

## Left ventricular adaptive response after surgery of aortic valve replacement for severe valvular stenosis

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### Abstract

**Background:** Myocardial hypertrophy is a compensatory mechanism in patients with severe aortic stenosis. The left ventricle fits the systolic pressure through a hypertrophic process with increased wall thickness. The effects of elevated ventricular afterload reduce ventricular myocardial elasticity and decrease coronary flow with increased myocardial work, oxygen consumption, and mortality. Aortic valve replacement surgery can cause regression of left ventricular hypertrophy and improve patient survival. The aim of this study was to evaluate left ventricular adaptive response after surgery of aortic valve replacement for severe valvular stenosis. **Material and Methods:** An observational, analytical, longitudinal study that included patients with diagnosis of aortic stenosis with evidence of left ventricular hypertrophy undergoing valve replacement during the period January 2013 to September 2014. Echocardiographic studies were performed before surgery and six months thereafter. Pre- and post-operative means were compared with Student *t* test for related samples. Statistical significance was considered at  $p \leq 0.05$ . **Results:** 24 patients were included, with an average age of 57.5 years, with no gender predominance, of which 87.5% had history of smoking and 50% with hypertension. There was no statistically significant difference in diastolic and systolic diameter before and after surgery. The interventricular septum was  $14.9 \pm 2.3$  mm preoperative and  $12.8 \pm 2.2$  mm postoperative ( $p = 0.001$ ). The back wall was  $14.2 \pm 1.8$  mm preoperative and  $12.5 \pm 2.2$  mm postoperative ( $p = 0.002$ ). The ventricular mass before surgery was  $154.8 \pm 54.3$  g/m<sup>2</sup> and then  $123.2 \pm 41.4$  g/m<sup>2</sup> ( $p = 0.000$ ). The maximum preoperative transvalvular gradient was  $93 \pm 35$  mmHg and postoperative was  $32.2 \pm 14.4$  mmHg ( $p = 0.00$ ). The average preoperative transvalvular gradient was  $56.3 \pm 19$  mmHg and postoperative was  $7.5 \pm 16.49$  mmHg ( $p = 0.00$ ). **Conclusions:** The interventricular septum, posterior wall, and left ventricular mass decreased significantly after aortic valve replacement. The maximum and mean transvalvular gradient decreased significantly after surgery for aortic valve replacement. (Gac Med Mex. 2016;152:171-5)

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## Background

The most common cause of aortic stenosis in adults is tricuspid aortic valve or congenital bicuspid valve calcification. Aortic stenosis is a condition with a deleterious natural evolution for the patient, which occurs in the general population, with higher incidence in older adults. Medical treatment offers suboptimal results for this population. Surgery remains the standard-of-care for aortic stenosis<sup>1-3</sup>.

Myocardial hypertrophy is a compensatory mechanism with important sequels. The left ventricle (LV) adapts to systolic pressure through a hypertrophic process with ventricular wall thickness augmentation. Elevated ventricular afterload effects include decreased ventricular myocardial elasticity and coronary flow with an increase in myocardial work and oxygen consumption. Ventricular hypertrophy progresses in the presence of significant aortic stenosis, usually developed over decades. In the hypertrophic heart, reduced coronary blood irrigation per gram of muscle can occur, with coronary vasodilatation limited reserve, even in the absence of coronary disease. Hypertrophic hearts also show increased sensitivity to ischemic lesion, with large infarctions and elevated mortality, in comparison with those where hypertrophy is absent<sup>4</sup>.

The development of hypertrophy secondary to asymptomatic severe aortic stenosis can impact on long-term survival even after replacement<sup>5</sup>. Surgery is the standard-of-care in patients with severe aortic stenosis, since valve replacement drastically changes the natural course of the disease<sup>6-16</sup>.

Valve replacement abruptly decreases LV hemodynamic overload. Echocardiographically, this entails rapid ventricular remodeling within the first months after surgery, including a reduction in LV hypertrophy<sup>5-16</sup>. In the literature, ventricular mass index ( $\text{g}/\text{m}^2$ ) after aortic valve replacement has been suggested to be a factor able to modify patient long-term prognosis. However, the association of ventricular hypertrophy with other conditions, such as hypertension, abnormal ejection fraction, prosthesis-patient disproportion or ischemic heart disease, influences on hypertrophy regression in patients with isolated stenosis<sup>17-20</sup>.

The purpose of this work was to assess the LV adaptive response after aortic valve replacement for severe valve stenosis in patients attended to at the High Specialty Medical Unit (UMAE) No. 34 of Monterrey, Nuevo León, since there are no reports of studies assessing this adaptive phenomenon in Mexican patients. In

addition, it is important to identify associated comorbidities and complications of patients undergoing this surgical procedure.

## Material and methods

An ambispective, longitudinal, analytical, observational study was carried out at the Cardiac Surgery Department of the UMAE, Cardiology Hospital No. 34, in Monterrey, Nuevo León, where patients with aortic stenosis and left ventricular hypertrophy that were treated with valve replacement surgery during the period encompassed from January 2013 to September 2014 were included.

Medical records were reviewed to retrieve demographic data, medical history, comorbidities, functional class, EuroScore II and complications.

An echocardiogram was performed prior to surgery and six months after aortic valve replacement. Left ventricular ejection fraction (LVEF), VI end diastolic and end systolic diameter, interventricular septum and posterior wall size, mean ventricular mass, flow rate and peak and mean transvalvular aortic gradient were measured.

Descriptive statistics was used and pre- and post-surgical means were compared with Student's t-test. Statistical significance was considered at a  $p$ -value  $\leq 0.05$ .

## Results

Twenty four patients who met the inclusion criteria were included. Average age was 57.5 years (16-76 years); there were 10 males (41.7%) and 14 females (58.3%). Twelve patients (50%) had arterial hypertension; 4 (16.7%), diabetes mellitus, and 8 (33.3%), were smokers. At the moment of surgery, half were in functional class II and the rest in functional class III. Preoperative ejection fraction was higher than 50% in 21 patients (87.5%) and lower than 50% in 3 (12.5%). Average EuroScore II was  $81.86 \pm 1.4$  (Table 1).

Pre- and post-operative echocardiographic LV measurements were performed. Preoperative LV end diastolic diameter was  $44.6 \pm 7.3$  mm, and postoperative,  $42.9 \pm 5.3$  mm ( $p = 0.176$ ). Preoperative LV end systolic diameter was  $29.5 \pm 8.4$  mm, and postoperative,  $28.2 \pm 5.7$  mm ( $p = 0.373$ ). Interventricular septum prior to surgery measured  $14.9 \pm 2.3$  mm, and after surgery,  $12.8 \pm 2.2$  mm ( $p = 0.001$ ). Pre-surgical posterior wall measured  $14.2 \pm 1.8$  mm, and post-surgical,

**Table 1. Clinical and demographic characteristics of 24 patients with severe aortic stenosis undergoing valve replacement at the UMAE No. 34 of Monterrey, Nuevo León**

Age (years)	57.5 ± 17.02
Males	10 (41.7%)
Females	14 (58.3%)
Functional class:	
II	12 (50%)
III	12 (50%)
Hypertension	12 (50%)
Diabetes mellitus	4 (16.6%)
Smoking	21 (87.5%)
EuroScore II	1.86 ± 1.4
LVEF > 50%	21 (87.5%)
Valve area:	
> 1 cm <sup>2</sup>	23 (95.8%)
< 1 cm <sup>2</sup>	1 (4.2%)

12.5 ± 2.2 mm ( $p = 0.002$ ). Previously, the ventricular mass was 154.8 ± 54.31 g/m<sup>2</sup>, and afterwards, 123.2 ± 41.4 g/m<sup>2</sup> ( $p = 0.000$ ). Preoperative flow rate was 6.47 ± 8.5 m/s, and after surgery, 2.74 ± 0.6 m/s ( $p = 0.07$ ). Mean preoperative peak transvalvular gradient was 56.3 ± 19 mmHg, and postoperative, 49 ± 7.5 mmHg ( $p = 0.00$ ) (Table 2).

Five patients had complications, which included postoperative bleeding, atrioventricular (AV) block, renal failure and infection. The patients with complications

had a EuroScore II of 2.4 ± 2.5 versus 1.7 ± 1 for those without complications ( $p = 0.02$ ) (Table 3).

## Discussion

Degenerative disease occurs in stenotic aortic valves of patients older than 65 years, and its prevalence increases with age. In this case series, average age was 57.5 years, which is somewhat lower than reports in the literature<sup>1,2</sup>.

Smoking increases the risk for stenosis by 35% and hypertension, by 20%; other associated factors are elevated lipoproteins, elevated low density cholesterol and diabetes mellitus<sup>1,2</sup>. Half the patients included on this study had arterial hypertension and a fifth part had diabetes mellitus. A third part of patients were found to be smokers. Studies report that hypertension has a strong negative impact on the reduction of left ventricular mass index and survival after surgery. Patients with hypertension tend to present higher left ventricular mass index, less hypertrophy reduction and worse clinical outcomes<sup>9</sup>.

EuroScore II is a model that attempts to predict the risk for experiencing complications during a surgical procedure<sup>18</sup>. In this study, 20% of patients were found to experience complications, with these subjects having a higher EuroScore II than those who showed no complications.

Patients with severe aortic stenosis who also have deteriorated ventricular function, lower than 50%, are considered at high risk for aortic replacement surgery. Survival of patients undergoing aortic valve

**Table 2. Echocardiographic measurements performed before and after aortic valve replacement surgery un patients operated at the UMAE No. 34 of Monterey, Nuevo León\***

	Preoperative	Postoperative	p
LV end diastolic diameter	44.67 ± 7.39	42.92 ± 5.34	0.176
LV end systolic diameter	29.54 ± 5.35	28.29 ± 5.76	0.373
Interventricular septum	14.92 ± 2.33	12.83 ± 2.2	0.001
LV posterior wall	14.29 ± 1.87	12.5 ± 2.2	0.002
Indexed ventricular mass	154.8 ± 54.31	123.21 ± 41.4	0.000
Flow rate (m/s)	6.47 ± 9.54	2.74 ± 0.63	0.070
Peak transvalvular gradient (mmHg)	93.08 ± 35.16	31.25 ± 14.45	0.000
Mean transvalvular gradient (mmHg)	56.38 ± 19.77	16.40 ± 7.54	0.000

\*Measurements with standard deviation, Student's t-test.

replacement surgery is more favorable in patients with preserved LVEF, but patients with low LVEF also experience a substantial benefit if compared with the natural course of the disease<sup>14,19</sup>. Goldberg et al. report that both patients with preserved ejection fraction and those with deteriorated ejection fraction show better short and long-term survival after surgery and, therefore, a patient with low LVEF should be referred to surgery<sup>19</sup>. Most patients had preserved LVEF and only 3 had LVEF lower than 50%.

LV hypertrophy secondary to severe aortic stenosis can impact on long-term survival even after effective valve replacement<sup>5</sup>. Thus, elevated left ventricular mass index is also associated with intra-hospital morbidity in patients undergoing aortic valve replacement surgery<sup>11</sup>. Patients with higher left ventricular hypertrophy regression and low transvalvular gradients have better survival<sup>15</sup>. In a study conducted in 30 patients, a ventricular mass reduction was found to exist in all patients regardless of the type of prosthesis used; a reduction was also found in the interventricular septum and posterior wall<sup>20</sup>. Lund et al. reported a reduction in the ventricular mass index indexed at 1.5 and 10 years<sup>13</sup>. Ali et al. referred a reduction in ventricular mass after aortic valve replacement surgery; in addition, they found a trend in the reduction of both end systolic and end diastolic LV dimensions, with no statistical significance being found<sup>15</sup>. Tasca et al. assessed 111 patients undergoing aortic valve replacement who subsequently had a control echocardiographic study performed, and observed regression in the interventricular septum, in the posterior wall, in end systolic and end diastolic diameters, and in ventricular mass; additionally, they reported a significant reduction in peak and mean transvalvular gradients<sup>16</sup>. In this case series, end diastolic and end systolic LV diameters were found to decrease after aortic valve replacement surgery, but with no statistically significant difference. There was an important and significant decrease in the LV septum and posterior wall, as well as in the indexed ventricular mass. Peak and mean transvalvular gradients were considerably reduced after surgery. These results are consistent with those reported by other authors<sup>13-20</sup>.

Another aspect that has been recently taken into account is peak transvalvular jet velocity. Patients with a rate of up to 4 m/s, even when asymptomatic, are considered to be able to benefit from early surgical treatment. In these patients, an exercise tolerance test should be performed in order to discover latent

**Table 3. Complications after aortic valve replacement surgery in patients operated at the UMAE No. 34 of Monterrey, Nuevo León**

Postoperative bleeding	2	(8.3%)
AV block	1	(4.1%)
Empyema	1	(4.1%)
Infection	1	(4.1%)

symptoms or hemodynamic instability<sup>21</sup>. In our study, mean pre-surgical rate was higher than 6 m/s and, therefore, most patients had aortic valve stenosis-related symptoms; after surgery, the rate decreased down to 2.7 m/s, which is an acceptable flow with which the patient can remain asymptomatic.

The results of this study, conducted in Mexican patients undergoing valve replacement surgery, show an adaptive response of the left ventricular mass after surgery, which is consistent with reports from other international studies. This ventricular remodeling has been associated with good response to surgical treatment and better survival if compared with the natural course of the disease or non-surgical treatment, which makes valve replacement surgery the best option so far for patients with severe aortic stenosis.

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