

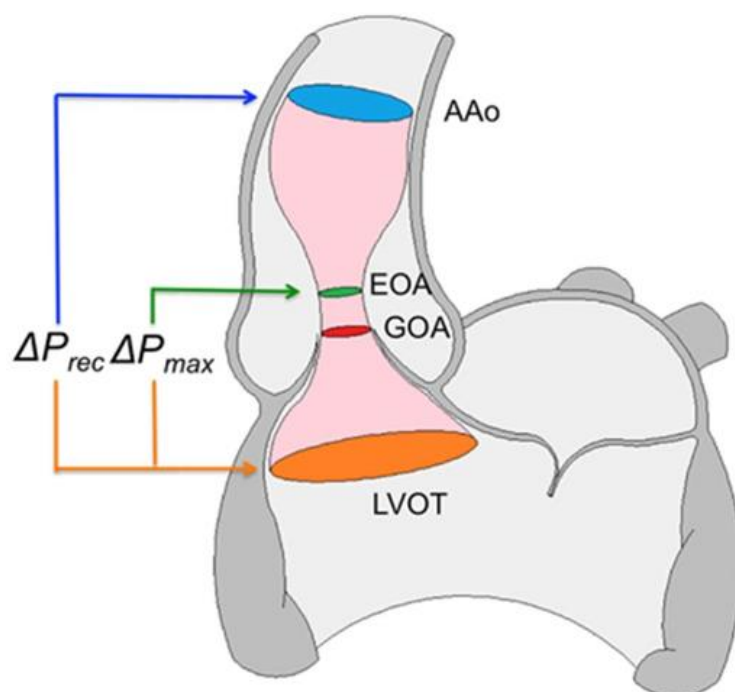


Figure 1. Schematic of flow through a stenotic aortic valve.

ΔP_{max} (pressure difference between LVOT and EOA at the venacontracta) is larger than ΔP_{rec} (pressure difference between LVOT and ascending aorta), due to pressure recovery.

AAo indicates ascending aorta; EOA, effective orifice area at the vena contracta; GOA, geometric orifice area; and LVOT, left ventricular outflow tract.

Saikrishnan N, *et al.* Accurate assessment of aortic stenosis: a review of diagnostic modalities and hemodynamics. *Circulation*. 2014;**129**:244–53

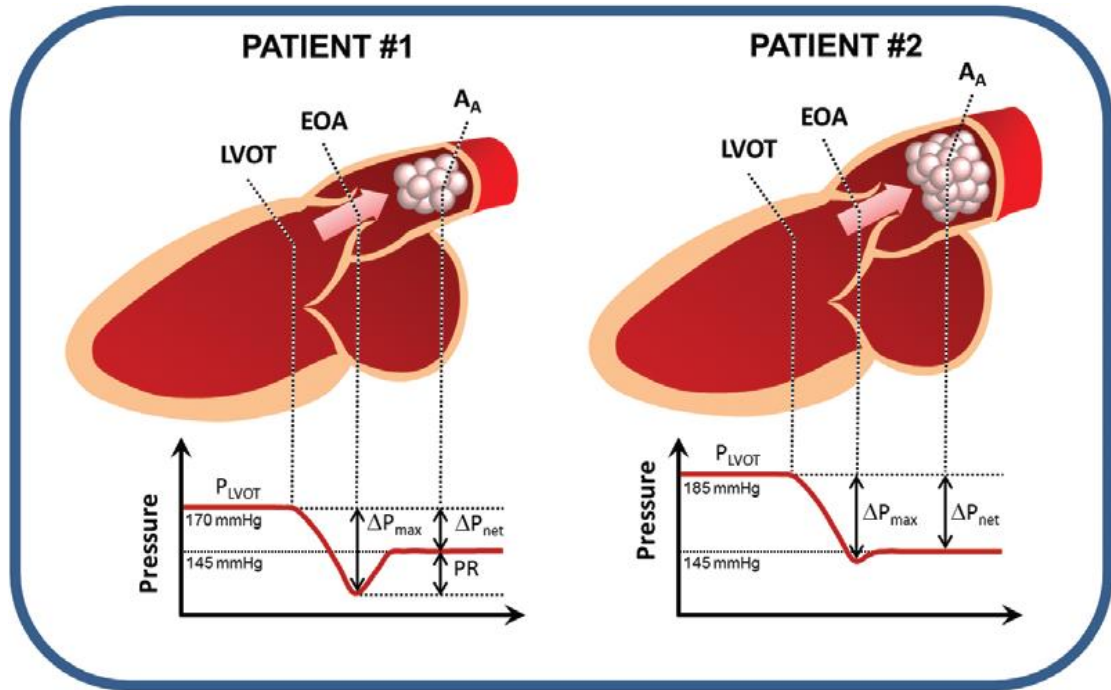


Figure 2. The phenomenon of pressure recovery in aortic stenosis.

Schematic representation of flow and blood pressure across the left ventricular outflow tract (PLVOT), aortic valve, and ascending aorta (AA) during systole in two theoretical patients having the same stroke volume (80 mL) and valve effective orifice area (EOA; 0.9 cm²) but different sizes of ascending aorta (2.0 cm diameter in patient 1 vs 4.0 cm in patient 2). The maximum pressure gradient recorded at vena contracta ($\Delta P_{\max}$, i.e. the mean gradient measured by Doppler) is the same in the two patients, but patient 1, with the small aorta, has a large amount of pressure recovery (PR) downstream of the valve, whereas patient 2 has minimal pressure recovery. Consequently, the net ‘irreversible’ gradient (ΔP_{net} , i.e. measured by catheter), and thus the left ventricular systolic pressure, is significantly higher in patient 2 than in patient 1.

LVOT indicates left ventricular outflow tract. Please note that in this figure EOA is indicated at the level of GOA.

Pibarot P, *et al.* Energy Loss Index in Aortic Stenosis: From Fluid Mechanics Concept to Clinical Application. *Circulation*. 2013;127:1101–4

Table 1. ACC/AHA 2020 GL on VHD. Stages of AS

Stage	Definition	Valve Anatomy	Valve Hemodynamics	Hemodynamic Consequences	Symptoms
A	At risk of AS	■ BAV (or other congenital valve anomaly) ■ Aortic valve sclerosis	Aortic V_{max} <2 m/s with normal leaflet motion	None	None
B	Progressive AS	■ Mild to moderate leaflet calcification/fibrosis of a bicuspid or trileaflet valve with some reduction in systolic motion or ■ Rheumatic valve changes with commissural fusion	■ Mild AS: aortic V_{max} 2.0–2.9 m/s or mean ΔP <20 mm Hg ■ Moderate AS: aortic V_{max} 3.0–3.9 m/s or mean ΔP 20–39 mm Hg	■ Early LV diastolic dysfunction may be present ■ Normal LVEF	None
C: Asymptomatic severe AS					
C1	Asymptomatic severe AS	Severe leaflet calcification/fibrosis or congenital stenosis with severely reduced leaflet opening	■ Aortic V_{max} $\geq$4 m/s or mean ΔP $\geq$40 mm Hg ■ AVA typically is $\leq$1.0 cm² (or AVAi 0.6 cm²/m²) but not required to define severe AS ■ Very severe AS is an aortic V_{max} $\geq$5 m/s or mean ΔP $\geq$60 mm Hg	■ LV diastolic dysfunction ■ Mild LV hypertrophy ■ Normal LVEF	■ None ■ Exercise testing is reasonable to confirm symptom status
C2	Asymptomatic severe AS with LV systolic dysfunction	Severe leaflet calcification/fibrosis or congenital stenosis with severely reduced leaflet opening	■ Aortic V_{max} $\geq$4 m/s or mean ΔP $\geq$40 mm Hg ■ AVA typically $\leq$1.0 cm² (or AVAi 0.6 cm²/m²) but not required to define severe AS	LVEF <50%	None
D: Symptomatic severe AS					
D1	Symptomatic severe high-gradient AS	Severe leaflet calcification/fibrosis or congenital stenosis with severely reduced leaflet opening	■ Aortic V_{max} $\geq$4 m/s or mean ΔP $\geq$40 mm Hg ■ AVA typically $\leq$1.0 cm² (or AVAi $\leq$0.6 cm²/m²) but may be larger with mixed AS/AR	■ LV diastolic dysfunction ■ LV hypertrophy ■ Pulmonary hypertension may be present	■ Exertional dyspnea, decreased exercise tolerance, or HF ■ Exertional angina ■ Exertional syncope or presyncope
D2	Symptomatic severe low-flow, low-gradient AS with reduced LVEF	Severe leaflet calcification/fibrosis with severely reduced leaflet motion	■ AVA $\leq$1.0 cm² with resting aortic V_{max} <4 m/s or mean ΔP <40 mm Hg ■ Dobutamine stress echocardiography shows AVA <1.0 cm² with V_{max} $\geq$4 m/s at any flow rate	■ LV diastolic dysfunction ■ LV hypertrophy ■ LVEF <50%	■ HF ■ Angina ■ Syncope or presyncope
D3	Symptomatic severe low-gradient AS with normal LVEF or paradoxical low-flow severe AS	Severe leaflet calcification/fibrosis with severely reduced leaflet motion	■ AVA $\leq$1.0 cm² (indexed AVA $\leq$0.6 cm²/m²) with an aortic V_{max} <4 m/s or mean ΔP <40 mm Hg AND ■ Stroke volume index <35 mL/m² ■ Measured when patient is normotensive (systolic blood pressure <140 mm Hg)	■ Increased LV relative wall thickness ■ Small LV chamber with low stroke volume ■ Restrictive diastolic filling ■ LVEF $\geq$50%	■ HF ■ Angina ■ Syncope or presyncope

AR indicates aortic regurgitation; AS, aortic stenosis; AVA, aortic valve area circulation; AVAi, AVA indexed to body surface area; BAV, bicuspid aortic valve; ΔP , pressure gradient between the LV and aorta; HF, heart failure; LV, left ventricular; LVEF, left ventricular ejection fraction; and V_{max} , maximum velocity.

Table 2. ESC/EACT 2025 GL on valvular heart disease. Classification of AS*Concordant criteria:*

- High-gradient AS [mean gradient ≥ 40 mmHg, $V_{\max} \geq 4.0$ m/s, $AVA \leq 1$ cm² (or ≤ 0.6 cm²/m²)] is considered severe irrespective of LV function and flow conditions.

Discordant criteria:

- Low-flow, low-gradient AS with reduced LVEF (mean gradient < 40 mmHg, $AVA \leq 1$ cm², $SVi \leq 35$ mL/m², LVEF $< 50\%$).
- Low-flow, low-gradient AS with preserved LVEF (mean gradient < 40 mmHg, $AVA \leq 1$ cm², $SVi \leq 35$ mL/m², LVEF $\geq 50\%$).
- Normal-flow, low-gradient AS with preserved EF (mean gradient < 40 mmHg, $AVA \leq 1$ cm², $SVi > 35$ mL/m², LVEF $\geq 50\%$).
- Discordant high-gradient AS (mean gradient ≥ 40 mmHg, $AVA > 1$ cm²).

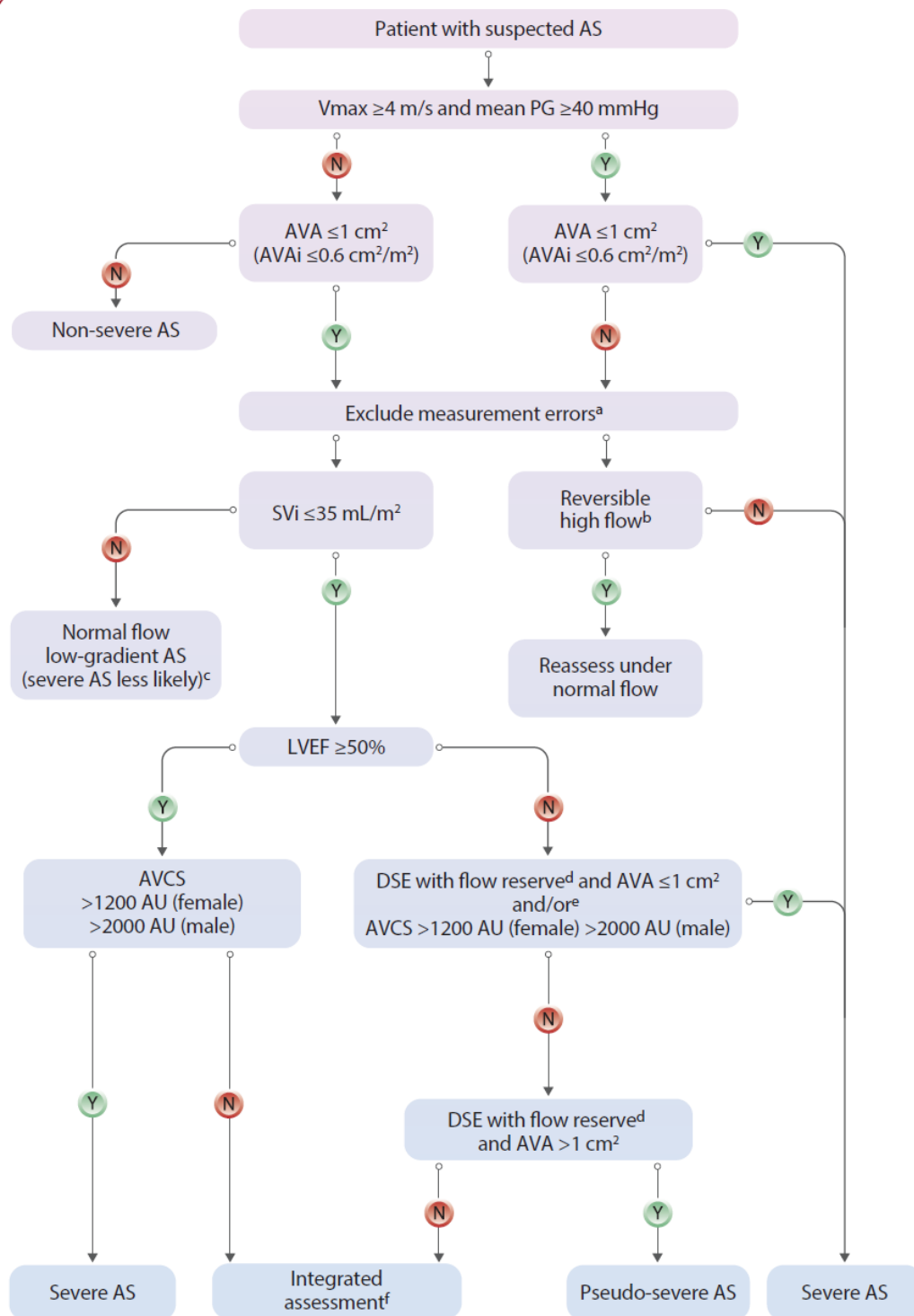


Figure 3. ESC/EACT 2025 GL on valvular heart disease. Integrated imaging assessment of patients with aortic stenosis.

AS, aortic stenosis; AU, Agatston units; AV, aortic valve; AVA, aortic valve area; AVAi; aortic valve area indexed for body surface area; AVCS, aortic valve calcium score; CCT, cardiac computed tomography; CT, computed tomography; DSE, dobutamine stress echocardiography; LVEF, left ventricular ejection fraction; LVOT, left ventricular outflow tract; MRI, magnetic resonance imaging;

mean PG, mean pressure gradient; SVi, stroke volume indexed for BSA; TOE, transoesophageal echocardiography; TTE, transthoracic echocardiography; Vmax, peak transvalvular velocity.

aIn particular, verify LVOT diameter and multiwindow Doppler interrogation.

bHigh flow may be reversible (anaemia, hyperthyroidism, or arteriovenous fistulae). Upper limit of normal flow using pulsed Doppler: cardiac index 4.3 L/min/m², SVi 58 mL/m².

cAvailable evidence refers to patients with preserved LVEF. Check for bradycardia or uncontrolled hypertension, which may lead to prolonged ejection time and reduced flow rate. Depending on symptoms, integrated assessment complemented by CCT AV calcium scoring may be pursued.

dFlow reserve: $\geq 20\%$ increase in stroke volume in response to low-dose dobutamine or if change in stroke volume of 10%–20%, calculate projected AVA.

eIf one test is not conclusive, complement diagnostics with the other test. fBased on clinical judgement (typical symptoms without other explanation), morphological valve changes, LV hypertrophy (in absence of coexistent hypertension), and consistent findings using different modes of assessment [TTE and TOE, invasive assessment, AV planimetry by CT or MRI (cut-off 1.2 cm²)].

TABLE 3. ACC/AHA 2020 GL on VHD. Recommendations for Diagnostic Testing: Initial Diagnosis of AS

In signs or symptoms of AS or a BAV, TTE for accurate diagnosis of the cause of AS, assessment of hemodynamic severity, measurement of LV size and systolic function, and determination of prognosis and timing of valve intervention	I-A
In suspected low-flow, low-gradient severe AS with normal LVEF (Stage D3), optimization of blood pressure control before measurement of AS severity by TTE, TEE, cardiac catheterization, or CMR	I-B-NR
In suspected low-flow, low-gradient severe AS with reduced LVEF (Stage D2), low-dose dobutamine stress testing with echocardiographic or invasive hemodynamic measurements to further define severity and assess contractile reserve	Ia-B-NR
In suspected low-flow, low-gradient severe AS with normal or reduced LVEF (Stages D2 Ia-B-NR And D3), calculation of the ratio of the outflow tract to aortic velocity to further define severity	
In suspected low-flow, low-gradient severe AS with normal or reduced LVEF (Stages D2 and D3), measurement of aortic valve calcium score by CT imaging to further define severity	Ia-B-NR

Table 4. ACC/AHA 2020 GL on VHD. Recommendations for Diagnostic Testing: Exercise testing in AS

In asymptomatic patients with severe AS (Stage C1), exercise testing to assess physiological changes with exercise and to confirm the absence of symptoms.	Ia-B-NR
In symptomatic patients with severe AS (Stage D1, aortic velocity ≥ 4.0 m/s or mean pressure gradient ≥ 40 mmHg), exercise testing should not be performed because of the risk of severe hemodynamic compromise.	III-B-NR (Harm)

Table 5. Medical therapy**ACC/AHA 2020 GL on VHD. Medical therapy of AS**

In patients at risk of developing AS (Stage A) and in patients with asymptomatic AS (Stages B and C), hypertension treated according to standard GDMT, started at a low dose, and gradually titrated upward as needed, with appropriate clinical monitoring	I-B-NR
In all patients with calcific AS, statin therapy is indicated for primary and secondary prevention of atherosclerosis on the basis of standard risk scores.	I-A
In patients who have undergone TAVI, renin–angiotensin system blocker therapy (ACE inhibitor or ARB) to reduce the long-term risk of all-cause mortality.	IIb-B-R
In patients with calcific AS (Stages B and C), statin therapy is not indicated for prevention of hemodynamic progression of AS.	III—A (No benefit)

Table 6. Intervention in AS**ACC/AHA 2020 GL on VHD. Timing of Intervention of AS****AVR in:**

Adults with severe high-gradient AS (Stage D1) and symptoms of exertional dyspnea, HF, angina, syncope, or presyncope by history or on exercise testing.	I-A
Asymptomatic patients with severe AS and an LVEF <50% (Stage C2)	I-B-NR
Asymptomatic patients with severe AS (Stage C1) who are undergoing cardiac surgery for other indications	I-B-NR
Symptomatic patients with low-flow, low-gradient severe AS with reduced LVEF (Stage D2)	I-B-NR
Symptomatic patients with low-flow, low-gradient severe AS with normal LVEF (Stage D3), if AS is the most likely cause of symptoms .	I-B-NR
Apparently asymptomatic patients with severe AS (Stage C1) and low surgical risk, when an exercise test demonstrates decreased exercise tolerance (normalized for age and sex) or a fall in systolic blood pressure of ≥ 10 mmHg from baseline to peak exercise.	IIa-B-NR
Symptomatic patients with very severe AS (defined as an aortic velocity of ≥ 5 m/s) and low surgical risk.	IIa-B-NR
Apparently asymptomatic patients with severe AS (Stage C1) and low surgical risk, when the serum B-type natriuretic peptide (BNP) level is >3 times normal.	IIa-B-NR
Asymptomatic patients with high-gradient severe AS (Stage C1) and low surgical risk, when serial testing shows an increase in aortic velocity ≥ 0.3 m/s per year.	IIa-B-NR
Asymptomatic patients with severe high-gradient AS (Stage C1) and a progressive decrease in LVEF on at least 3 serial imaging studies to $<60\%$.	IIb-B-NR
Patients with moderate AS (Stage B) who are undergoing cardiac surgery for other indications	IIb-C-EO

ESC/EACTS 2025 GL on valvular heart disease.

Recommendations on indications for intervention in symptomatic and asymptomatic aortic stenosis and recommended mode of intervention.

Symptomatic patients with severe aortic stenosis		
Intervention is recommended in symptomatic patients with severe, high-gradient AS [mean gradient ≥ 40 mmHg, $V_{\max} \geq 4.0$ m/s, $AVA \leq 1.0$ cm ² (or ≤ 0.6 cm ² /m ² BSA)]. ^{388,471–474}	I	B
Intervention is recommended in symptomatic patients with low-flow ($SVI \leq 35$ mL/m ²), low-gradient (< 40 mmHg) AS with reduced LVEF ($< 50\%$) after careful confirmation that AS is severe. ^{342,345,346,348,475}	I	B
Intervention should be considered in symptomatic patients with low-flow ($SVI \leq 35$ mL/m ²), low-gradient (< 40 mmHg) AS with normal LVEF ($\geq 50\%$) after careful confirmation that AS is severe. ^{c 293,348,349,476–481}	IIa	B
Asymptomatic patients with severe aortic stenosis		
Intervention is recommended in asymptomatic patients with severe AS and LVEF $< 50\%$ without another cause. ^{14,354–359}	I	B
Intervention should be considered in asymptomatic patients (confirmed by a normal exercise test, if feasible) with severe, high-gradient AS and LVEF $\geq 50\%$ as an alternative to close active surveillance, if the procedural risk is low. ^{360–363,367,368}	IIa	A
Intervention should be considered in asymptomatic patients with severe AS and LVEF $\geq 50\%$ if the procedural risk is low and one of the following parameters is present: • Very severe AS (mean gradient ≥ 60 mmHg or $V_{\max} > 5.0$ m/s).^{14,362,363,482–484} • Severe valve calcification (ideally assessed by CCT) and $V_{\max}$ progression ≥ 0.3 m/s/year.^{303,353,364} • Markedly elevated BNP/NT-proBNP levels (more than three times age- and sex-corrected normal range, confirmed on repeated measurement without other explanation).^{97,365} • LVEF $< 55\%$ without another cause.^{14,354,356–359}	IIa	B
Intervention should be considered in asymptomatic patients with severe AS and a sustained fall in BP (> 20 mmHg) during exercise testing.	IIa	C
Mode of intervention		
It is recommended that AV interventions are performed in Heart Valve Centres that report their local expertise and outcome data, have on-site interventional cardiology and cardiac surgical programmes, and a structured collaborative Heart Team.	I	C
It is recommended that the mode of intervention is based on Heart Team assessment of individual clinical, anatomical, and procedural characteristics, incorporating lifetime management considerations and estimated life expectancy.	I	C
TAVI is recommended in patients ≥ 70 years of age with tricuspid AV stenosis, if the anatomy is suitable. ^{d 1–4,389–397,465,485,486}	I	A
SAVR is recommended in patients < 70 years of age, if the surgical risk is low. ^{e 413,429,487}	I	B
SAVR or TAVI are recommended for all remaining candidates for an aortic BHV according to Heart Team assessment. ^{2,4,396,397,429,488–490}	I	B
Non-transfemoral TAVI should be considered in patients who are unsuitable for surgery and transfemoral access. ^{417–423,491–498}	IIa	B
TAVI may be considered for the treatment of severe BAV stenosis in patients at increased surgical risk, if the anatomy is suitable. ^{430–432,434,499–502}	IIb	B
Balloon aortic valvotomy may be considered as a bridge to SAVR or TAVI in haemodynamically unstable patients, and (if feasible) in those with severe AS who require urgent high-risk NCS.	IIb	C

AS, aortic stenosis; AV, aortic valve; AVA, aortic valve area; BAV, bicuspid aortic valve; BHV, biological heart valve; BNP, brain natriuretic peptide; BP, blood pressure; BSA, body surface area; CCT, cardiac computed tomography; EuroSCORE, European System for Cardiac Operative Risk Evaluation; LVEF, left ventricular ejection fraction; NCS, non-cardiac surgery; NT-proBNP, N-terminal pro-B-type natriuretic peptide; SAVR, surgical aortic valve replacement; STS-PROM, Society of Thoracic Surgeons predicted risk of mortality; SVI, stroke volume index; TAVI, transcatheter aortic valve implantation; $V_{\max}$, peak transvalvular velocity.

cExplanations (such as measurement errors, uncontrolled blood pressure, and conditions lowering the stroke volume) other than severe AS for a small AVA but low gradient despite preserved LVEF are frequent and must be carefully excluded.

dSuitability regarding transfemoral access, annulus dimensions, device landing zone calcification pattern, and coronary obstruction risk.

eSurgical risk based on STS-PROM (<http://riskcalc.sts.org/stswebriskcalc/#/calculate>) and EuroSCORE II (<http://www.euroscore.org/calc.html>) $< 4\%$ and Heart Team assessment.

Recommendations on indications for concomitant aortic valve replacement at the time of coronary artery bypass grafting or ascending aorta surgery

SAVR is recommended in symptomatic and asymptomatic patients with severe AS undergoing CABG or surgical intervention on the ascending aorta.	I	C
SAVR should be considered in symptomatic and asymptomatic patients with moderate AS ^c undergoing CABG or surgical intervention on the ascending aorta.	IIa	C

AS, aortic stenosis; AVA, aortic valve area; CABG, coronary artery bypass grafting; SAVR, surgical aortic valve replacement.

cDefined as an AVA of 1.0–1.5 cm² (or mean aortic gradient of 25–40 mmHg) in normal-flow conditions. Clinical assessment is essential to determine whether SAVR is appropriate for an individual patient.

Table 7. ACC/AHA 2020 GL on VHD.

Intervention for mixed AS and AR

AVR in symptomatic patients with combined AS and AR and a peak transvalvular jet velocity of at least 4.0 m/s or a mean transvalvular gradient of at least 40 mmHg. I-B-NR

Surgical AVR in asymptomatic patients with combined AS and AR who have a jet velocity of $\geq$ 4.0 m/s with an LVEF <50%. I-C-EO

AS/MR Mixed Valve Disease

Severe AS	Severe MR	Surgical Risk	Procedure
SAVR candidate	- Primary MR - Repairable valve	Low intermediate	- SAVR - Surgical mitral valve repair
SAVR candidate	- Primary MR - Valve not repairable	Low intermediate	- SAVR - Surgical mitral valve replacement
TAVI candidate	- Primary - Repairable valve	High prohibitive	- TAVI - Mitral TEER*
SAVR candidate TAVI candidate	Secondary MR	Low intermediate	- SAVR - Surgical mitral valve repair/mitral valve replacement Or - TAVI - Mitral TEER*
TAVI candidate	Secondary MR	High prohibitive	- TAVI - Mitral TEER*

*Consider TEER as a later staged procedure if symptoms and severe MR persist after treatment of the AS.

AS indicates aortic stenosis; MR, mitral regurgitation; SAVR, surgical aortic valve replacement; TAVI, transcatheter aortic valve implantation; and TEER, transcatheter edge-to-edge repair.

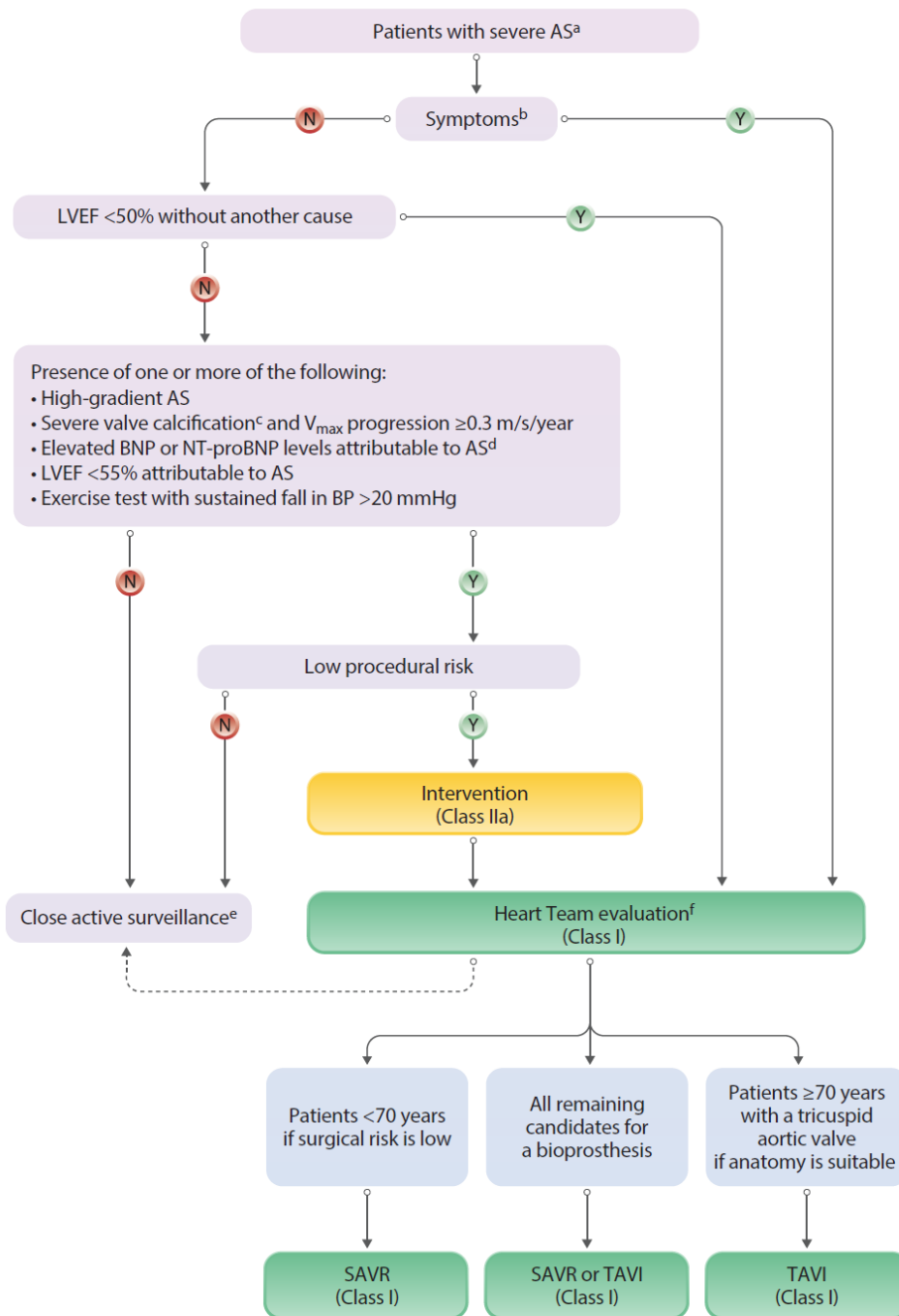


Figure 4. ESC/EACT 2025 GL on valvular heart disease. Management of patients with severe aortic stenosis.

AS, aortic stenosis; AVCS, aortic valve calcium score; BNP, brain natriuretic peptide; BP, blood pressure; LVEF, left ventricular ejection fraction; NT-proBNP, N-terminal pro-B-type natriuretic peptide; SAVR, surgical aortic valve replacement; TAVI, transcatheter aortic valve implantation; V_{max}, peak transvalvular velocity.

^aIntegrative imaging assessment of AS.

^bConfirmed

by a normal exercise test, if feasible.

^cAVCS >2000 in men, >1200 in women.

^dMore than three times age- and sex-corrected normal range.

^eEducate patient and reassess at least every 6 months (or promptly if symptoms occur).

^fHeart Team assessment based upon individual patient factors.

Dashed arrow only applies to asymptomatic patients.

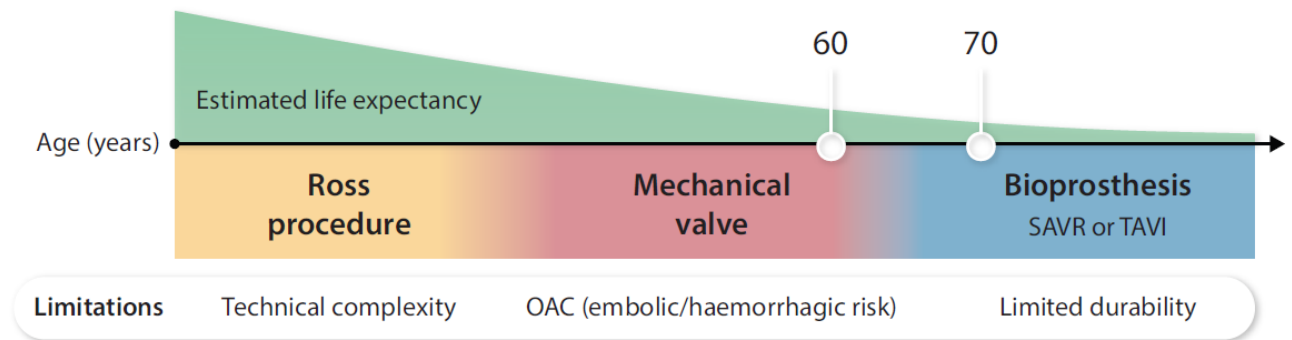


Figure 5. ESC/EACT 2025 GL on valvular heart disease. Aortic valve treatment options.

OAC, oral anticoagulation; SAVR, surgical aortic valve replacement; TAVI, transcatheter aortic valve implantation.

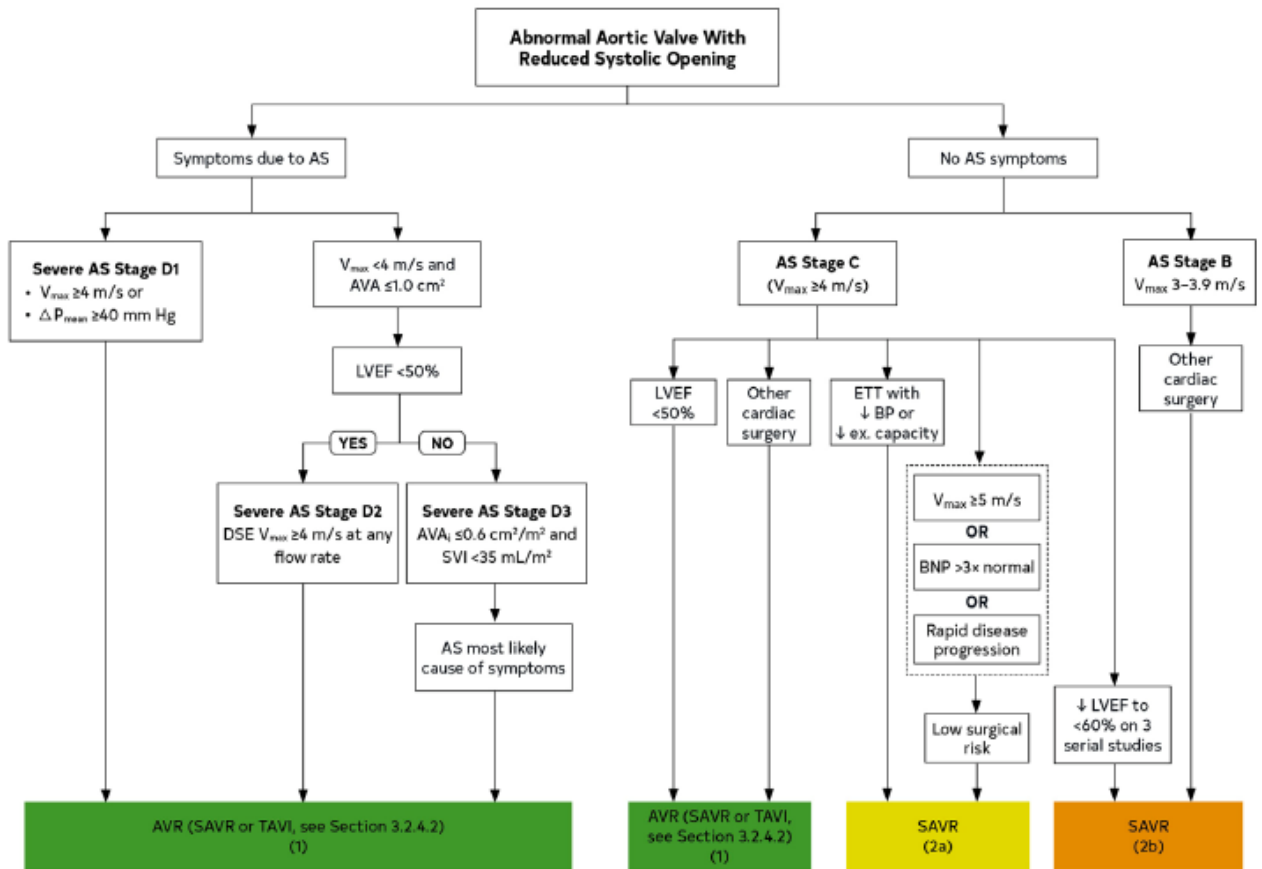


Figure 6. ACC/AHA 2020 GL on Valvular Heart Disease. Timing of intervention for AS

Arrows show the decision pathways that result in a recommendation for AVR. Periodic monitoring is indicated for all patients in whom AVR is not yet indicated, including those with asymptomatic (Stage C) and symptomatic (Stage D) AS and those with low-gradient AS (Stage D2 or D3) who do not meet the criteria for intervention. See Figure 19.7 for choice of valve type (mechanical versus bioprosthetic [TAVI or SAVR]) when AVR is indicated.

AS indicates aortic stenosis; AVA, aortic valve area; AVAi, aortic valve area index; AVR, aortic valve replacement; BNP, B-type natriuretic peptide; BP, blood pressure; DSE, dobutamine stress echocardiography ETT, exercise treadmill test; LVEF, left ventricular ejection fraction; DPmean, mean systolic pressure gradient between LV and aorta; SAVR, surgical aortic valve replacement; SVI, stroke volume index; TAVI, transcatheter aortic valve implantation; TAVR, transcatheter aortic valve replacement; and Vmax, maximum velocity.

Table 8. ACC/AHA/HRS 2018 GL on bradycardia. Pacing After Aortic Valve Surgery

Routine placement of temporary epicardial pacing wires in patients undergoing surgical aortic valve replacement or repair,	I-C-LD
Permanent pacing before discharge in patients who have new postoperative SND or AV block associated with persistent symptoms or hemodynamic instability that does not resolve after aortic valve replacement	I-B-NR
Intraoperative placement of a permanent epicardial left ventricular lead in patients undergoing aortic valve surgery who will likely require future CRT or ventricular pacing	IIB-C-EO

Table 9. ACC/AHA 2020 GL on VHD. Recommendations for Choice of SAVR Versus TAVI for Patients for Whom a Bioprosthetic AVR Is Appropriate

SAVR for symptomatic and asymptomatic patients with severe AS who are <65 years of age or have a life expectancy >20 years.	I-A
For symptomatic patients with severe AS who are 65 to 80 years of age and have no anatomic contraindication to transfemoral TAVI, either SAVR or transfemoral TAVI after shared decision making about the balance between expected patient longevity and valve durability.	I-A
Transfemoral TAVI for symptomatic patients with severe AS who are >80 years of age or for younger patients with a life expectancy <10 years and no anatomic contraindication to transfemoral TAVI.	I-A
In asymptomatic patients with severe AS and an LVEF <50% who are ≤80 years of age and have no anatomic contraindication to transfemoral TAVI, the decision between TAVI and SAVR as for symptomatic patients in Recommendations above.	I-B-NR
SAVR for asymptomatic patients with severe AS and an abnormal exercise test, very severe AS, rapid progression, or an elevated BNP (IIa indications for AVR).	I-B-NR
SAVR for patients for whom a bioprosthetic valve is preferred but valve or vascular anatomy or other factors are not suitable for transfemoral TAVI.	I-A
TAVI for symptomatic patients of any age with severe AS and a high or prohibitive surgical risk, TAVI is recommended if predicted post-TAVI survival is >12 months with an acceptable quality of life.	I-A
Palliative care after shared decision-making for symptomatic patients with severe AS for whom predicted post-TAVI or post-SAVR survival is <12 months or for whom minimal improvement in quality of life is expected.	I-C-EO
In critically ill patients with severe AS, percutaneous aortic balloon dilation as a bridge to SAVR or TAVI	IIB-C-EO

Table 10. ACC/AHA 2020 GL on VHD. A Simplified Framework With Examples of Factors Favoring SAVR, TAVI, or Palliation Instead of Aortic Valve Intervention

	Favors SAVR	Favors TAVI	Favors Palliation
Age/life expectancy*	■ Younger age/longer life expectancy	■ Older age/fewer expected remaining years of life	■ Limited life expectancy
Valve anatomy	■ BAV ■ Subaortic (LV outflow tract) calcification ■ Rheumatic valve disease ■ Small or large aortic annulus †	■ Calcific AS of a trileaflet valve	
Prosthetic valve preference	■ Mechanical or surgical bioprosthetic valve preferred ■ Concern for patient-prosthesis mismatch (annular enlargement might be considered)	■ Bioprosthetic valve preferred ■ Favorable ratio of life expectancy to valve durability ■ TAVI provides larger valve area than same size SAVR	
Concurrent cardiac conditions	■ Aortic dilation ‡ ■ Severe primary MR ■ Severe CAD requiring bypass grafting ■ Septal hypertrophy requiring myectomy ■ AF	■ Severe calcification of the ascending aorta ("porcelain" aorta)	■ Irreversible severe LV systolic dysfunction ■ Severe MR attributable to annular calcification
Noncardiac conditions		■ Severe lung, liver, or renal disease ■ Mobility issues (high procedural risk with sternotomy)	■ Symptoms likely attributable to noncardiac conditions ■ Severe dementia ■ Moderate to severe involvement of ≥2 other organ systems
Frailty	■ Not frail or few frailty measures	■ Frailty likely to improve after TAVI	■ Severe frailty unlikely to improve after TAVI
Estimated procedural or surgical risk of SAVR or TAVI	■ SAVR risk low ■ TAVI risk high	■ TAVI risk low to medium ■ SAVR risk high to prohibitive	■ Prohibitive SAVR risk (>15%) or post-TAVI life expectancy <1 y
Procedure-specific impediments	■ Valve anatomy, annular size, or low coronary ostial height precludes TAVI ■ Vascular access does not allow transfemoral TAVI	■ Previous cardiac surgery with at-risk coronary grafts ■ Previous chest irradiation	■ Valve anatomy, annular size, or coronary ostial height precludes TAVI ■ Vascular access does not allow transfemoral TAVI
Goals of Care and patient preferences and values	■ Less uncertainty about valve durability ■ Avoid repeat intervention ■ Lower risk of permanent pacer ■ Life prolongation ■ Symptom relief ■ Improved long-term exercise capacity and QOL ■ Avoid vascular complications ■ Accepts longer hospital stay, pain in recovery period	■ Accepts uncertainty about valve durability and possible repeat intervention ■ Higher risk of permanent pacer ■ Life prolongation ■ Symptom relief ■ Improved exercise capacity and QOL ■ Prefers shorter hospital stay, less postprocedural pain	■ Life prolongation not an important goal ■ Avoid futile or unnecessary diagnostic or therapeutic procedures ■ Avoid procedural stroke risk ■ Avoid possibility of cardiac pacer

*Expected remaining years of life can be estimated from U.S. Actuarial Life Expectancy tables. The balance between expected patient longevity and valve durability varies continuously across the age range, with more durable valves preferred for patients with a longer life expectancy. Bioprosthetic valve durability is finite (with shorter durability for younger patients), whereas mechanical valves are very durable but require lifelong anticoagulation. Long-term (20-y) data on outcomes with surgical bioprosthetic valves are available; robust data on transcatheter bioprosthetic valves extend only to 5 y, leading to uncertainty about longer-term outcomes. The decision about valve type should be individualized on the basis of patient-specific factors that might affect expected longevity.

†A large aortic annulus may not be suitable for currently available transcatheter valve sizes. With a small aortic annulus or aorta, a surgical annulus-enlarging procedure may be needed to allow placement of a larger prosthesis and avoid patient-prosthesis mismatch.

‡Dilation of the aortic sinuses or ascending aorta may require concurrent surgical replacement, particularly in younger patients with a BAV.

AF indicates atrial fibrillation; AS, aortic stenosis; BAV, bicuspid aortic valve; CAD, coronary artery disease; LV, left ventricular; MR, mitral regurgitation; QOL, quality of life; SAVR, surgical aortic valve replacement; and TAVI, transcatheter aortic valve implantation.

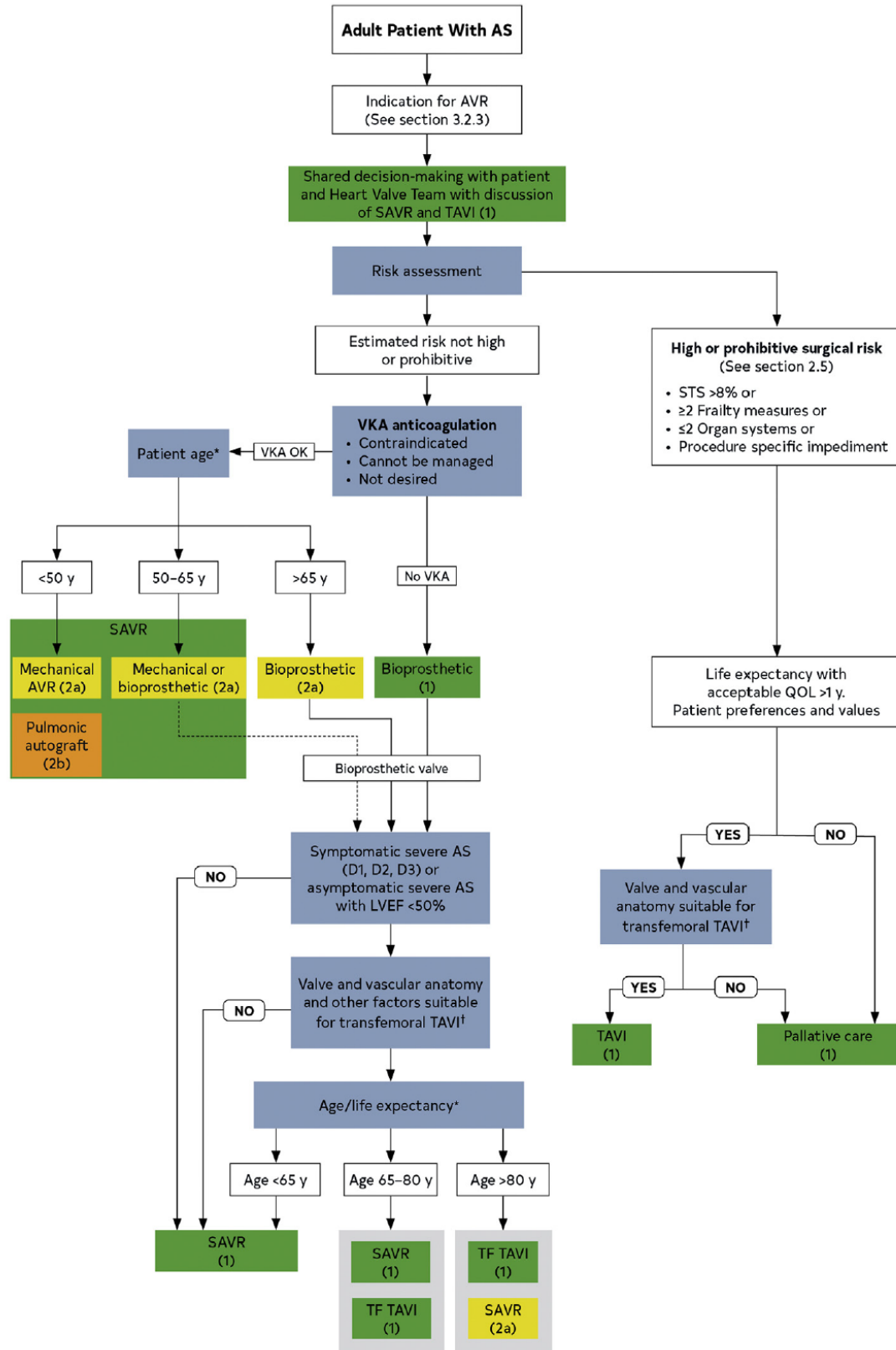


Figure 7. ACC/AHA 2020 GL on Valvular Heart Disease. Choice of SAVR Versus TAVI When AVR is Indicated for Valvular AS

*Approximate ages, based on US Actuarial Life Expectancy tables, are provided for guidance. The balance between expected patient longevity and valve durability varies continuously across the age range, with more durable valves preferred for patients with a longer life expectancy. Bioprosthetic valve durability is finite (with shorter durability for younger patients), whereas mechanical valves are very durable but require lifelong anticoagulation. Long-term (20-y) data on outcomes with surgical bioprosthetic valves are available; robust data on transcatheter bioprosthetic valves extend to only 5 years, leading to uncertainty about longer-term outcomes. The decision about valve type should be individualized on the basis of patient-specific factors that might affect expected longevity. †Placement of a transcatheter valve requires vascular anatomy that allows transfemoral delivery and the absence of aortic root dilation that would require surgical replacement. Valvular anatomy must be suitable for placement of the specific prosthetic valve, including annulus size and shape, leaflet number and calcification, and coronary ostial height.

AS indicates aortic stenosis; AVR, aortic valve replacement; LVEF, left ventricular ejection fraction; QOL, quality of life; SAVR, surgical aortic valve replacement; STS, Society of Thoracic Surgeons; TAVI, transcatheter aortic valve implantation; TF, transfemoral; and VKA, vitamin K antagonist.

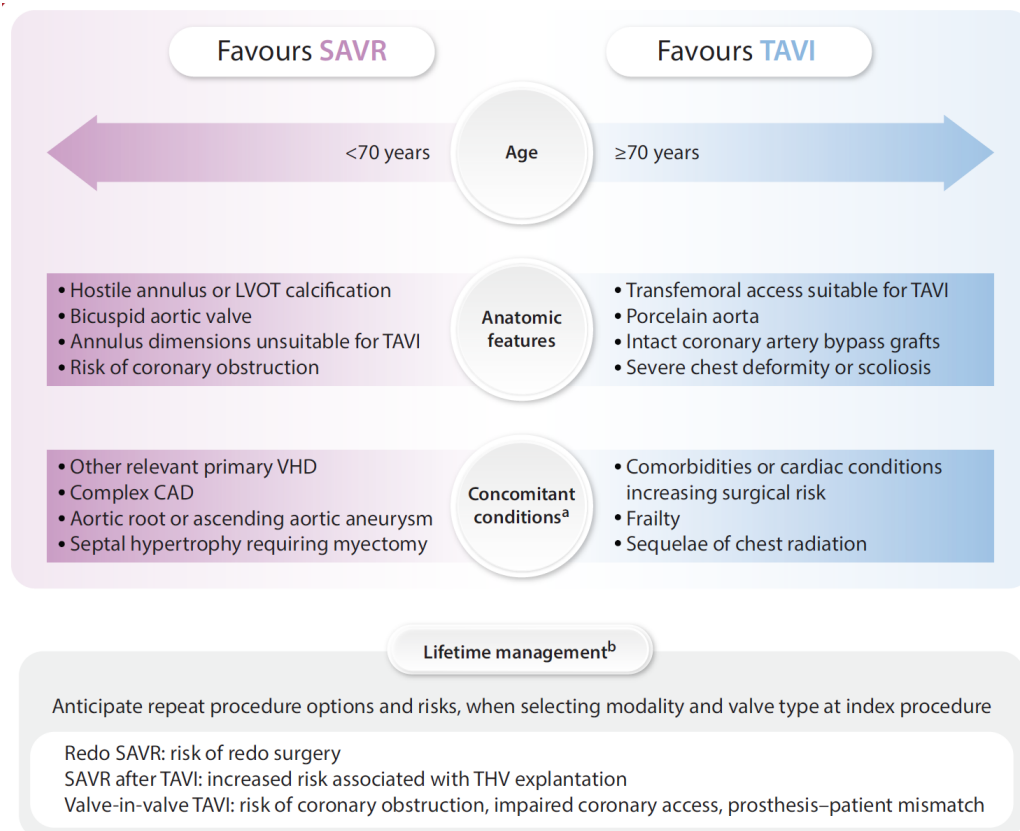


Figure 8. ESC/EACT 2025 GL on valvular heart disease. Factors to be considered when selecting the mode of intervention for aortic stenosis.

CAD, coronary artery disease; LV, left ventricular; LVOT, left ventricular outflow tract; SAVR, surgical aortic valve replacement; TAVI, transcatheter aortic valve implantation; THV, transcatheter heart valve; VHD, valvular heart disease.

^aLV thrombus and infective endocarditis are relative contraindications to TAVI and are therefore not listed.

^bParticularly relevant for patients in whom the anticipated life expectancy is thought to exceed valve durability.

Table 11. ESC 2026 GL on HF. Recommendations for valvular heart disease in patients with heart failure

Aortic stenosis		
Aortic valve intervention, SAVR or TAVI, is recommended in patients with severe aortic stenosis and HF ^c to improve symptoms and reduce the risk of death. 758–765	I	B1

Table 12. Conduction disturbances after TAVI. Predictors for permanent pacing after transcatheter aortic valve implantation

ACC/AHA/HRS 2018 GL on bradycardia. Conduction Disturbances After Transcatheter Aortic Valve Replacement

Permanent pacing before discharge in patients who have new atrioventricular block after TAVR associated with symptoms or hemodynamic instability that does not resolve	I-B-NR
Careful surveillance for bradycardia in patients with new persistent bundle branch block after TAVR	IIa-B-NR
Implantation of a PPM patients with new persistent LBBB after TAVR	IIb-B-NR

ESC 2021 GL on pacing and CRT. Predictors for permanent pacing after transcatheter aortic valve implantation

Characteristics
ECG
Right BBB
PR-interval prolongation
Left anterior hemiblock
Patient
Older age (per 1-year increase)
Male sex
Larger body mass index (per 1-unit increase)
Anatomical
Severe mitral annular calcification
LV outflow tract calcifications
Membranous septum length
Porcelain aorta
Higher mean aortic valve gradient
Procedural
Self-expandable valve
Deeper valve implantation
Larger ratio between prosthesis diameter versus annulus or LV outflow tract diameter
Balloon post-dilatation
TAVI in valve-in-valve vs. native valve procedure

AVB = atrioventricular block; BBB = bundle branch block; ECG = electrocardiogram; LV = left ventricular; TAVI = transcatheter aortic valve implantation.

ESC 2021 GL on pacing and CRT. Recommendations for cardiac pacing after transcatheter aortic valve implantation

Permanent pacing in patients with complete or high-degree AVB that persists for 24 – 48 h after TAVI	I B
Permanent pacing in patients with new-onset alternating BBB after TAVI.	I C
Early ^a permanent pacing in patients with pre-existing RBBB who develop any further conduction disturbance during or after TAVI. ^b	IIa B
Ambulatory ECG monitoring ^c or EPS ^d for patients with new LBBB with QRS >150 ms or PR >240 ms with no further prolongation during the >48 h after TAVI.	IIa C
Ambulatory ECG monitoring ^c or EPS ^d for patients with a pre-existing conduction abnormality who develop prolongation of QRS or PR >20 ms. ^e	IIb C
Prophylactic permanent pacemaker implantation is not indicated before TAVI in patients with RBBB and no indication for permanent pacing.	III C

a Immediately after procedure or within 24 h.

b Transient high-degree AVB, PR prolongation, or QRS axis change.

c Ambulatory continuous ECG monitoring (implantable or external) for 7-30 days.

d EPS should be performed ≥ 3 days after TAVI. Conduction delay with HV ≥ 70 ms may be considered positive for permanent pacing.

e With no further prolongation of QRS or PR during 48-h observation.

Note: CRT in patients requiring pacing after TAVI has the same indication as for general patients.

AF = atrial fibrillation; AVB = atrioventricular block; BBB = bundle branch block; CRT = cardiac resynchronization therapy; ECG = electrocardiogram; EPS = electrophysiology study; HV = His-ventricular interval; LBBB = left bundle branch block; RBBB = right bundle branch block; SR = sinus rhythm; TAVI = transcatheter aortic valve implantation.

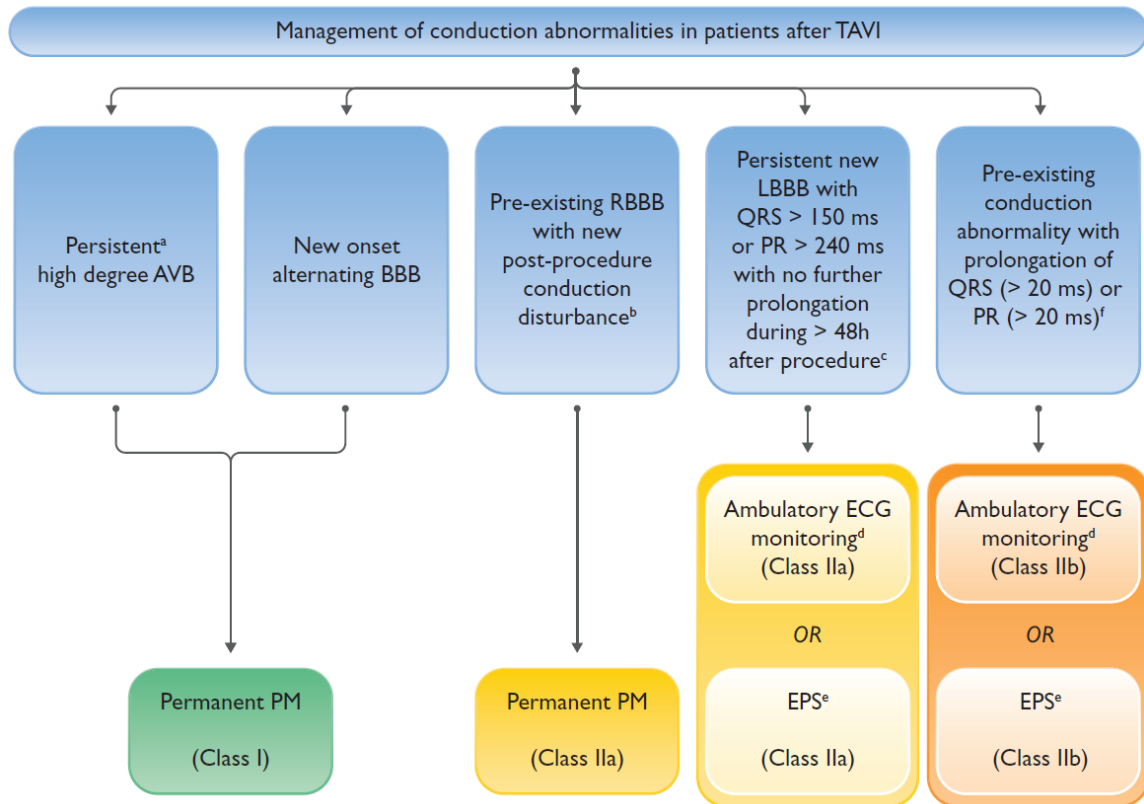


Figure 9. ESC 2021 GL on pacing and CRT. Management of conduction abnormalities after transcatheter aortic valve implantation.

a 24-48 h post-procedure.

b Transient high-degree AVB, PR prolongation, or axis change.

c High-risk parameters for high-degree AV block in patients with new-onset LBBB include: AF, prolonged PR interval, and LVEF <40%.

d Ambulatory continuous ECG monitoring for 7 - 30 days.

e EPS with HV ≥ 70 ms may be considered positive for permanent pacing.

f With no further prolongation of QRS or PR during 48-h observation.

AF = atrial fibrillation; AV = atrioventricular; AVB = atrioventricular block; BBB = bundle branch block; ECG = electrocardiogram; EPS = electrophysiology study; HV = His-ventricular interval; LBBB = left bundle branch block; LVEF = left ventricular ejection fraction; PM = pacemaker; QRS = Q, R, and S waves; RBBB = right bundle branch block; TAVI = transcatheter aortic valve implantation.

Table 13. ACC/AH 2020 guideline on valve disease. Recommendations for Management of CAD in Patients Undergoing TAVI

In patients undergoing TAVI, to assess coronary anatomy and guide revascularization	I-C-EO
1) contrast-enhanced coronary CT angiography (in patients with a low pretest probability for CAD) or 2) an invasive coronary angiogram is recommended	
Revascularization by PCI before TAVI In patients with significant left main or proximal CAD with or without angina	IIa-C-LD
In patients with significant AS and significant CAD (luminal reduction >70% diameter, FFR <0.8, instantaneous wave-free ratio <0.89) consisting of complex bifurcation left main and/or multivessel CAD with a SYNTAX score >33, SAVR and CABG are preferred over TAVI and PCI.	IIa-C-LD

Table 14. Non-cardiac surgery

ESC 2022 GL on non-cardiac surgery. Recommendations for management of valvular heart disease in patients undergoing non-cardiac surgery

(SAVR or TAVI) in symptomatic patients with severe AS who are scheduled for elective intermediate- or high-risk NCS.	I C
In asymptomatic patients with severe AS who are scheduled for elective high-risk NCS, AVR (SAVR or TAVI) should be considered after Heart Team discussion.	IIa C
In patients with severe symptomatic AS in need of time-sensitive NCS or in whom the TAVI and SAVR are unfeasible, BAV may be considered before NCS as a bridge to definitive aortic valve repair.	IIb C

ACC/AHA 2024 GL on Noncardiac surgery

1	C-LD	1. Patients with severe AS should be evaluated for the need for aortic valve intervention before elective NCS to reduce perioperative risk.* ^{1,2}
1	C-EO	2. In patients with suspected moderate or severe AS who are undergoing elevated-risk NCS, preoperative echocardiography is recommended before elective NCS to guide perioperative management.*
2a	C-LD	3. In asymptomatic patients with moderate or severe AS and normal LV systolic function as assessed by echocardiography within the past year, it is reasonable to proceed with elective low-risk NCS. ³⁻⁵
2a	B-NR	1. For patients who undergo successful transcatheter aortic valve implantation (TAVI), it is reasonable to perform NCS early* as clinically indicated. ¹⁻³

*Evidence supports the safety of NCS within 30 days of TAVI, if indicated.

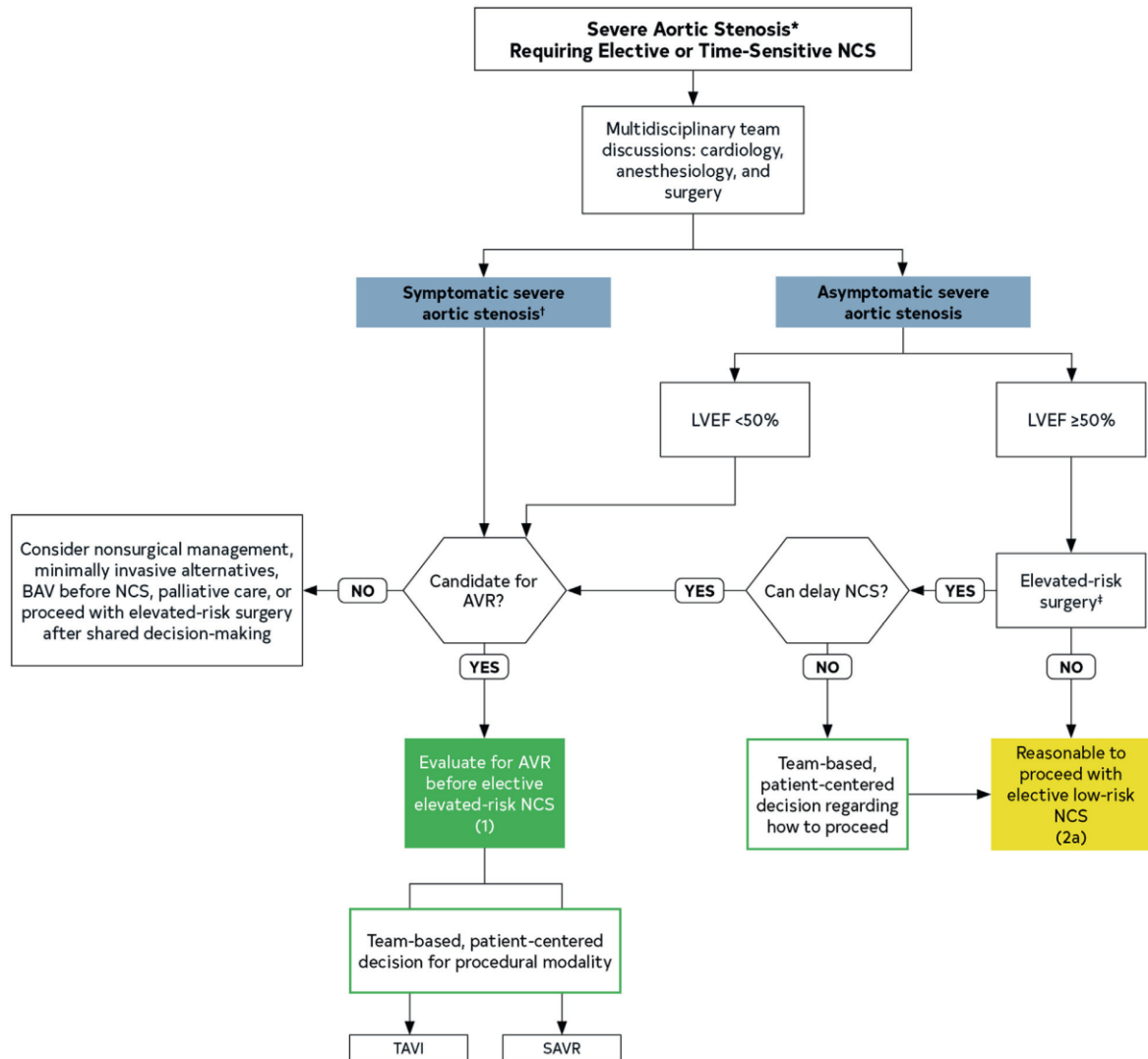


Figure 10. AHA/ACC 2024 GL on Noncardiac Surgery. Management of Patients With Severe Aortic Stenosis Requiring Elective or Time-Sensitive Noncardiac Surgery

*Severe aortic stenosis: aortic valve area <1.0 cm², mean aortic valve gradient ≥40 mm Hg, or peak aortic valve velocity V_{max} ≥4.0 m/s.

†Symptoms of exertional dyspnea, angina, heart failure, syncope, or presyncope. ‡Including elevated risk for hemodynamic instability, large volume shifts, or major bleeding. AVR indicates aortic valve replacement; BAV, balloon aortic valvuloplasty; LVEF, left ventricular ejection fraction; NCS, noncardiac surgery; SAVR, surgical aortic valve replacement; and TAVI, transcatheter aortic valve implantation.

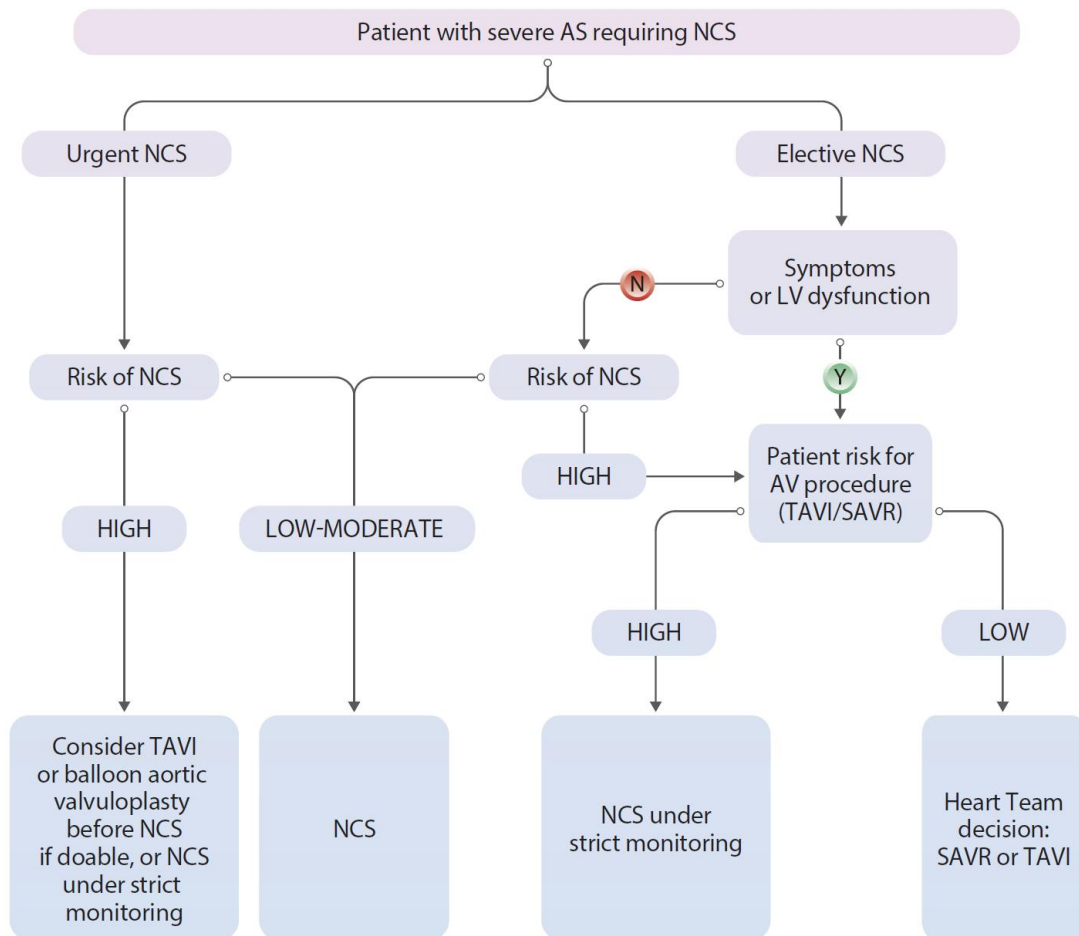


Figure 11. ESC/EACTS 2025 GL on valve disease. Management of non-cardiac surgery in patients with severe aortic stenosis.

AS, aortic stenosis; AV, aortic valve; LV, left ventricular; NCS, non-cardiac surgery; SAVR, surgical aortic valve replacement; TAVI, transcatheter aortic valve implantation.

Table 15. ESC 2020 GL on Sports. Aortic Stenosis**Recommendations for exercise and participation in recreational/ leisure-time sports in asymptomatic individuals with aortic stenosis*****Mild**

Participation in all recreational sports	I C
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Moderate

Participation in all recreational sports involving low to moderate intensity, if LVEF>_50%, good functional capacity, and normal exercise test.	IIa C
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Severe

Participation in all recreational sports/exercise involving low intensity, if LVEF>_50% and normal BP response during exercise.	IIb C
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Participation in competitive or recreational sports/exercise of moderate and high intensity is not recommended.	III C
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Recommendations for participation in competitive sports in asymptomatic individuals with aortic stenosis***Mild**

Participation in all competitive sports	I C
---	-----

Moderate

Participation in all competitive sports involving low to moderate effort, if desired, if LVEF>_50%, good functional capacity, and normal BP response during exercise.	IIb C
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Severe

Participation in low-intensity skill sports in a select group of individuals with LVEF>_50%.	IIb C
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Participation in sports or exercise of moderate or high intensity is not recommended.	III C
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BP = blood pressure; LVEF = left ventricular ejection fraction.

* For mixed valvular disease, the recommendation for the predominant lesion should be followed.

Table 16. Pregnancy and AS**ACC/AH 2020 guideline on valve disease.****Recommendations for Pre-Pregnancy Intervention in Women with VHD**

Valve intervention before pregnancy in asymptomatic women with severe AS (aortic velocity ≥ 4.0 m/s or mean pressure gradient ≥ 40 mmHg, Stage C) who are considering pregnancy	IIa-C-EO
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Medical management during pregnancy to avoid prosthetic valve replacement in asymptomatic women with severe AS (aortic velocity ≥ 4.0 m/s or mean pressure gradient ≥ 40 mmHg, Stage C1), do not meet COR 1 criteria for intervention, and have a preconception evaluation confirming the absence of symptoms (including normal exercise stress testing and serum BNP measurements)	IIb-C-EO
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Recommendations for Intervention During Pregnancy in Women with VHD

In severe AS (mean pressure gradient ≥ 40 mmHg, Stage D), valve intervention during pregnancy if there is hemodynamic deterioration or if there are NYHA class III or IV HF symptoms	IIa-B-NR
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