Computed tomography calcium scoring in routine clinical practice for assessing severity of aortic valve stenosis

Łukasz Wiewiórka[1, 2, 3], Jacek Legutko[1, 4], Jarosław Trębacz[1], Paweł Kleczyński[1, 4], Joanna Szachowicz-Jaworska[2], Maciej Krupiński[2], Paweł Banyś[2], Krzysztof Żmudka[1, 4], Maciej Stąpór[1]

[1]Clinical Department of Interventional Cardiology, St. John Paul II Hospital, Kraków, Poland
[2]Department of Radiology, St. John Paul II Hospital, Kraków, Poland
[3]University of Applied Sciences in Nowy Targ, Nowy Targ, Poland
[4]Institute of Cardiology, Department of Interventional Cardiology, St. John Paul II Hospital, Jagiellonian University Medical College, Kraków, Poland

Correspondence to:
Maciej Stąpór, MD, PhD,
Clinical Department of Interventional Cardiology,
St. John Paul II Hospital,
Prądnicka 80,
31–202 Kraków, Poland,
phone: +48 12 614 35 01,
e-mail: m.stapor@szpitaljp2.krakow.pl

DOI: 10.33963/v.phj.102780

Received:
September 12, 2024

Accepted:
September 23, 2024

Early publication date:
October 3, 2024

INTRODUCTION

Aortic valve stenosis (AS) is the most common valvular heart disease requiring intervention, with its incidence rising due to population aging [1]. Treatment decisions rely on AS severity and symptoms, but accurate assessment can be challenging in some patients [2, 3].

Transthoracic echocardiography (TTE) is the standard for evaluating AS, though it has methodological limitations that can hinder proper qualification for invasive treatment [4]. Contemporary AS assessment also incorporates cardiac biomarkers, computed tomography (CT), and cardiac magnetic resonance [5, 6]. CT calcium scoring (CTCS) offers valuable insights into AS severity and has been endorsed by the European Society of Cardiology, although its use is primarily limited to university centers [7, 8].

To our knowledge, there are no reports on using CTCS in everyday clinical practice except for topics concerning low-gradient AS or validation of cutoff values. Therefore, our study aimed to identify the main indications for CTCS in assessing AS in an unselected population and to evaluate patient outcomes.

METHODS

We retrospectively analyzed data from all consecutive AS patients who underwent CTCS between November 2017 and September 2021 at a single heart valve center. This confirmatory study included patients with suspected low-gradient severe AS and those with potential errors in AV evaluation. The only exclusion criterion was inaccessible TTE recording. The study adhered to the principles of the Declaration of Helsinki and received approval from the local ethics committee. The follow-up was conducted for up to 12 months after CTCS.

The TTE recordings, stored in DICOM format, were analyzed in accordance with current guidelines, by two independent cardiologists certified by the European Association of Cardiovascular Imaging, who were blinded to the clinical data and CTCS results. The image analysis was facilitated using ComPACS (Medimatic S.R.L., Genova, Italy).

The CT scans were conducted using a second-generation dual-source scanner (SOMATOM Drive, Siemens Medical Solutions, Forchheim, Germany), following guidelines. Two independent radiologists evaluated the data on a Syngo.via Multimodality workstation (Siemens-Healthineers, Munich, Germany 2020). AV calcification was categorized according to the European Society of Cardiology guidelines [1]. Participants were stratified into two groups: the highly likely group (HLG) with CTCS >3000 AU in men and >1600 AU in women, and the not-very likely group (NVLG) with CTCS below these thresholds.

Statistical analysis

Normality was assessed using the Shapiro–Wilk test. Descriptive statistics were used, presenting continuous variables with non-normal distribution as medians (interquartile ranges [IQR]), and categorical variables as numbers (percentages). The Wilcoxon rank-sum test was used for non-normally distributed variables. Pearson's χ^2 test and Fisher's exact test were employed for unpaired categorical

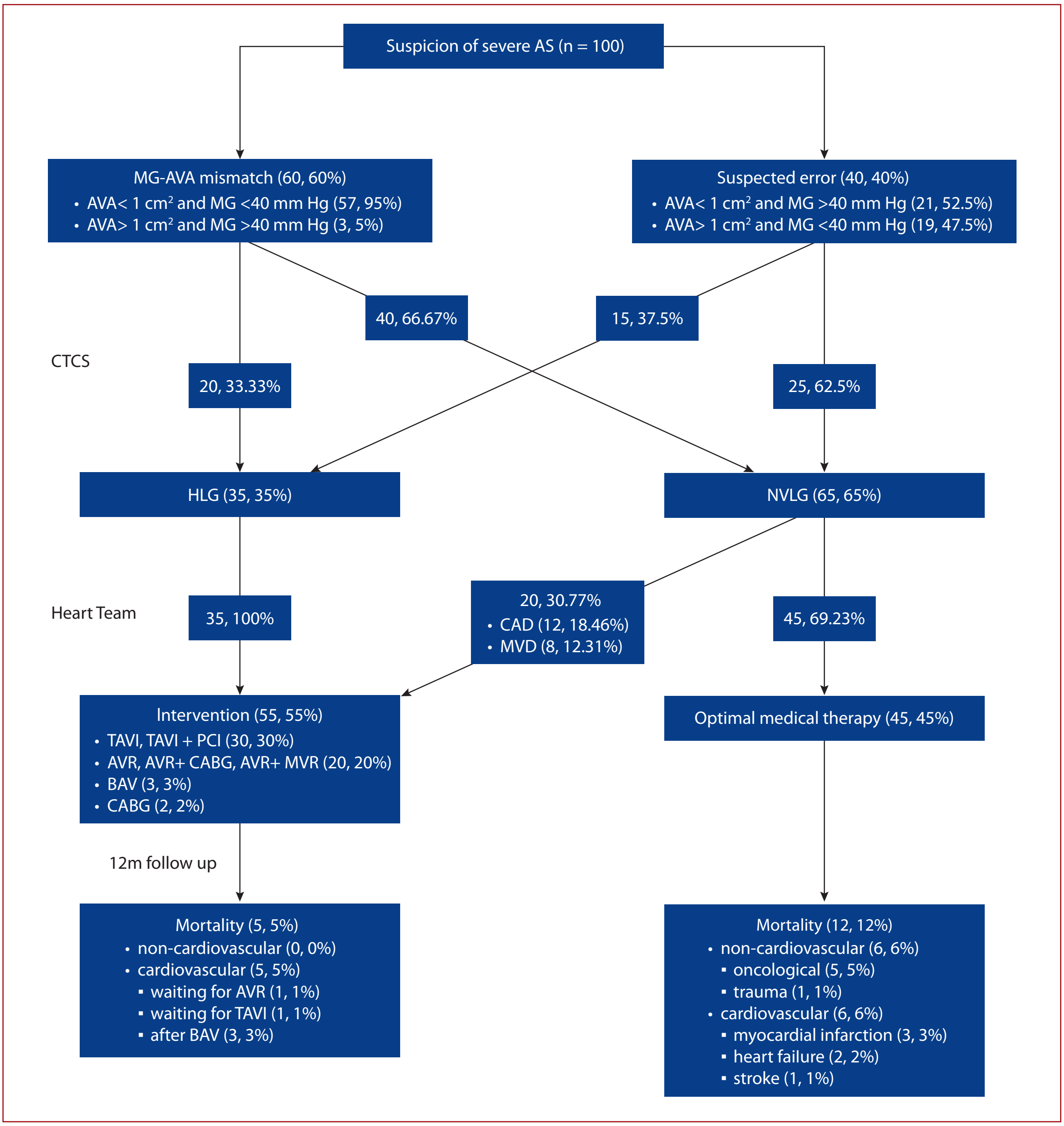

Figure 1. Study flowchart

Abbreviations: AVA, atrioventricular area; AVR, aortic valve replacement; BAV, balloon aortic valvuloplasty; CABG, coronary artery bypass graft; CAD, coronary artery disease; CTCS, computed tomography calcium scoring; HLG, highly likely group; MG, mean gradient; MVD, mitral valve disease; MVR, mitral valve replacement; NVLG, not-very likely group; PCI, percutaneous coronary intervention; TAVI, transcatheter pulmonary valve implantation

data. Statistical analyses were conducted using Statistica 13.3 (Tibco Software, Inc., Palo Alto, CA, US), with a two-tailed *P*-value <0.05 considered statistically significant.

RESULTS AND DISCUSSION

One hundred patients (median age 78.5 [IQR 72.5–83] years) were included, and 57 (57%) were female. They were mostly (70, 70%) overweight or obese and predominantly in New York Heart Association functional class II or III (40 [40%] and 38 [38%], respectively). The median AV area (AVA) was 0.9 (IQR 0.8–1) cm², and the median mean gradient (MG) was 31 (IQR 25.5–40) mm Hg.

The primary indication for CTCS was the MG-AVA mismatch. Echocardiographic discordance was found in 60 (60%) patients, mainly due to the coexistence of AVA <1 cm² and MG <40 mm Hg in 57 (95%) of these patients. In this group, severe AS was observed in only 33.3% of patients. This observation is consistent with published data indicating that significant low-gradient AS with preserved ejection fraction occurs in approximately 20%–30% of cases [2].

The second reason for CTCS was the suspicion of AS underestimation. Concordant values of AVA <1 cm^2 and MG >40 mm Hg, and AVA >1 cm^2 and MG <40 mm Hg were observed in 21 (21%) and 19 (19%) patients, respectively. Technical issues, such as the underestimation of Doppler velocities and inaccurate assessment of the left ventricular outflow tract, were the most common causes of AS underestimation [9]. Other factors contributing to echocardiographic ambiguity included impaired filling pressures, atrial fibrillation, ventricular remodeling, and the pressure recovery phenomenon [4].

The median CTCS was 1703.2 (IQR 1103.7–2739.5) AU. Thirty-five patients (35%) were assigned to the HLG, while 65 (65%) were in the NVLG. The median CTCS in the HLG was 3432 (IQR 2398–5144) AU, while in the NVLG, it was 1310 (IQR 881–1707.4) AU; P <0.001. CTCS values were higher in men compared to women: 2282 (IQR 1469–3072) AU vs. 1473 (IQR 1015–2495) AU; P = 0.03. However, we found no significant difference in the incidence of severe stenosis between sexes (P = 0.09). The median AVA was lower in the HLG: 0.8 (IQR 0.6–0.9) cm^2 vs. 0.9 (IQR 0.8–1.1) cm^2; P = 0.001, while the median MG was higher in the HLG: 36 (IQR 27–51) mm Hg vs. 30 (IQR 23–36) mm Hg; P = 0.001. More patients in New York Heart Association class III or IV were in the HLG (71.4%) compared to the NVLG (36.4%; P = 0.003). Moreover, patients in the HLG were 5 years older than those in the NVLG (82 [IQR 74–84] years vs. 77 [IQR 72–81] years; P = 0.01). This aligns with recent studies, suggesting that CTCS correlates with age and the frequency of severe AS, reaching 10% in octogenarians [10].

After evaluation, 45 patients (45%) were qualified for observation with optimal medical therapy. More than half (55%) of patients were reviewed by the Heart Team. Of these, 35 (66%) were deemed eligible for transcatheter aortic valve implantation, while 15 (28.3%) were recommended for aortic valve replacement. Only 3 (5.7%) patients were eligible for palliative balloon aortic valvuloplasty. The number of patients suitable for invasive treatment (55, 55%) exceeded the number of patients with confirmed severe AS (35, 35%), owing to concurrent valvular or coronary artery disease necessitating surgery.

Twelve-month all-cause mortality in the study group was 17%, lower than reported by Clavel et al. [11]. The HLG experienced five deaths (14.3%), while the NVLG had twelve (18.5%; P = 0.6). However, cardiovascular mortality at 12 months was 11%, with 5 deaths in the HLG (14.3%) and 6 in the NVLG (9.2%; P = 0.44). CTCS in non-survivors measured 1719 (IQR 1100–2692) AU, compared to 1561 (IQR 1150–3072) AU; P = 0.048 in survivors. In the HLG, 2 deaths occurred while awaiting transcatheter aortic valve implantation or aortic valve replacement. However, it is important to note that the study took place during the COVID-19 pandemic.

CT has greatly enhanced our understanding of heart diseases. While not yet widely adopted, CTCS offers promising advantages in AS evaluation, often surpassing echocardiography in accuracy [12]. We are the first to describe the use of CTCS in everyday clinical practice for indications beyond low-gradient AS. Given the critical role of accurate AS assessment in treatment decisions, broader utilization of CTCS could provide valuable diagnostic insights.

Our study's limitations include a small sample size and a retrospective analysis from a single-center registry. Additionally, TTEs were conducted by various echocardiographers, which reflects real-life practice.

In conclusion, the primary reason for assessing AS severity with CTCS was discordance between AVA (<1 cm^2) and MG (<40 mm Hg), where CTCS often indicated non-severe AS. In older symptomatic patients with inconclusive echocardiographic results, CTCS generally confirmed significant AS. Larger valve calcification was linked to poorer twelve-month outcomes.

Article information

Conflict of interest: None declared.

Funding: None.

REFERENCES

1. Vahanian A, Beyersdorf F, Praz F, et al. 2021 ESC/EACTS Guidelines for the management of valvular heart disease. EuroIntervention. 2022; 17(14): e1126–e1196, doi: 10.4244/EIJ-E-21-00009, indexed in Pubmed: 34931612.
2. Lancellotti P, Magne J, Donal E, et al. Clinical outcome in asymptomatic severe aortic stenosis: insights from the new proposed aortic stenosis grading classification. J Am Coll Cardiol. 2012; 59(3): 235–243, doi: 10.1016/j.jacc.2011.08.072, indexed in Pubmed: 22240128.
3. Płońska-Gościniak E, Kasprzak JD, Kukulski T, et al. Polish Multicenter Registry (Pol-LAS-SE registry). Stress echocardiography in low-gradient aortic stenosis in Poland: numbers, settings, results, complications and clinical practice. Kardiol Pol. 2021; 79(5): 517–524, doi: 10.33963/KP.15929, indexed in Pubmed: 34125924.
4. Baumgartner H, Hung J, Bermejo J, et al. Recommendations on the echocardiographic assessment of aortic valve stenosis: A focused update from the European Association of Cardiovascular Imaging and the American Society of Echocardiography. J Am Soc Echocardiogr. 2017; 30(4): 372–392, doi: 10.1016/j.echo.2017.02.009, indexed in Pubmed: 28385280.
5. Saikrishnan N, Kumar G, Sawaya FJ, et al. Accurate assessment of aortic stenosis: a review of diagnostic modalities and hemodynamics. Circulation. 2014; 129(2): 244–253, doi: 10.1161/CIRCULATIONAHA.113.002310, indexed in Pubmed: 24421359.
6. Parma R, Zembala MO, Dąbrowski M, et al. Transcatheter aortic valve implantation. Expert Consensus of the Association of Cardiovascular Interventions of the Polish Cardiac Society and the Polish Society of Cardio-Thoracic Surgeons, approved by the Board of the Polish Cardiac Society. Kardiol Pol. 2017; 75(9): 937–964, doi: 10.5603/KP.2017.0175, indexed in Pubmed: 28895996.
7. Wang TK, Flamm SD, Schoenhagen P, et al. Diagnostic and prognostic performance of aortic valve calcium score with cardiac CT for aortic stenosis: A meta-analysis. Radiol Cardiothorac Imaging. 2021; 3(4): e210075, doi: 10.1148/ryct.2021210075, indexed in Pubmed: 34498008.
8. Wiktorowicz A, Wit A, Dziewierz A, et al. Calcium pattern assessment in patients with severe aortic stenosis via the Chou's 5-steps rule. Curr Pharm

Des. 2019; 25(35): 3769–3775, doi: 10.2174/1381612825666190930101258, indexed in Pubmed: 31566130.
9. Kuperstein R, Michlin M, Barbash I, et al. Pseudo-discordance mimicking low-flow low-gradient aortic stenosis in transcatheter aortic valve replacement patients with severe symptomatic aortic stenosis. Cardiol J. 2023; 30(3): 422–430, doi: 10.5603/CJ.a2021.0106, indexed in Pubmed: 34581429.
10. Altes A, Thellier N, Rusinaru D, et al. Dimensionless index in patients with low-gradient severe aortic stenosis and preserved ejection fraction. Circ Cardiovasc Imaging. 2020; 13(10): e010925, doi: 10.1161/CIRCIMAGING.120.010925, indexed in Pubmed: 33076698.
11. Clavel MA, Magne J, Pibarot P. Low-gradient aortic stenosis. Eur Heart J. 2016; 37(34): 2645–2657, doi: 10.1093/eurheartj/ehw096, indexed in Pubmed: 27190103.
12. Clavel MA, Burwash IG, Pibarot P. Cardiac imaging for assessing low-gradient severe aortic stenosis. JACC Cardiovasc Imaging. 2017; 10(2): 185–202, doi: 10.1016/j.jcmg.2017.01.002, indexed in Pubmed: 28183438.