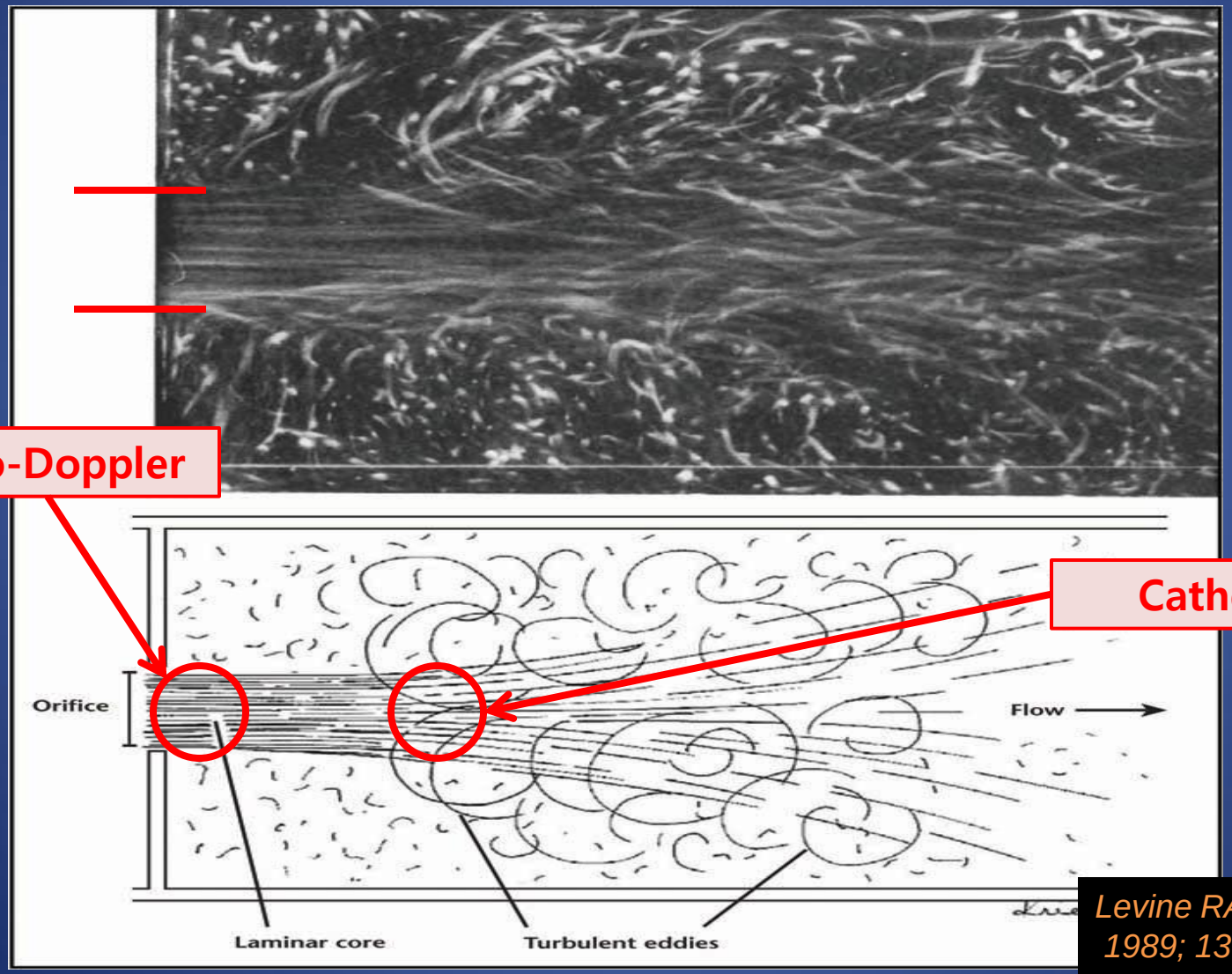
Background

- In aortic stenosis, echo-Doppler derived aortic valve area (AVA_{Dop}) overestimates the severity of AS compared with catheter derived aortic valve area (AVA_{Cath}) due to pressure recovery phenomenon.

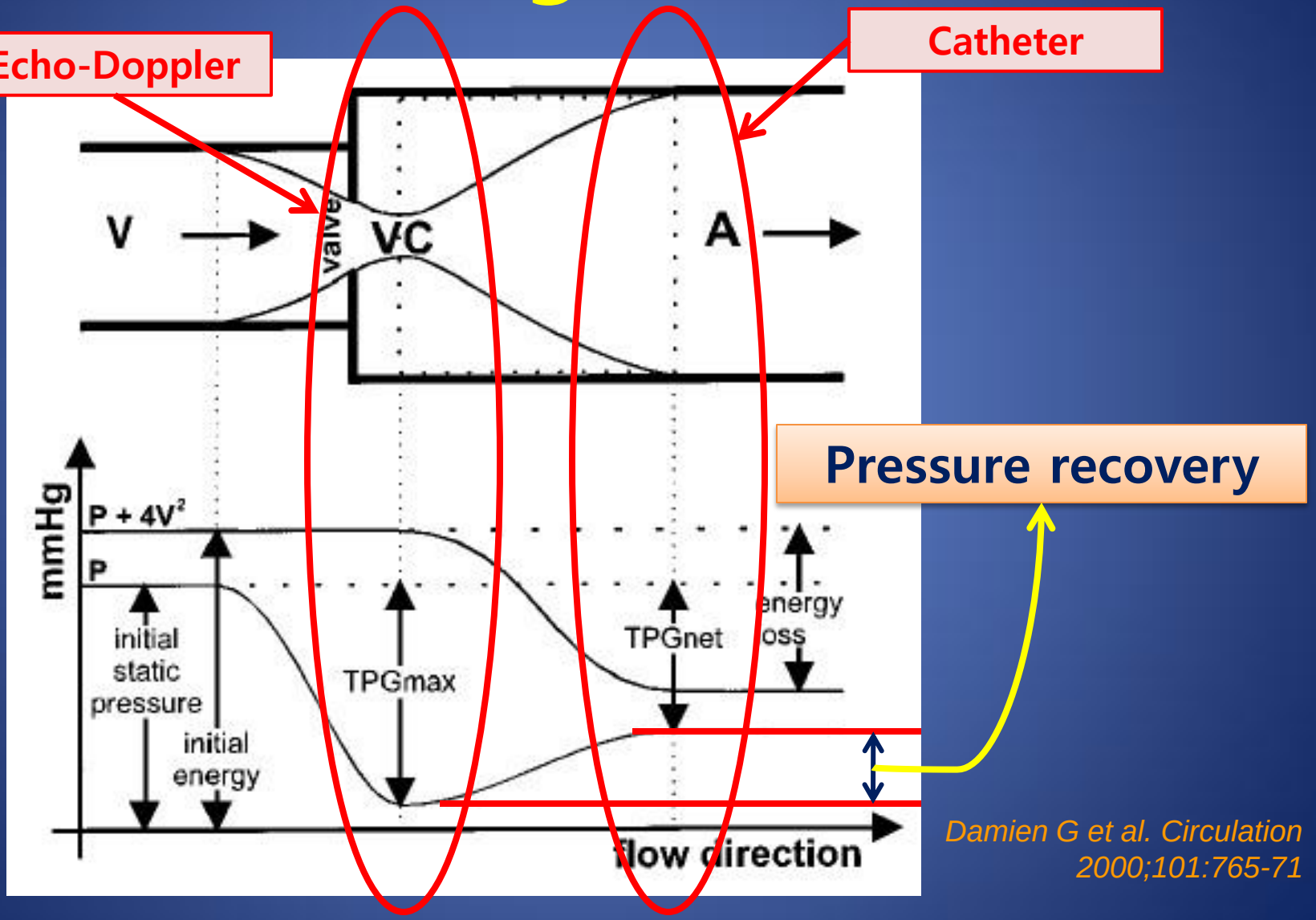
Laskey WK et al. Circulation 1994;89:116-21

Background



Levine RA et al. JACC. 1989; 13:706–715.

Background



Damien G et al. Circulation 2000;101:765-71

Background

- In the pediatric population with aortic stenosis, AVA_{Cath} has been the accepted standard for determination of prognosis and timing of intervention.

Wagner HR et al. Circulation 1977;56:I147-56
Wagner HR et al. Circulation 1977;56:I120-3

- AVA_{PR} was superior to AVA_{Dop} in predicting adverse outcomes (death or AVR) in patients with aortic stenosis.

Damien G et al. Circulation 2000;101:765-71

Background

- AVA after adjusting pressure recovery

$$AVA_{PR} = \frac{AAA \times AVA_{Dop}}{AAA - AVA_{Dop}}$$

(AAA (cm^2) = cross-sectional area of the proximal ascending aorta, r^2=0.98)

Damien G et al. Circulation 2000;101:765-71

Background

- In Korean population, the incidence of overestimation may more frequent than western people, because of smaller body surface area and aortic diameter.

- Up to the present, no clinical data about incidence and condition of overestimation were available in Korean population.

Objectives

- Incidence of clinically meaningful overestimation of AVA_{Dop} in Korean population.

- Define the clinical situations requiring adjustment of pressure recovery phenomenon

Method

- We reviewed echocardiographic data of aortic stenosis (from 2007,1~2009,10) → total 1068 patients.
- We excluded subjects with moderate to severe AR, unavailable to assess AVA, LV dysfunction (EF<50%)
- Finally, total 295 patients enrolled.

Method

- Measurement of Doppler-derived AVA by continuity equation

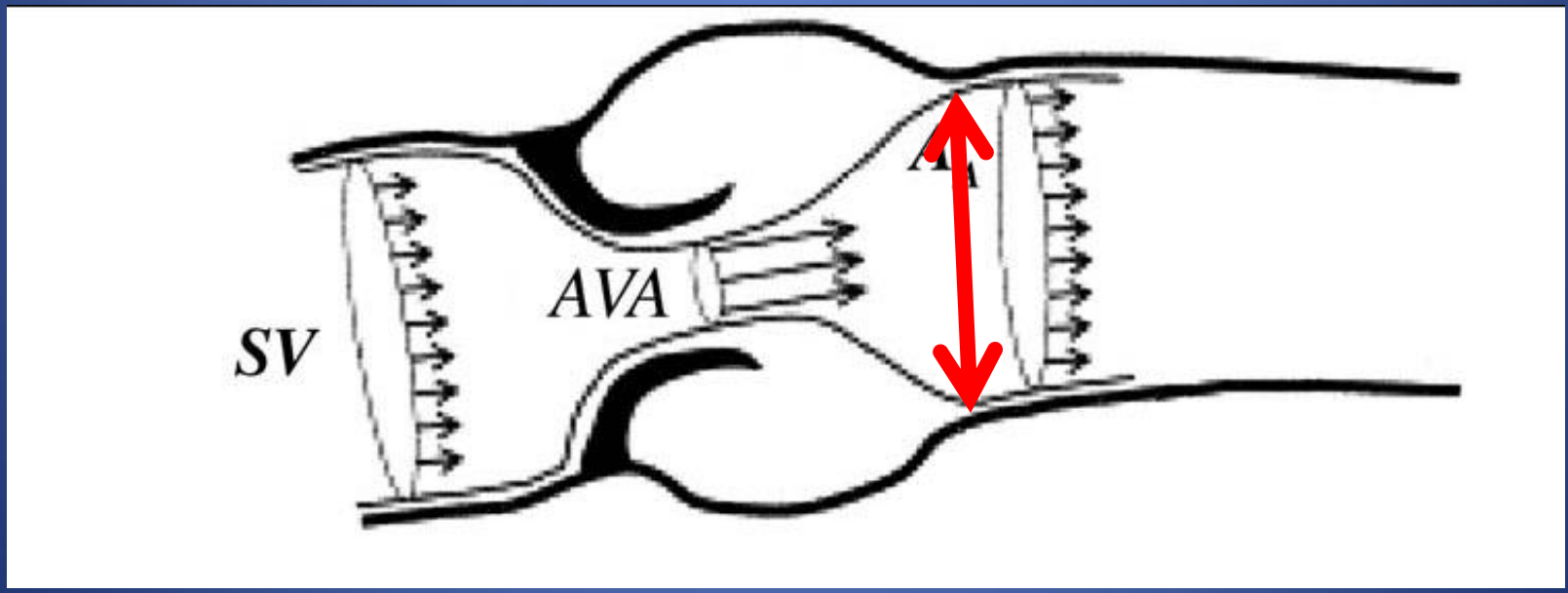
$$AVA_{Dop} = A_{LVOT} \times \frac{TVI_{LVOT}}{TVI_{AV}}$$

- Measurement of cross-sectional area of proximal ascending aorta

$$AAA = \pi \times (\text{aortic root diameter}/2)^2$$

Method

- Measurement of cross-sectional area of ascending aorta



Briand M et al. JACC 2005;46:291-8

Method

- Classification of AS severity (ACC/AHA)

Indicator	Aortic stenosis		
	Mild	Moderate	Severe
Jet velocity (m/sec)	<3.0	3.0 – 4.0	>4.0
Mean PG (mmHg)	<25	25 – 40	>40
Valve area (cm^2)	>1.5	1.0 – 1.5	<1.0
Valve area index (cm^2/m^2)			<0.6

Statistics

- All data were expressed as mean ± SD.
- Student's t-test, Multivariate logistic regression, One-way ANOVA

→ In one-way ANOVA, multiple comparison analysis was used with Rank of each variables using Tukey's multiple comparison test.

- A value of $P < 0.05$ was considered statistically significant

Result

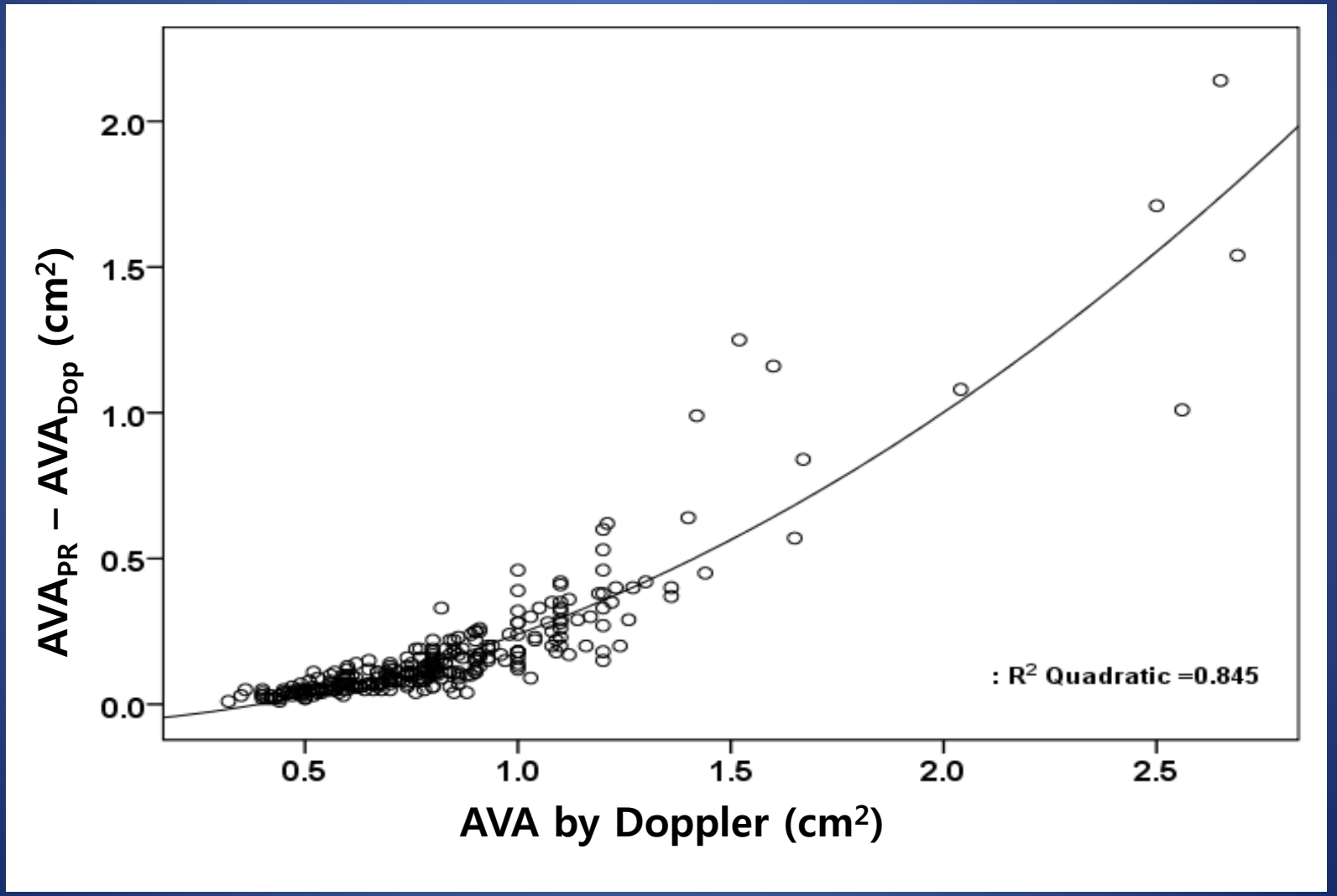
Baseline characteristics

Male	139/295 (47%)
Age (years)	67.4 ± 12.3
LV ejection fraction (%)	63.0 ± 5.0
Peak pressure gradient (mmHg)	79.2 ± 32.4
Mean pressure gradient (mmHg)	47.6 ± 21.0
Sinotubular junction diameter (mm)	28.0 ± 4.7
LV mass (g)	244.7 ± 73.3
Mild/moderate/severe AS (by AVA_{Dop})	9(3%) / 62(21%) / 224(76%)
Difference between AVA_{PR} and AVA_{Dop} (cm^2)	0.178 ± 0.240

Characteristics by AS severity

Parameters	Mild AS (n=9)	Moderate AS (n=62)	Severe AS (n=224)	P value
Age	71.2±12.8	65.2±13.8	67.9±11.8	0.202
STJ diameter (mm)	27.1±4.1	27.2±4.1	28.3±4.8	0.187
LVEF (%)	61.6±4.6	62.7±4.6	63.1±5.1	0.601
AVA_{Dop} (cm^2)	2.10±0.50	1.13±0.12	0.69±0.16	<0.001
AVA_{PR} (cm^2)	3.35±0.89	1.44±0.24	0.78±0.20	<0.001
$AVA_{PR\text{-}Dop}$ (cm^2)	1.26±0.48	0.31±0.15	0.10±0.06	<0.001

Relation between AVA_{Dop} and difference of AVA_{Dop} and AVA_{PR}



Categorization of AS severity by AVA_{Dop} and AVA_{PR}

Using AVA_{PR}	Total	Using AVA_{Dop}		
		Mild	**Moderate**	**Severe**
Mild	28 (9%)	9	**19 (31%)**	0
Moderate	79 (27%)	0	43	**36 (12%)**
Severe	188 (64%)	0	0	188
Total	295 (100%)	9 (3%)	62 (21%)	224 (76%)

Comparison between reclassification group and others

	No reclassification (n=240)	Reclassification (n=55)	P value	Multivariate analysis	
				Odds ratio	P value
Age (yrs)	67±13	71±10	0.015	…	NS
LVEF (%)	63.1±5.0	62.7±5.2	0.602	…	NS
Sinus diameter (mm)	32.7±4.4	31.0±3.7	0.009	…	NS
STJ diameter (mm)	28.6±4.8	25.6±2.9	<0.001	1.326	<0.001
$AVA_{PR\text{-}Dop}$	0.15±0.25	0.28±0.17	<0.001	…	NS
Mean PG (mmHg)	50.8±21.4	33.7±11.6	<0.001	1.062	<0.001

Risk of overestimation

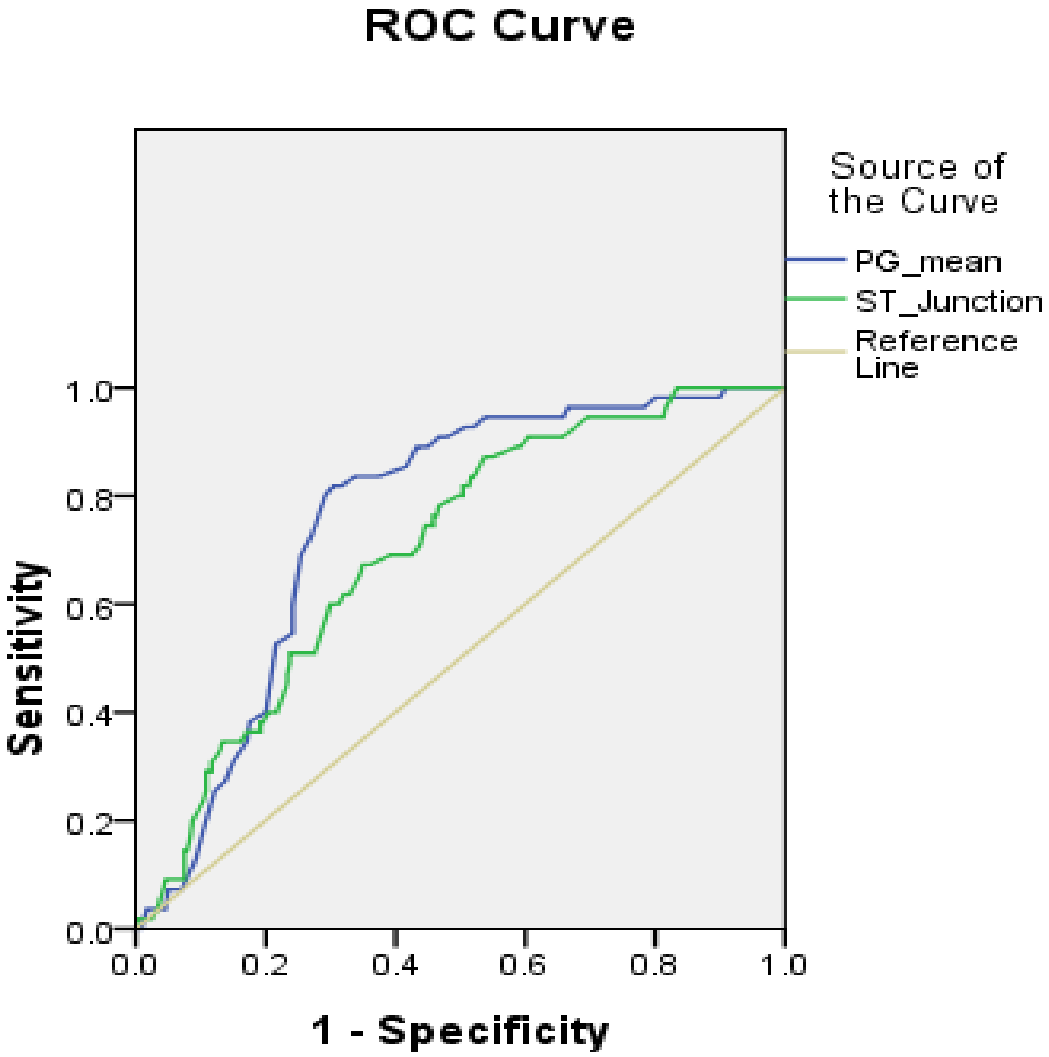
- **Cross-sectional area of proximal ascending aorta**

  → Smaller STJ diameter, more probability of reclassification (OR 1.326, 95% CI: 1.138~1.544)

- **Trans-aortic mean pressure gradient**

  → Smaller mean PG, more probability of reclassification (OR 1.062 95% CI: 1.034~1.091)

ROC curve

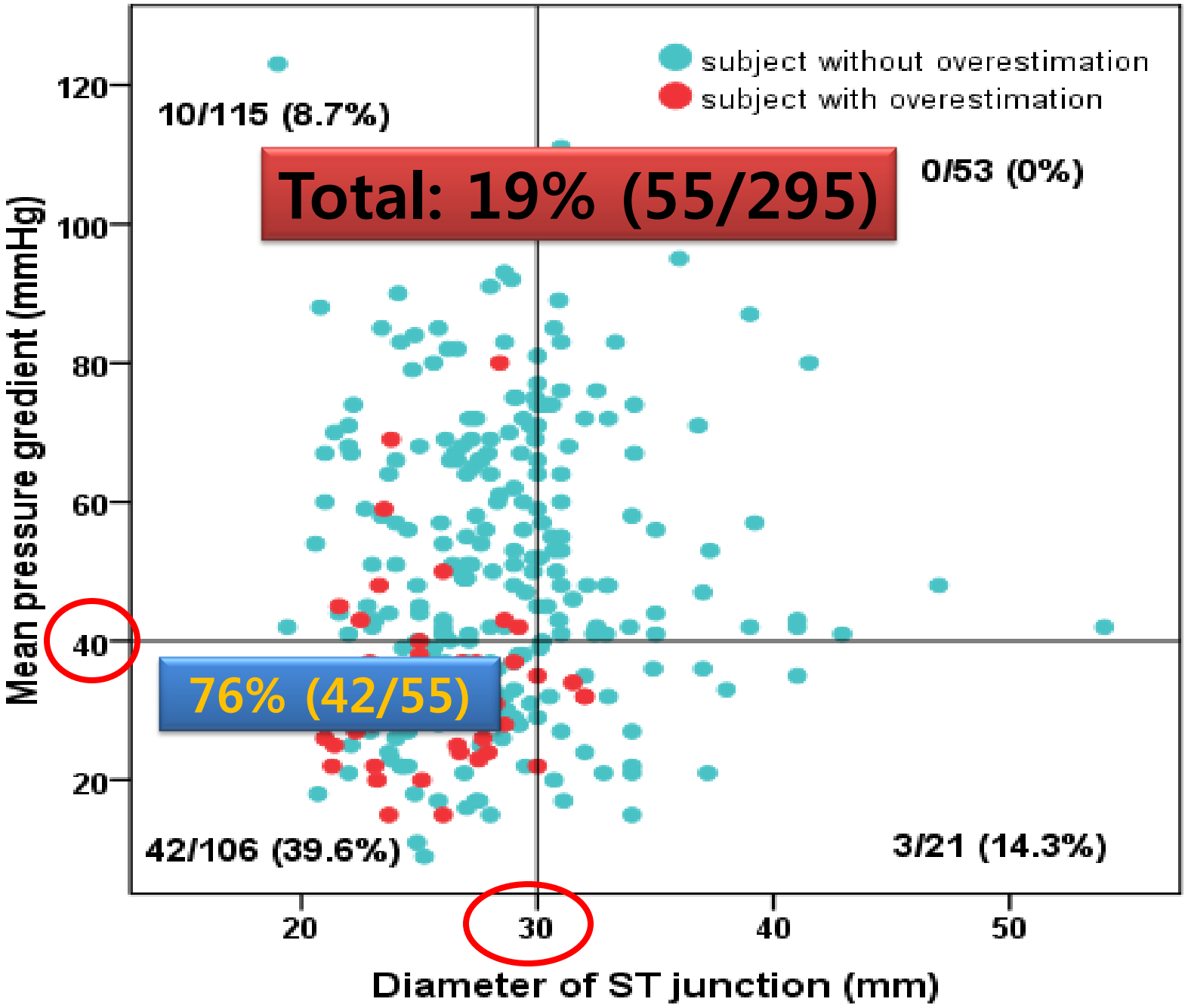


Mean PG

37.5mmHg 일때
→Sensitivity 80.0%, Specificity 70.8%
(AUC:0.757, 95%CI: 0.696~0.817)

ST junction

27.95mm 일때
→Sensitivity 78.2%, Specificity 53.3%
(AUC: 0.702, 95%CI: 0.633~0.771)


subject without overestimation
subject with overestimation
10/115 (8.7%)
0/53 (0%)
Total: 19% (55/295)
76% (42/55)
42/106 (39.6%)
3/21 (14.3%)
Mean pressure gredient (mmHg)
120
100
80
60
40
20
20
30
40
50
Diameter of ST junction (mm)

Summary

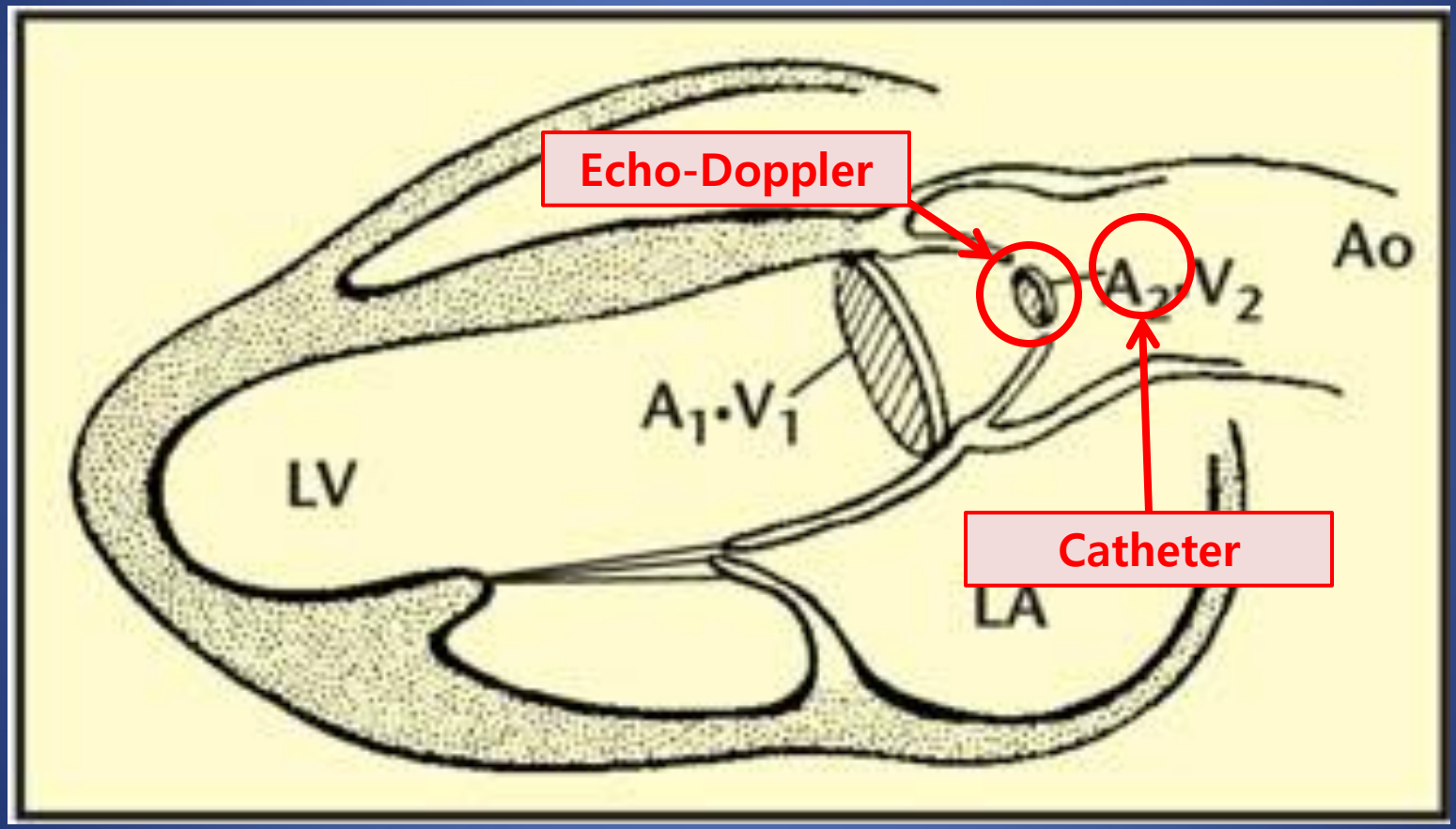
- As increase AVA_{Dop}, the discrepancy between AVA_{Dop} and AVA_{PR} was increased.
- In our study, 19% of AS patients were reclassified after adjusting pressure recovery phenomenon.
- 76% of reclassified patients has small ST junction diameter (≤30mm) and lower trans-aortic mean PG (≤40mmHg).

Conclusion

- Clinically significant overestimation of AVA by continuity equation is not rare especially, in patients with small sinotubular junction diameter (**<30mm**) and low mean pressure gradient (**<40mmHg**).


경청해주셔서 감사합니다

Background



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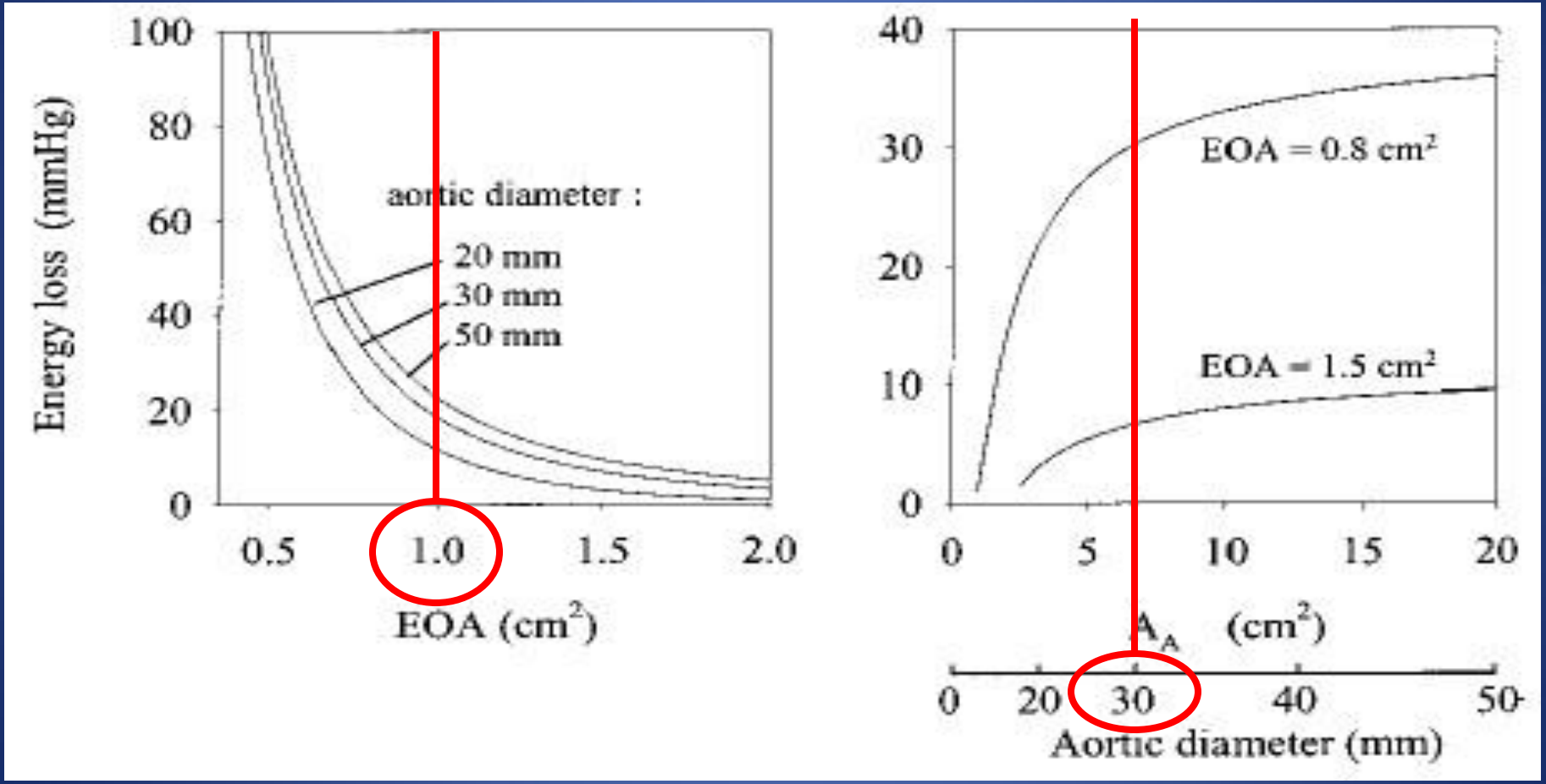
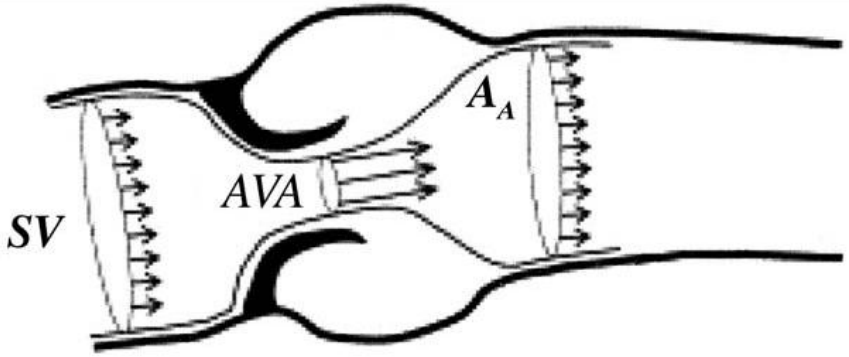


Damien G et al. Circulation 2000;101:765-71

Categorization of AS severity by mean pressure gradient

Using AVA_{PR}	Total	Using PG		
		Mild	**Moderate**	**Severe**
Mild	28 (9%)	13	**10 (11%)**	5
Moderate	79 (27%)	19	50	**10 (7%)**
Severe	188 (64%)	3	32	153
Total	295 (100%)	35 (12%)	92 (31%)	168 (57%)



$$Z_{VA} = \frac{LVSP}{SVi} = \frac{SAP + MG_{net}}{SVi}$$