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Relation of Weights of Operatively Excised Stenotic Aortic Valves to Preoperative Transvalvular Peak Systolic Pressure Gradients and to Calculated Aortic Valve Areas

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OBJECTIVES The purpose of this study was to correlate the weights of operatively excised stenotic aortic valves to preoperative transvalvular peak systolic gradients and to calculated aortic valve areas.

BACKGROUND No previous publication has correlated the weights of stenotic aortic valves to the transvalvular gradients or to the calculated aortic valve areas.

METHODS We weighed operatively excised stenotic aortic valves in 324 adults who had undergone preoperative left-sided cardiac catheterization.

RESULTS As the weights of the operatively excised stenotic aortic valves increased (from <1 g to >6 g), the average transvalvular peak systolic pressure gradients progressively increased. For any valve weight, in general, the women had higher average transvalvular gradients ($p \leq 0.005$) and lower average valve areas ($p \leq 0.008$) than did the men. Correlation between aortic valve weight and transvalvular gradient improved further when gender was taken into account.

CONCLUSIONS Preoperative transvalvular peak systolic pressure gradients across stenotic aortic valves correlate better with the weights of the operatively excised valves than do the calculated valve areas. (J Am Coll Cardiol 2004;44:1847–55) © 2004 by the American College of Cardiology Foundation

Recently, we reported weights of operatively excised stenotic unicuspid, bicuspid, and tricuspid aortic valves in 499 adults and their relation to age, gender, body mass index (BMI), and presence or absence of concomitant coronary artery bypass grafting (CABG) (1). No previous studies have compared weights of stenotic aortic valves to transvalvular pressure gradients across them or to calculated aortic valve areas. Such is the purpose of this study.

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METHODS

From January 1998 through June 2003 (65 months), a total of 1,272 patients had one or more cardiac valves or portions of cardiac valves submitted to the surgical pathology unit of the Department of Pathology of Baylor University Medical Center (Fig. 1). After elimination of the 33 patients with active infective endocarditis, the 6 who had isolated tricuspid valve replacement, the 444 who had mitral valve replacement or repair, and the 58 who had combined mitral and aortic valve replacements, 731 patients who had isolated aortic valve replacement remained. Of them, 151 had the valve replacement for pure aortic regurgitation (no element of valve stenosis) and 580 for aortic valve stenosis (with or without some associated aortic regurgitation). Of the 580 patients with stenotic aortic valves, the operatively excised valve was weighed by one of us (W.C.R.) in 575 patients; of them, 251 were eliminated from this study because cardiac catheterization was not performed before aortic valve replacement, the data obtained at cardiac catheterization was not available to us, or the left-sided cardiac hemodynamic data was missing or incomplete. The present study is limited to the 324 patients who had isolated aortic valve replacement to excise a stenotic aortic valve, had peak left ventricular (LV) to systemic arterial peak systolic pressure gradients ≥10 mm Hg, had calculated aortic valve areas obtained at cardiac catheterization before the aortic valve replacement, and had the operatively excised stenotic aortic valve weighed.

Each operatively excised cardiac valve arrived at the surgical pathology unit in a container filled with formaldehyde. The valve was removed from the container, placed on absorbing paper to absorb excess formaldehyde, and then weighed on an Ohaus scale (Ohaus Corp., Florham Park, New Jersey), which has an accuracy to 0.01 g. The age and gender of each patient were obtained from the patient identification label pasted on the container submitted from the operating room. The type of dysfunction of the operatively excised aortic valve was determined initially by gross inspection of the valve, and confirmation that the valve was stenotic was obtained from the cardiac catheterization report. The interval from the cardiac catheterization to aortic valve replacement was <3 months (usually <1 week) in 312 (96%) of the 324 patients, from >3 to 6 months in

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Abbreviations and Acronyms

BMI = body mass index
CABG = coronary artery bypass grafting
LV = left ventricular

5 patients, from >6 to 12 months in 6 patients, and 14 months in 1 patient. Most of the pertinent clinical information, including age, gender, BMI, whether or not concomitant CABG was performed, was obtained from the Baylor University Medical Center Apollo Advance Cardiovascular Data Integration system. In the 26 patients in whom cardiac catheterization was not performed at Baylor University Medical Center, the record room chart was reviewed to obtain the pertinent hemodynamic data.

Statistical analysis was performed by using SigmaStat Version 2.0 (SPSS Inc., Chicago, Illinois). Parametric tests were used for the analysis of the data that passed the assumption tests of normality and equal variance: for continuous variables, the unpaired *t* test was performed for two variable comparisons and one-way analysis of variance for more than two variable comparisons. When the data did not pass the assumption tests, nonparametric tests (i.e., Mann-Whitney rank-sum test for two variable comparisons and Kruskal-Wallis one-way analysis of variance on ranks test for more than two continuous variable comparisons) were used. The correlation coefficient (r) was obtained by using either the parametric Pearson product moment test or the nonparametric Spearman rank order test. A value $p < 0.05$ was considered to be statistically significant. The study protocol was approved by the Institutional Review Board of Baylor University Medical Center.

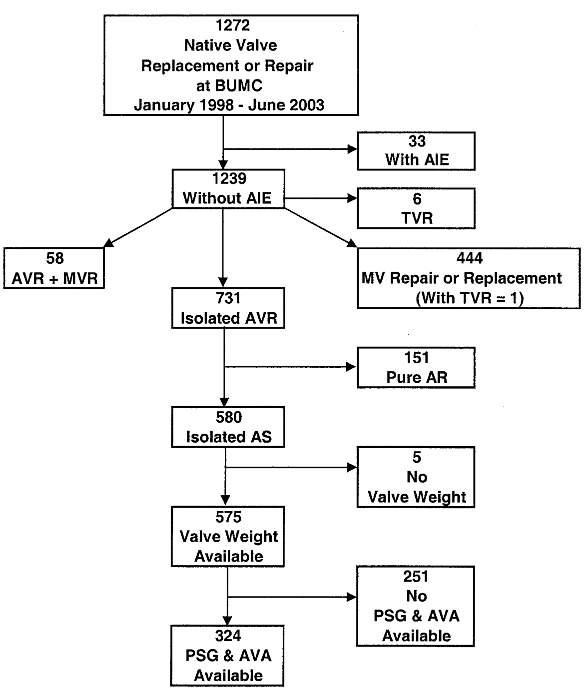

Figure 1. Algorithm showing breakdown of the 1,272 patients having valve replacement or repair at Baylor University Medical Center (BUMC) in a 65-month period and the origin of the 324 cases included in the present study. AIE = active infective endocarditis; AR = aortic regurgitation; AS = aortic stenosis; AVA = aortic valve area; AVR = aortic valve replacement; MV = mitral valve; MVR = mitral valve replacement; PSG = peak systolic gradient; TVR = tricuspid valve replacement.

RESULTS

The weights of the operatively excised stenotic aortic valves ranged from 0.69 to 11.30 g (mean 2.72 g), a 16-fold difference between the smallest and the largest (Table 1). The ages, BMIs, LV to aortic peak systolic pressure gradients, calculated aortic valve areas, whether or not concomitant CABG was performed, and ejection fractions are summarized for both men and women according to the aortic valve weights in Table 1. The transvalvular peak systolic pressure gradients in both men and women increased as the valve weights increased ($p < 0.001$, Kruskal-Wallis one-way analysis of variance on ranks test) (Table 1), the calculated aortic valve areas also decreased as the valve weights increased ($p \leq 0.002$, Kruskal-Wallis one-way analysis of variance on ranks test), but the changes were not as impressive (Table 1). The men in general had higher valve weights than did the women ($p < 0.001$, Mann-Whitney rank-sum test), lower transvalvular gradients ($p \leq 0.005$, unpaired *t* test), and higher valve areas ($p \leq 0.008$, unpaired *t* test) (Table 1).

The valve weights, gradients, and valve areas in both men and women according to aortic valve structure (unicuspid, bicuspid, or tricuspid) are summarized in Table 2. The fewer the number of aortic valve cusps, the heavier the valves were, the greater the peak transvalvular gradients, and the smaller the valve areas.

Valve weights, gradients, and valve areas were not significantly different (by Kruskal-Wallis one-way analysis of variance on ranks test) in patients ≤40 years, 41 to 70 years, and 71 to 90 years of age (Table 3). Valve weights, gradients, and mean areas varied relatively little in patients with BMIs <25 kg/m^2, 25 to 30 kg/m^2, and >30 kg/m^2 (Table 4).

Compared with the 166 patients having coronary bypass, the 158 patients not having concomitant bypass grafting had heavier valves ($p < 0.001$, Mann-Whitney rank-sum test), higher transvalvular peak pressure gradients ($p = 0.045$, Mann-Whitney rank-sum test), but similar valve areas (Table 5).

Valve weights, gradients, and areas were insignificantly different (by either Kruskal-Wallis one-way analysis of variance on ranks test or one-way analysis of variance) when women were compared with women and men with men with LV ejection fractions ≤35%, 36% to 45%, and >45% (Table 6).

The relation of aortic valve weight to transvalvular peak systolic gradient for each of the 201 men is illustrated in Figure 2 and in the 123 women, in Figure 3. The relation of aortic valve weight to aortic valve area in each of the 201 men is shown in Figure 4 and in each of the 123 women in Figure 5.

Table 1. Ages, BMI, and Concomitant Coronary Artery Bypass, LV to Aortic PSG, and AV Areas in Seven AV Weight Groups in Men and Women

AV Weight (g)	No. of Patients	Ages (yrs) Range (Average)	BMI (kg/m^2) Range (Average)	AV Weights (g) Range (Average)	LV-Aorta PSG (mm Hg) Range (Average)	AV Area (cm^2) Range (Mean)	Coronary Bypass	UAV or BAV	Ejection Fraction (%) No.	Ejection Fraction (%) Range (Mean)	Ejection Fraction (%) No. (%) ≤ 40	Ejection Fraction (%) No. (%) >40
Men												
≤1	0	—	—	—	—	—	—	—	—	—	—	—
>1–2	41	47–90 (72)	19–37 (27)	1.16–2.00 (1.64)	11–81 (36)	0.27–1.43 (0.86)	27 (66%)	11 (27%)	37	15–78 (48)	13 (35%)	24 (65%)
>2–3	60	29–87 (69)	20–43 (29)	2.01–3.00 (2.58)	15–97 (45)	0.42–2.25 (0.89)	32 (53%)	24 (40%)	52	10–85 (51)	14 (27%)	38 (73%)
>3–4	50	37–84 (69)	17–40 (27)	3.03–4.00 (3.40)	20–100 (56)	0.20–1.63 (0.75)	26 (52%)	30 (60%)	44	15–80 (53)	7 (16%)	37 (84%)
>4–5	29	42–87 (69)	18–45 (28)	4.01–4.84 (4.40)	20–108 (64)	0.32–1.06 (0.67)	11 (38%)	25 (86%)	26	15–70 (53)	5 (19%)	21 (81%)
>5–6	12	49–90 (70)	24–36 (28)	5.03–5.93 (5.60)	50–116 (71)	0.40–0.88 (0.60)	3 (25%)	10 (83%)	10	20–65 (43)	4 (40%)	6 (60%)
>6	9	38–84 (58)	21–38 (28)	6.24–11.30 (7.92)	35–141 (87)	0.39–1.23 (0.71)	2 (22%)	8 (89%)	8	15–70 (51)	2 (25%)	6 (75%)
Subtotal	201 (62%)	29–90 (69)	17–45 (28)	1.16–11.30 (3.27)	11–141 (52)	0.20–2.25 (0.79)	101 (50%)	108 (54%)	177	10–85 (51)	45 (25%)	132 (75%)
Women												
≤1	10	55–85 (74)	21–44 (30)	0.69–0.95 (0.83)	15–62 (28)	0.34–1.28 (0.83)	7 (70%)	2 (20%)	9	30–70 (47)	4 (44%)	5 (56%)
>1–2	73	19–88 (71)	17–51 (29)	1.02–1.99 (1.46)	10–119 (49)	0.18–1.49 (0.72)	40 (55%)	14 (19%)	66	15–80 (56)	9 (14%)	57 (86%)
>2–3	29	30–87 (70)	18–50 (28)	2.04–3.00 (2.42)	26–113 (63)	0.27–1.09 (0.58)	15 (52%)	12 (41%)	23	30–80 (54)	4 (17%)	19 (83%)
>3–4	10	47–85 (73)	17–35 (26)	3.14–4.00 (3.42)	53–131 (85)	0.23–0.78 (0.51)	3 (30%)	9 (90%)	9	45–75 (53)	0	9 (100%)
>4–5	1	83	29	4.27	53	0.75	0	1 (100%)	1	50	0	1 (100%)
>5–6	0	—	—	—	—	—	—	—	—	—	—	—
>6	0	—	—	—	—	—	—	—	—	—	—	—
Subtotal	123 (38%)	19–88 (71)	17–51 (29)	0.69–4.27 (1.82)	10–131 (53)	0.18–1.49 (0.68)	65 (53%)	38 (31%)	108	15–80 (55)	17 (16%)	91 (84%)

AV = aortic valve; BAV = bicuspid aortic valve; BMI = body mass index; LV = left ventricular; No. = number; PSG = peak systolic gradient; UAV = unicuspid aortic valve.

Table 2. Ages, BMI, Concomitant Coronary Bypass, and AV Weights in Men Versus Women According to AV Structure

Valve Structure	No. of Patients	Ages (yrs)	BMI (kg/m²)	AV Weights (g)	LV-Aorta PSG (mm Hg) Range (Average)	AV Area (cm²) Range (Mean)	Coronary Bypass	Ejection Fraction (%) No.	Ejection Fraction (%) Range (Mean)	Ejection Fraction (%) No. (%) ≤40	Ejection Fraction (%) No. (%) >40
Men											
Unicuspid	8 (4%)	29–51 (44)	21–42 (30)	2.89–8.00 (4.98)	26–141 (64)	0.48–1.82 (0.91)	0	7	15–74 (51)	1 (14%)	6 (86%)
Bicuspid	100 (50%)	37–90 (67)	17–42 (28)	1.20–11.30 (3.74)	13–121 (56)	0.30–1.63 (0.76)	48 (48%)	92	10–78 (51)	24 (26%)	68 (74%)
Tricuspid	93 (46%)	42–90 (74)	19–43 (28)	1.16–6.60 (2.63)	11–100 (47)	0.20–2.25 (0.82)	53 (57%)	78	15–85 (50)	20 (26%)	58 (74%)
Women											
Unicuspid	1 (1%)	33	26	1.35	65	0.88	0	—	—	—	—
Bicuspid	37 (30%)	19–85 (68)	18–42 (27)	0.79–4.27 (2.35)	16–131 (66)	0.23–1.09 (0.59)	12 (32%)	31	20–70 (51)	4 (13%)	27 (87%)
Tricuspid	85 (69%)	30–88 (73)	17–51 (30)	0.69–3.14 (1.60)	10–119 (48)	0.18–1.49 (0.71)	53 (63%)	77	15–80 (57)	13 (17%)	64 (83%)

Abbreviations as in Table 1.

Table 3. Gender, BMI, Concomitant Coronary Artery Bypass, AV Weights, LV to Aortic PSG, and AV Areas in Three Age Groups

Ages (yrs)	Gender	No. of Patients	BMI (kg/m²) Range (Average)	AV Weights (g) Range (Average)	LV-Aorta PSG (mm Hg) Range (Average)	AV Area (cm²) Range (Mean)	Coronary Bypass	UAV or BAV	Ejection Fraction (%) No.	Ejection Fraction (%) Range (Mean)	Ejection Fraction (%) No. (%) ≤40	Ejection Fraction (%) No. (%) >40
≤40	Men	4	25–42 (32)	2.90–8.00 (5.40)	31–141 (66)	0.65–1.63 (1.03)	0	4 (100%)	4	15–64 (50)	1 (25%)	3 (75%)
	Women	4	25–31 (27)	1.30–2.76 (1.87)	37–75 (55)	0.40–1.09 (0.80)	0	3 (75%)	2	58–60 (59)	0 (0%)	2 (100%)
41–70	Men	99	17–45 (29)	1.16–9.04 (3.28)	11–116 (54)	0.20–1.90 (0.82)	45 (45%)	71 (72%)	88	10–78 (51)	23 (26%)	65 (74%)
	Women	47	18–51 (31)	0.87–4.00 (1.75)	11–131 (55)	0.28–1.49 (0.72)	16 (34%)	18 (38%)	42	20–77 (55)	6 (14%)	36 (86%)
71–90	Men	98	18–43 (27)	1.20–11.30 (3.18)	14–121 (50)	0.27–2.25 (0.76)	56 (57%)	33 (34%)	86	15–85 (52)	19 (22%)	67 (78%)
	Women	72	17–44 (27)	0.69–4.27 (1.86)	10–119 (52)	0.18–1.28 (0.64)	49 (68%)	17 (24%)	63	15–80 (54)	13 (21%)	50 (79%)

Abbreviations as in Table 1.

Table 4. Gender, Ages, Concomitant Coronary Artery Bypass, AV Weights, LV to Aortic PSG, and AV Areas in Three BMI Groups

BMI (kg/m²)	Gender	No. of Patients	Ages (yrs) Range (Average)	AV Weights (g) Range (Average)	LV-Aorta PSG (mm Hg) Range (Average)	AV Area (cm²) Range (Mean)	Coronary Bypass	UAV or BAV	Ejection Fraction (%)			
									No.	Range (Mean)	No. (%) ≤40	No. (%) >40
<25	Men	53	45–90 (73)	1.15–9.04 (3.23)	17–121 (54)	0.20–1.82 (0.71)	29 (55%)	25 (47%)	45	15–78 (49)	12 (27%)	33 (73%)
	Women	34	58–88 (75)	0.90–4.00 (1.94)	11–105 (57)	0.23–1.10 (0.57)	17 (50%)	11 (31%)	29	15–80 (50)	9 (31%)	20 (69%)
25–30	Men	93	38–87 (71)	1.20–11.30 (3.33)	11–141 (51)	0.39–1.43 (0.79)	50 (54%)	52 (56%)	86	10–85 (51)	22 (26%)	54 (74%)
	Women	51	30–85 (71)	0.76–4.27 (1.79)	10–119 (48)	0.18–1.28 (0.70)	28 (54%)	20 (39%)	43	15–80 (56)	7 (16%)	36 (84%)
>30	Men	55	29–84 (63)	1.23–7.70 (3.21)	15–116 (52)	0.44–2.25 (0.89)	22 (39%)	31 (56%)	47	15–80 (53)	9 (19%)	38 (81%)
	Women	38	19–84 (68)	0.69–4.00 (1.75)	12–131 (57)	0.27–1.49 (0.74)	20 (51%)	8 (21%)	35	25–75 (56)	3 (9%)	32 (91%)

Abbreviations as in Table 1.

Table 5. Ages, BMI, AV Weights, LV to Aortic PSG, and AV Areas in Patients Without Versus Patients With Concomitant Coronary Artery Bypass Grafting

Coronary Bypass	Gender	No. of Patients	Ages (yrs) Range (Average)	BMI (kg/m²) Range (Average)	AV Weights (g) Range (Average)	LV-Aorta PSG (mm Hg) Range (Average)	AV Area (cm²) Range (Mean)	UAV or BAV	Ejection Fraction (%)			
									No.	Range (Mean)	No. (%) ≤40	No. (%) >40
0	Men	100	29–90 (66)	18–45 (28)	1.21–11.30 (3.64)	11–141 (55)	0.20–1.82 (0.79)	60 (60%)	84	10–80 (55)	13 (15%)	71 (85%)
	Women	58	19–85 (66)	18–51 (28)	0.74–4.27 (1.98)	10–131 (55)	0.23–1.28 (0.67)	26 (45%)	50	15–80 (56)	5 (10%)	45 (90%)
+	Men	101	51–90 (72)	17–43 (27)	1.16–8.30 (2.91)	13–121 (49)	0.30–2.25 (0.80)	48 (48%)	93	15–85 (47)	32 (34%)	61 (66%)
	Women	65	52–88 (75)	17–50 (29)	0.69–3.25 (1.68)	16–119 (52)	0.18–1.49 (0.68)	12 (18%)	58	20–80 (55)	12 (21%)	46 (79%)

Abbreviations as in Table 1.

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Table 6. Gender, Age, BMI, Concomitant Coronary Artery Bypass, AV Weights, LV to Aortic PSG, and AV Areas in Three Ejection Fraction Groups

Ejection Fraction (%)	Gender	No. of Patients	Age (yrs)	BMI (kg/m^2) Range (Average)	AV Weights (g) Range (Average)	LV-Aorta PSG (mm Hg) Range (Average)	AV Area (cm^2) Range (Mean)	Coronary Bypass	UAV or BAV
≤35	Men	34	39–90 (70)	17–35 (27)	1.16–8.30 (3.17)	11–121 (45)	0.30–1.43 (0.80)	27 (73%)	18 (53%)
	Women	10	58–83 (72)	20–30 (24)	0.76–2.19 (1.47)	10–94 (41)	0.39–1.28 (0.65)	7 (70%)	4 (40%)
36–45	Men	22	50–88 (69)	21–42 (28)	1.19–5.55 (3.01)	19–93 (49)	0.41–1.28 (0.80)	13 (59%)	14 (64%)
	Women	17	48–87 (73)	17–44 (27)	0.90–4.00 (2.09)	22–105 (56)	0.23–1.01 (0.57)	9 (53%)	5 (29%)
>45	Men	121	29–90 (69)	18–45 (28)	1.24–11.30 (3.35)	15–141 (53)	0.27–2.25 (0.82)	53 (44%)	67 (55%)
	Women	81	19–88 (71)	17–51 (30)	0.69–4.27 (1.78)	11–131 (55)	0.18–1.49 (0.72)	42 (52%)	22 (27%)

The ejection fractions were obtained from cardiac catheterization in 190 patients, 34 from echocardiogram, and 61 from an unspecified source.
Abbreviations as in Table 1.

Of the 324 patients, only 13 had moderate (3+ of 4+) or severe (4+ of 4+) aortic regurgitation, and the data in these 13 patients are tabulated in Table 7. Although these patients were considered to have moderate or severe aortic regurgitation after cardiac catheterization, only three had dilated LV cavities, and these were the three with low LV ejection fractions.

DISCUSSION

The present study shows that the peak systolic pressure gradients across stenotic aortic valves correspond reasonably well with the weights of the operatively excised stenotic aortic valves in adults when gender is considered (Figs. 2 and 3). Although the average transvalvular peak systolic pressure gradients were similar in both men and women (approximately 52 mm Hg), the mean weights of the stenotic aortic valves in the men were nearly twice (1.8 ×) those is the women. Thus, for any given weight, the peak systolic pressure gradients across stenotic aortic valves were greater in the women than in the men. The smallest valves belonged to the women, and the largest ones to the men (Table 1).

No previous attempts have been made to estimate the valve weight from the transvalvular peak pressure gradient. The present data suggest that in women, each 1-mm Hg peak systolic pressure gradient represents about 35 mg of stenotic aortic valve, and in men each 1-mm Hg peak gradient represents about 65 mg of stenotic aortic valve. Thus, a 53-mm Hg peak systolic gradient across a stenotic aortic valve in a woman calculates into a 1.80-g valve, and a 52-mm Hg transvalvular peak gradient across a stenotic aortic valve in a man translates into a 3.27-g valve.

The peak systolic transvalvular gradients correlated better with valve weights than did the valve areas. In the men, as the valve weights progressively increased from >1 to >6 g, the average transvalvular peak systolic pressure gradients progressively increased from an average of 36 to 87 mm Hg (Fig. 2), whereas the valve areas decreased from 0.86 to 0.71 cm^2 (Fig. 4). In the women, as the valve weights progressively increased from <1 to 4 g, the transvalvular peak systolic pressure gradients progressively increased from 28 to 85 mm Hg (Fig. 3), whereas the valve areas decreased from 0.83 to 0.51 cm^2 (Fig. 5).

Although valve area is used in many medical centers as the gold standard of valve stenosis (2–4), the present study—the first to correlate either transvalvular peak systolic pressure gradient or the calculated aortic valve area with valve weight—demonstrates that the peak systolic transvalvular pressure gradient is more indicative of the degree of valvular obstruction than is the calculated valve area, particularly in the patients with low transvalvular peak systolic pressure gradients.

We are well aware that the gradient across a stenotic valve is dependent on flow across that valve. Several publications have discussed patients with "low gradient-severe aortic stenosis," but in none of these reports has the operatively excised valve been illustrated, described, or weighed (5–11). The peak systolic gradient across a stenotic aortic valve is, of course, a direct measurement. The aortic valve area, in contrast, is

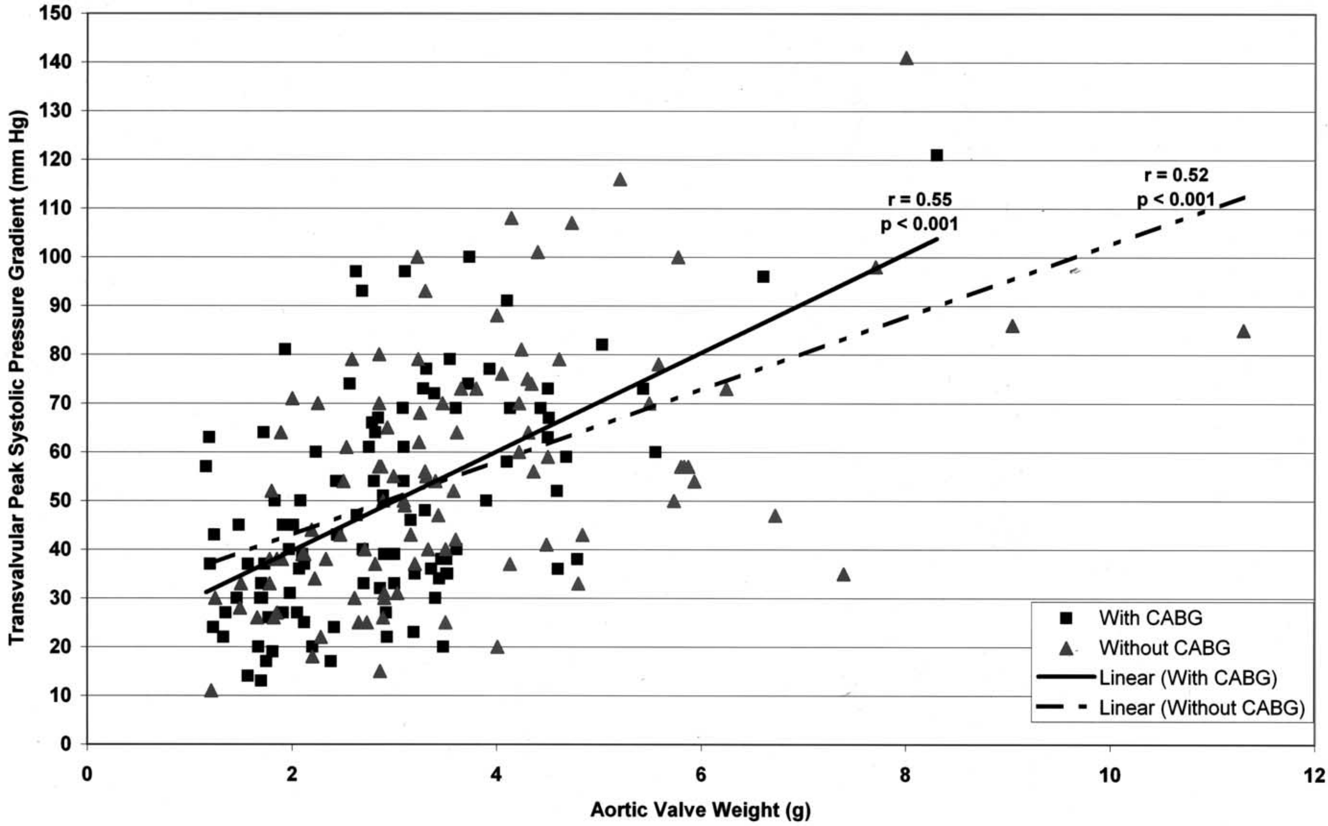

Figure 2. Relation of weights (g) of the operatively excised stenotic aortic valves to preoperative transvalvular peak systolic pressure gradients (mm Hg) in the 201 men. CABG = coronary artery bypass grafting.

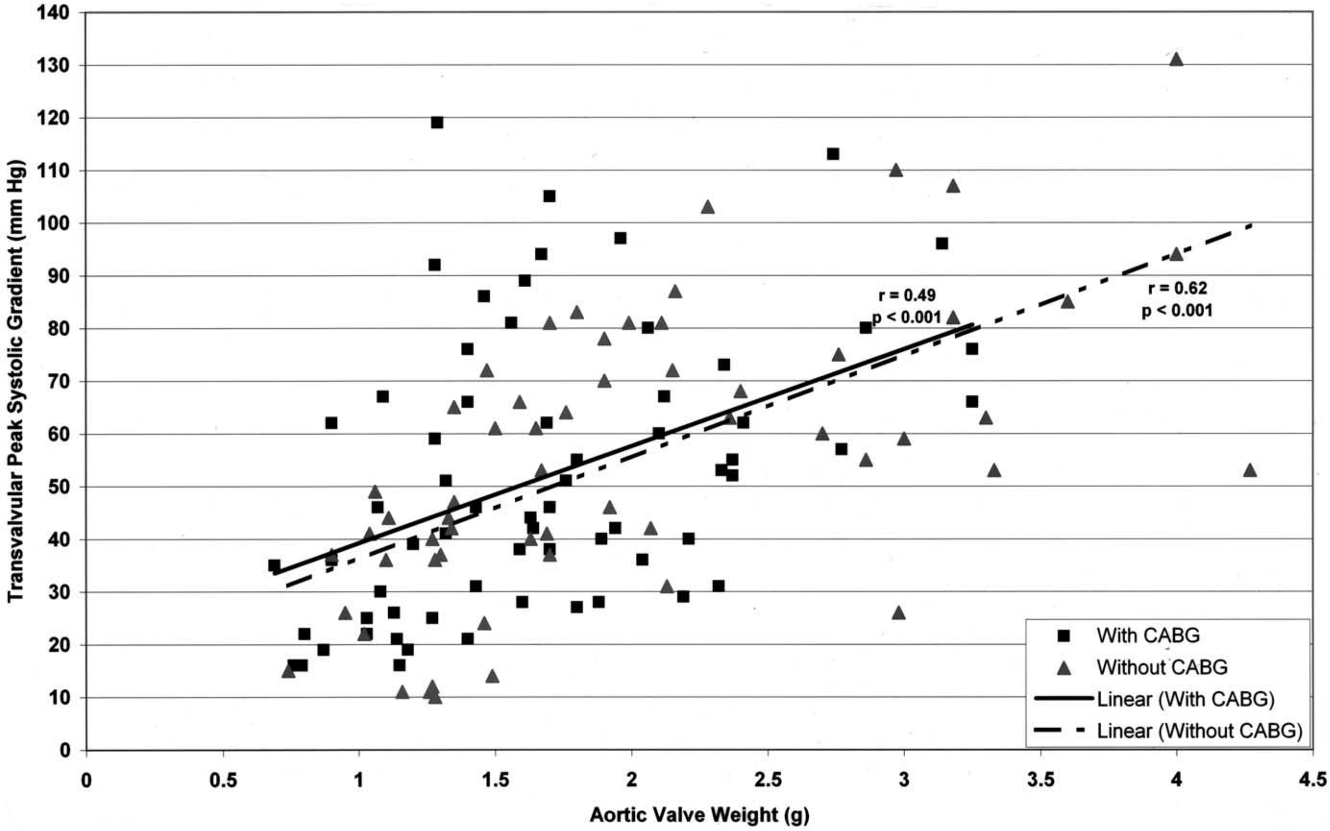

Figure 3. Relation of weights (g) of the operatively excised stenotic aortic valves to preoperative transvalvular peak systolic pressure gradients (mm Hg) in the 123 women. CABG = coronary artery bypass grafting.

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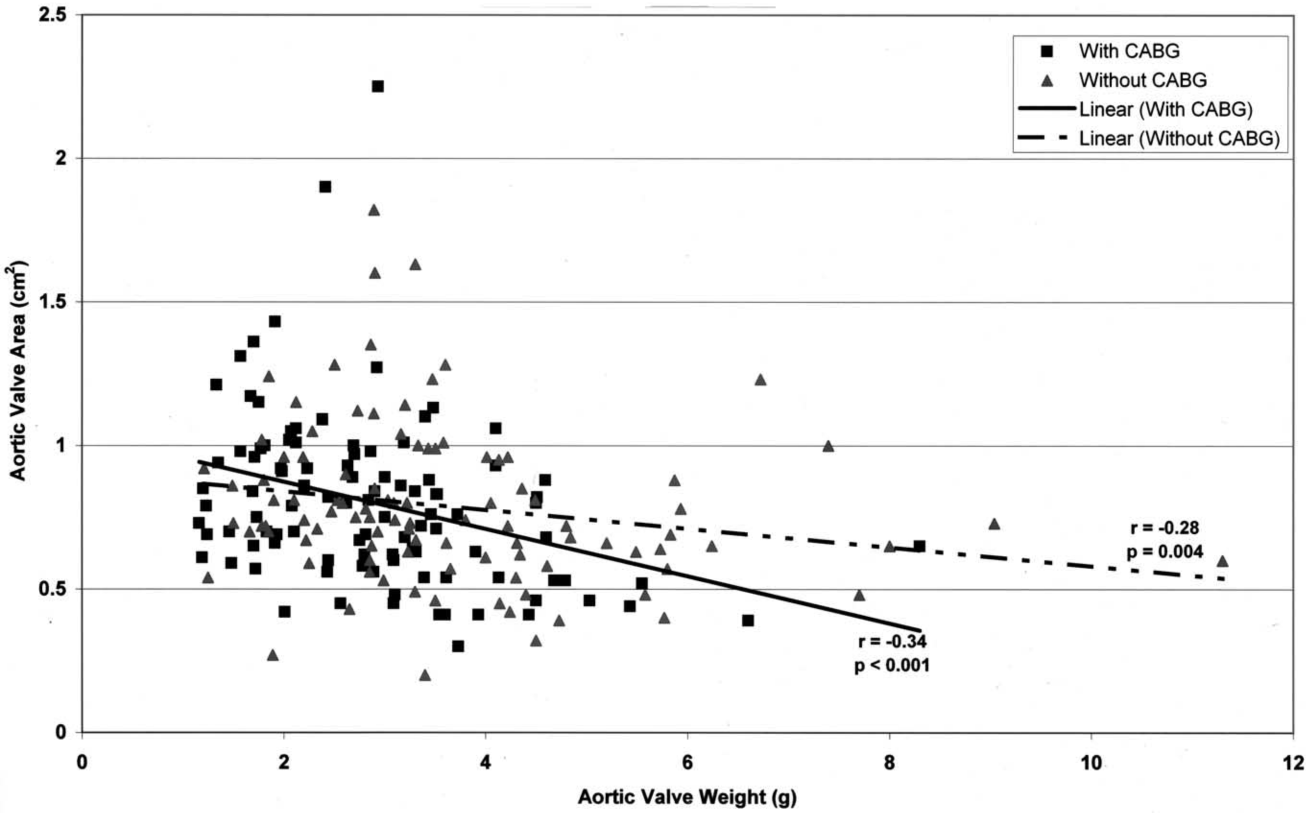

Figure 4. Relation of weights (g) of the operatively excised stenotic aortic valves to preoperative aortic valve area (cm^2) in the 201 men. CABG = coronary artery bypass grafting.

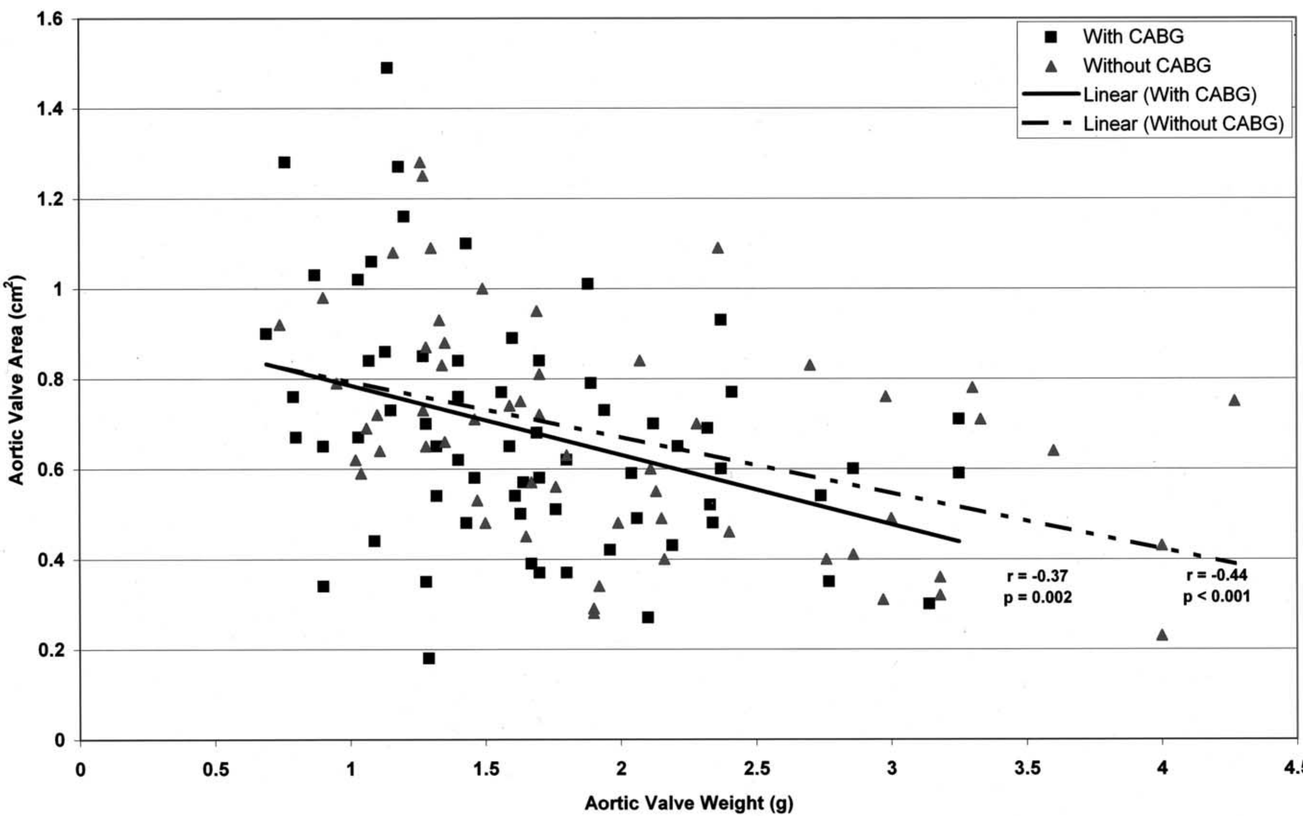

Figure 5. Relation of weights (g) of the operatively excised stenotic aortic valves to preoperative aortic valve area (cm^2) in the 123 women. CABG = coronary artery bypass grafting.

Table 7. Clinical Findings on 13 Patients With Moderate or Severe AR

	Age (yrs)	Gender	AR (3+/4+, 4+/4+)	LV Pressure (s/d) (mm Hg)	Aortic Pressure (s/d) (mm Hg)	LV-Ao PSG (mm Hg)	AV Area (cm^2)	Ao Pulse Pressure (mm Hg)	Cardiac Output (l/min)	EF (%)	Dilated LV Cavity	Number of Coronary Arteries Narrowed >50%	CABG	Body Weight (lbs)	Height (in.)	BMI (kg/m^2)	Number of Cusps	Valve Weight (g)
1	42	M	4	160/34	145/58	15	1.35	87	—	50	0	0	0	240	67	38	2	2.86
2	73	M	4	203/34	178/58	25	1.12	120	6.3	50	0	0	0	207	71	29	3	2.73
3	60	M	3	176/31	150/73	26	0.72	77	4.0	30	+	0	0	146	68	22	3	1.82
4	75	M	3	173/29	143/71	30	1.60	72	6.1	70	0	0	0	174	72	24	3	2.90
5	29	M	4	194/38	163/64	31	0.85	99	5.6	50	0	0	0	300	71	42	1	2.90
6	39	M	3	155/19	114/64	35	1.00	50	—	15	+	0	0	176	70	25	1	7.39
7	62	M	3	151/16	113/50	38	0.81	63	4.8	50	0	0	0	192	70	28	2	1.90
8	43	M	3	173/22	126/67	47	1.23	59	7.7	70	0	0	0	235	71	33	2	6.72
9	77	M	3	179/33	129/59	50	0.8	79	4.9	40	+	0	0	234	76	29	2	3.09
10	68	M	3	209/35	145/76	64	0.57	69	—	60	0	1	+	227	70	33	2	1.72
11	47	M	4	185/23	121/52	64	0.66	69	5.0	75	0	0	0	208	68	32	1	3.61
12	83	F	4	183/23	172/51	11	1.08	121	2.6	55	0	0	0	136	63	24	3	1.16
13	30	F	4	187/37	145/79	42	0.84	66	4.9	60	0	0	0	144	64	25	3	2.07

Ao = aorta; AR = aortic regurgitation; CABG = coronary bypass grafting; EF = ejection fraction; s/d = peak systolic/end diastolic; other abbreviations as in Table 1.

indirect and calculated from the cardiac output, the heart rate, the systolic LV ejection period, a constant (44.3), and the square root of the mean transvalvular gradient. The major message of this study is that care must be taken in concluding that "severe" stenosis can or does occur in the absence of a large peak systolic pressure gradient across the valve. The data herein support the view that a low gradient—irrespective of flow—means non-severe stenosis, and that the valve area calculation is, or can be, very unreliable in patients with low peak systolic gradients across stenotic aortic valves.

The positive features of the present study are the fact that a large group of patients were analyzed, that all valves were weighed by the same person, and that all cases analyzed were seen over a relatively short period (65 months). The negative feature of this study is the fact that the cardiac catheterizations were performed by numerous cardiologists and that the standards of each probably varied, and that most (98%) of the ejection fractions were estimated rather than calculated.

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