Correlation between hemodynamic assessment in isolated aortic stenosis and multivalvular disease

ABSTRACT

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| No one can deny the unpredictable progressive character of aortic stenosis. Aortic stenosis (AS) is a frequent valvular heart disease in the elderly, marked by narrowing of the aortic valve, leading to left ventricular hypertrophy and diastolic dysfunction.Calcification of the valve leaflets is the main pathological mechanism, often accompanied by lipid infiltration and fibrosis.  AS is asymptomatic for years, with symptoms like dyspnea, angina, and syncope signaling disease progression.  This study retrospectively analyzed 100 adult patients with severe AS from July 2021 to October 2024. Echocardiography assessed AS severity via jet velocity, mean gradient, and aortic valve area (AVA).  Data were analyzed using SPSS; t-tests and Chi-square tests compared clinical variables.  Mean patient age was 57.26 years; 56.9% were male.Most had preserved left ventricular function and concentric hypertrophy.Severe AS was defined by AVA <1 cm², mean gradient >40 mmHg, and velocity >4 m/s.  Males had a higher prevalence of pure AS; hemodynamic parameters were similar across sexes.  Calcific AS is now recognized as an active inflammatory condition, not just degenerative. Echocardiography remains central in diagnosis and severity grading but CT and MRI can provide advanced structural insights but are not routinely used.  Despite being asymptomatic initiall,. AS progression varies, and untreated symptomatic patients face high mortality within 3 years so that early detection and accurate grading are crucial for timely intervention.AS has poor outcomes post-symptom onset without intervention. So that valve replacement is indicated upon symptom development; management of asymptomatic patients remains complex.  The aim of our study was to investigate the correlation between hemodynamic assessment in isolated aortic stenosis and multivalvular disease |

*Keywords: Aortic stenosis; multivalvular disease; AVA; hemodynamic valvular assessment*

1. INTRODUCTION

[(The aortic stenosis is a common valvular heart disease in the eldery characterized by a narrowing of the aortic valve surface , responsible of a remodeling and hypertrophy of left ventricular that leads furtheraway to diastolic dysfunction.

Valve leaflet calcification is the main culprit lesion of AS. In addition to aortic valve calcification (AVC), lipid infiltration, aberrant extracellular matrix remodeling, and extensive valvular fibrosis may also contribute to the thickening and stiffening of aortic valve leaflets and thus to the development of AS.

This valvular heart disease remains quite for a while before the manifestations appear: dyspnea, chest pain , syncope. The manifestation of symptoms signifies a pivotal stage in disease progression, thereby necessitating the reassessment and potential modification of therapeutic interventions. Those symptoms are the reflection of specific hemodynamic patterns that are well investigated by two dimensional 2D and doppler echocardiography.

2. material and methods

**Study design and population**

Clinical and echocardiographic data of 100 adult patients who presented with a severe aortic valve stenosis from July 2021 to October 2024 in a cardiac surgery department were analyzed retrospectively.

Patients in whom echocardiography with an assessment of the AV was indicated were considered eligible for the analysis. No additional tests, in particular no MSCT, were performed for the study. Exclusion criteria were: congenital heart disease except bicuspid aortic , previous aortic valve surgery and infective endocarditis.

All patients underwent routine transthoracic echocardiography.

**Transthoracic echocardiography**

Echocardiographic studies were performed using Vivid S70 (GE Vingmed Ultrasound, Horton, Norway; trans- ducer M5Sc-D, 1.4–4.6 MHz) and Philips EPIQ 7G (Philips Medical Sys- tems, Andover, MA, USA; transducer X5-1, 1–5 MHz) .

All echocardiographic studies were conducted by experienced clinicians. Image analysis and all measurements were carried out according to the current guidelines .

**Classification and inclusion of patients**

As recommended by current guidelines, the severity of AS was based on visual assessment and hemodynamic parameters: the peak jet velocity across the aortic valve, the mean transvalvular pressure gradient, and the effective aortic valve area by continuity equation.

In the case of incongruent data in AVA, peak jet velocity and mean gradient, such as patients with low-flow, low-gradient AS, the results were labelled as inconsistent grading.

**Visual assessment of aortic valve**

Visual grading of AV morphology and of degenerative changes was performed using two-dimensional images only. Degenerative changes of the AV were evaluated using four characteristics: echogenicity, thickening, localization of valve lesions, and mobility of AV leaflets .

**Statistical analysis:**

The collected data were entered using Word, graphs were created with Excel, and data processing and analysis were performed using SPSS software, version 26. Continuous variables were described using the mean ± standard deviation or the median and interquartile range, and compared using the Student's t-test. Categorical variables were described using frequencies and percentages, and compared using the Chi-square test.

3. results and discussion

**Results:**

100 Patients (mean age 57.26 ± 13.31years, 56.9% men) were included in this study. Clinical and echocardiographic patient characteristics are summarized in Table [1](#_bookmark2). Patients with AS were older . Men had a higher prevalence of a pur AS compared to women.

Most of the patients diagnosed with isolated aortic stenosis had a normal left ventricular function. Hemodynamic parameters of AS were similar between female and male patients. In patients with severe AS, the average mean gradient was 51.79 ± 16.99 mmHg, the average peak aortic jet velocity was 4.51 ± 0.7 m/s and the average AVA was 1 cm2, without a significant difference in these parameters between female and male patients (Sup- plementary Table 1)

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| Parameter | Results | | Groups by valvular desease | | | P value |
| Isolated AS | | Multi valvular disease |
| Age >57 Y.O | 57.26+/-13.31 | | 18 | | 9 | 0.001 |
| Sexe | 56.9% | | 18 | | 15 | 0.039 |
| Hypertension | 13% | | 03 | | 04 | 0.469 |
| Smoking | 20.7% | | 03 | | 08 | 0.391 |
| Diabetes mellitus | 12.1% | | 05 | | 02 | 0.107 |
| ACD | 13.8% | | 05 | | 03 | 0.233 |
| CKD | 6.89% | | 01 | | 03 | 0.346 |
| ***Echocardiography*** | | | | | | |
| LV EF <50% | 57.77%+/-9.84 | 2 | | 9 | | 0.064 |
| Dilated LV | 20.7% | | 1 | | 11 | 0.006 |
| Concentric hypertrophy of LV | 81% | | 59 | | 22 | 0.001 |
| ***Aortic valve parameters*** | | | | | | |
| Bicuspid valve | 1.7% | | 01 | | 00 | 0.246 |
| AVA <1 cm² | 79.3% | | 21 | | 25 | 0.443 |
| Mean gradient >40 mmHg | 51.79+/-16.99 | | 23 | | 23 | 0.038 |
| Peak velocity>4 m/s | 4.51+/0.7 | | 23 | | 24 | 0.064 |

# Table 1: clinical and echocardiographic characteristics in both groups

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Figure 1:A parasternal short-axis view showing a heavily calcified aortic valve with features suggestive of severe aortic stenosis. Figure 2 : A parasternal long-axis view showing a calcified aortic valve with restricted opening, leading to left ventricular hypertrophy.

# Discussion

Aortic stenosis is a critical condition caused by the narrowing of the aortic valve, responsible of reducing cardiac output and decreased functional capacity. It develops gradually so it is more seen with population ageing. Aortic stenosis is asymptomatic for years, initial diagnosis of AS typically occurs during routine physical examination with the presence of a heart murmur, click, or other abnormal sounds, but undiagnosed patients may experience the onset of severe symptoms. This gradual development underline the necessity of surveying such patients, until the valve becomes severely narrowed so the symptoms starts to appear : syncope; angina ; heart failure signs… (1).

Multiple etiologies can lead to aortic valvular stenosis principally aortic valve calcification, which is the main process leading to aortic stenosis and the degree of AVC-AS anatomic severity is closely related to AS haemodynamic severity as assessed using echocardiography. (2)

The native AV experiences a complex mechanical environment, including leaflet stretch, fluid shear stress, bending stresses, and pressure forces. The forces experienced by the leaflet vary spatially and temporally over the cardiac cycle and may be altered significantly because of disease. Calcific AS was initially believed to be a passive disease associated with the wear and tear of valve tissue due to aging. However, multiple studies have shown that AV calcification is the result of active inflammatory processes, mediated by hemodynamic and genetic factors. (3) In fact,the disruption of the aortic valvular endothelium with endothelial dysfunction, lipid accumulation, and infiltration of lymphocytes and macrophages that release pro-inflammatory molecules; they recruit fibroblasts and activate osteoblasts, leading to valve fibrosis, progressive thickening, that, over time, evolves into severe valve calcification.(4)

Calcific aortic valve disease was long considered as a degenerative and, therefore, permanent condition. Clinical and histological similarities with atherosclerosis have led to the hypothesis that statins may prevent AS progression. The Scottish Aortic Stenosis and Lipid Lowering Trial, Impact on Regression (SALTIRE), SEAS and Aortic Stenosis Progression Observation: Measuring Effects of Rosuvastatin (ASTRONOMER) trials assessed the effect of statins on progression of AS in asymptomatic patients and failed to demonstrate any effect.It has thus been suggested that any effect of statins may only be observable in the early phase in patients with mild AS or even in patients with aortic valve sclerosis (5,6,7)

Evaluation of aortic valve stenosis as bases on data obtained from two dimensional 2D and doppler echocardiography plays a key role in the grading of aortic valve stenosis .(8)

The first echocardiographic approach in the evaluation of AS begins with the characterization of aortic valve morphology by transthoracic parasternal long- and short-axis views, in order to identify the number, mobility, thickness, and calcification of the cusps and to evaluate the etiology;

AS haemodynamic severity is usually assessed using echocardiography based on mean gradient, peak velocity, and calculating the aortic valve area.

Current guidelines/recommendations define severe stenosis as an aortic valve area (AVA) <1 cm2 (or <0.6 cm2 adjusted for body surface area), mean pressure gradient (ΔPm) >40 mmHg, or peak flow velocity (Vmax) >4 m/s(9). If the left ventricular function is normal, the three parameters should yield a consistent classification of a particular aortic stenosis as either mild; moderate or severe. (10)

Computed tomography (CT) provides the highest-resolution anatomic data of the AV in calcific AS. Additionally, CT provides the best assessment of calcification on the valve leaflets and annulus among all imaging modalities. Although cardiac CT was initially used to detect and quantify coronary artery calcification, its applicability to assess AVC was also demonstrated in early studies. Currently, multidetector CT scanners are most commonly used because of their lower cost and superior spatial and temporal resolution so that they gained prominence recently in the treatment of AS with the use of transcatheter aortic valve replacements (TAVRs) .(11,14).

MRI has been used to a much lesser extent in the diagnosis of AS. The attractiveness of MRI lies in the avoidance of radiation exposure and in the ability to obtain both anatomic and hemodynamic measurements and full 3-dimensional information provided by the modality. On the other hand, the inherent disadvantages of MRI include the inability to accurately identify calcification, signal voids due to flow turbulence, lower spatial resolution in comparison with CT, imaging artifacts due to implanted medical devices, increased scan times, and higher costs.(15,18)

The progression of AS is variable between patients, with many being asymptomatic. However, studies have found that 75% of patients die within three years of symptom onset if no interventions are performed.(19)

In the management of patients with aortic valve stenosis , symptoms attributable to aortic stenosis (syncope, angina and dyspnoea) determine which patient should undergo valve replacement. On the other hand , decisions on management of asymptomatic patients particulary with severe stenosis are more difficult and exact grading becomes more important . Risk of rapid progression of disease, imminent heart failure and sudden death must be weighed against perioperative morbidity and mortality, valve deterioration and problems associated with possible long-term anticoagulation .(20)

4. Conclusion

Aortic stenosis is a progressive and potentially life-threatening condition, often silent for years before the onset of symptoms. Its development, primarily driven by active calcific and inflammatory processes, highlights the complexity of the disease beyond simple degeneration. Early diagnosis through echocardiographic evaluation is essential for appropriate grading and timely intervention. As symptom onset marks a turning point with significantly increased mortality risk, close surveillance and individualized management strategies are critical, particularly in asymptomatic patients with severe stenosis.

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