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The Small Aortic Annulus: A Big Challenge in Contemporary TAVI

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Abstract

A small aortic annulus complicates trans catheter aortic valve implantation (TAVI) by limiting prosthetic effective orifice area and increasing the risk of residual gradients and prosthesis–patient mismatch (PPM). This focused narrative review discusses anatomical assessment, valve selection and interpretation of post procedural hemodynamics. Randomized evidence supports better 12-month hemodynamics and fewer bio prosthetic valve dysfunction events with a studied supra-annular self-expanding platform than with an intra-annular balloon-expandable platform. These findings do not establish lower mortality or superior long-term durability. Valve selection should integrate expected hemodynamics with coronary anatomy, conduction risk and future intervention options. Distinguishing measured from predicted PPM and interpreting Doppler findings in relation to flow and the post implantation baseline can help avoid misclassification. Individualized planning should balance valve performance with procedural safety and future treatment options.

Keywords: Aortic Stenosis, Small Aortic Annulus, TAVI, Prosthesis–Patient Mismatch, Valve Selection

Introduction

Successful treatment of aortic stenosis requires both relief of obstruction and an appropriate prosthetic orifice for the patient. A small annulus makes this balance more demanding: a technically successful implant may still leave unfavourable hemodynamics. Women form a large proportion of this population; 621 of the 716 participants in SMART were women. Its prespecified female analysis demonstrated less valve dysfunction with the self-expanding platform, emphasizing the relevance of device selection in this frequently encountered group [1,2]. This focused narrative review addresses practical decision-making and is not a systematic review or meta-analysis.

Literature Identification and Scope

Principal publications were identified through targeted online searches using terms related to small aortic annulus, TAVI/TAVR, prosthesis–patient mismatch and valve hemodynamics, with bibliographic verification against PubMed records and publisher websites. The core comparative and guidance literature summarized here was published between 2019 and 2025; two case reports published in 2026 were included solely as clinical illustrations. Randomized trials were prioritized for treatment comparisons, observational studies for longer follow-up and external validity, and guidelines or consensus documents for imaging and endpoint definitions. Selection was based on relevance to small-annulus planning and post implantation assessment. This was a selective narrative synthesis, without an exhaustive systematic search, formal risk-of-bias assessment or meta-analysis.

Defining the Problem and Planning with CT

Definitions of a small annulus differ across studies. SMART used a computed tomography (CT) annular area

≤430 mm^2, whereas VIVA enrolled patients with a mean annular diameter <23 mm [3,4]. These thresholds describe trial populations rather than a universal biological boundary. Annular size should also be interpreted relative to body size and expected prosthetic performance.

CT planning extends beyond a single diameter. Annular area and perimeter, left ventricular outflow tract calcium, coronary ostial heights, sinus dimensions, sinotubular junction geometry and vascular access should be assessed together [5]. A small annulus should not prompt indiscriminate oversizing: device-specific sizing and the distribution of calcification remain central to procedural safety. The same CT examination should inform both immediate implantation and the feasibility of later coronary access or repeat valve intervention.

Prosthesis–Patient Mismatch: More Than a High Gradient

PPM occurs when a normally functioning prosthesis has an effective orifice area (EOA) that is too small for the patient. Under VARC-3 criteria, moderate PPM corresponds to an indexed EOA >0.65 to ≤0.85 cm^2/m^2 and severe PPM to ≤0.65 cm^2/m^2 when body mass index is <30 kg/m^2. For body mass index ≥30 kg/m^2, the respective thresholds are >0.55 to ≤0.70 and ≤0.55 cm^2/m^2, avoiding overestimation from indexing to body surface area in obesity [6].

Measured PPM uses the individual patient's Doppler-derived EOA, calculated with the continuity equation and indexed to body surface area. Predicted PPM instead uses a published reference EOA for the prosthesis model and size, indexed to the same patient's body surface area. Prediction can inform valve selection before implantation but does not measure actual prosthetic performance. The two approaches are not interchangeable: the IMPPACT TAVR registry found substantially different PPM frequencies and little agreement between them [7].

An elevated Doppler gradient alone does not establish PPM. Low flow can reduce measured EOA and produce apparent PPM, whereas high flow can elevate gradients without a disproportionately small orifice. Indexed EOA should be interpreted together with stroke volume, mean gradient, Doppler velocity index (DVI), leaflet appearance and measurement quality. DVI avoids the left ventricular outflow tract diameter term but still depends on correct Doppler sampling and is not diagnostic alone. PPM is generally present from implantation; a new gradient increase or declining EOA/DVI relative to a stable postimplantation baseline raises concern for acquired dysfunction, including thrombosis or structural deterioration. Echocardiography is first line; CT or transesophageal imaging may clarify discordant findings [8].

Valve Selection: Evidence and Its Limits

SMART randomized 716 patients to a supra-annular self-expanding Evolut or intra-annular balloon-expandable SAPIEN platform. Through 12 months, Kaplan–Meier estimates for death, disabling stroke or heart failure rehospitalisation were 9.4% versus 10.6%, meeting non inferiority for this clinical composite. Bio prosthetic valve dysfunction estimates were 9.4% versus 41.6%; mean gradients at 12 months were 7.7 versus 15.7 mmHg and EOA was 1.99 versus 1.50 cm^2, respectively [1]. The valve dysfunction composite includes hemodynamic criteria and must not be equated with irreversible leaflet degeneration. These results establish a 12-month valve performance advantage for the studied platform, not lower mortality, durable clinical superiority or a class effect across all devices.

Longer-term observational evidence remains hypothesis-generating. In 565 patients with small annuli, Matsuhiro [9] reported less hemodynamic structural valve deterioration and bioprosthetic valve failure with supra-annular self-expanding valves over a median 3.6-year follow-up [9]. Residual confounding and device-era differences preclude a causal claim of superior durability. Separately, the 151-patient randomized VIVA trial did not establish superiority of TAVI over surgery for its hemodynamic endpoint [4]. Thus, small annular size informs, but does not independently determine, the choice of intervention.

Translating Evidence into Practice

Leaflet position and frame design matter alongside expansion mechanism. A supra-annular design merits consideration when predicted PPM risk is substantial, but future coronary engagement may be challenging with some tall-frame devices. RE-ACCESS reported unsuccessful coronary cannulation in 7.7% of 300 patients, predominantly after Evolut R/PRO implantation [10]. These earlier-generation findings support considering root geometry, implantation depth and commissural alignment, rather than assuming the same access risk for every contemporary device.

Published case reports describing Myval OctaPro+ implantation and staged treatment of ischemic cardiomyopathy with low-flow, low-gradient aortic stenosis illustrate device use and individualized treatment sequencing, respectively [11,12]. Neither specifically establishes outcomes in small annuli or provides comparative evidence for valve selection or PPM prevention. Table 1 summarizes practical priorities.

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Clinical priority	Planning implication
Avoid residual obstruction	Estimate predicted indexed EOA using model- and size-specific reference values; consider supra-annular leaflet position [1,6,8].
Protect procedural safety	Integrate calcium distribution, annular dimensions and device-specific sizing [5].
Preserve coronary access	Assess aortic root geometry, frame height, implantation depth and commissural alignment [5,10].
Interpret follow-up gradients	Use multiparametric assessment of flow, measured indexed EOA and DVI against the postimplantation baseline; distinguish PPM from acquired dysfunction [7,8].

Table 1: Practical priorities when planning TAVI in a small aortic annulus.

Conclusion

A small aortic annulus requires individualized planning. Randomized evidence supports better 12-month hemodynamics with the studied supra-annular self-expanding platform, without proving a mortality advantage or superior long-term durability. Valve selection should balance expected indexed EOA with procedural safety, coronary access and future intervention options. Follow-up should integrate flow-sensitive Doppler measurements and baseline comparison rather than classify dysfunction from a gradient alone.

Declarations

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