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Tweet/handle: @vktanguturi @SammyElmariahMD; Aortic stenosis is complicated. It's only more complicated in the COVID era! Check out our strategies for managing severe AS during the COVID pandemic in #JACCINT

ABSTRACT

The novel coronavirus-19 (COVID-19) pandemic has created uncertainty in the management of patients with severe aortic stenosis (AS). This population experiences high mortality from delays in treatment of valve disease but is largely overlapping with the population of highest mortality from COVID-19. We present strategies for managing patients with severe AS in the COVID-era. We suggest transitions to virtual assessments and consultation, careful pruning and planning of necessary testing, as well as fewer and shorter hospital admissions. These strategies center on minimizing patient exposure to COVID-19 and expenditure of human and health-care resources without significant sacrifice to patient outcomes during this public health emergency. Areas of innovation to improve our care during this time include increased use of wearable and remote devices to assess patient performance and vital signs, devices for facile cardiac assessment, and widespread use of clinical protocols for expedient discharge with virtual physical therapy and cardiac rehabilitation options.

INTRODUCTION

Coronavirus-19 (COVID-19) has altered the clinical landscape due to its infectivity rate and the severity of respiratory and hemodynamic distress from infection.(1) Strategies to mitigate COVID-19 spread decrease interpersonal interaction, a significant disruption to our typical evaluation and management of patients with severe aortic stenosis (AS). Severe, symptomatic AS carries high morbidity and mortality when left untreated.(2) However, severe AS most commonly affects elderly patients and is frequently accompanied by co-morbidities of hypertension, coronary artery disease (CAD), and type 2 diabetes—the same conditions that pose the greatest risk for poor outcomes from COVID-19 infection.(3)

COVID-19 risk mitigation strategies focus on reduction of face-to-face clinical visits and unnecessary interventions that consume protective equipment (PPE) and healthcare resources while exposing patients to risk of infection.(4–6). The Center for Medicaid and Medicare Services (CMS) suggested postponing elective procedures and limiting cardiac surgical procedures to only high-acuity and "highly symptomatic" patients.(7) Thus, providers face the complex task of balancing the risks of delayed AVR in severe symptomatic AS versus those of COVID-19 exposure and infection in an at risk population (**Figure 1).** Here, we present clinical strategies for the management of patients with severe AS in the COVID-19 era. In this unprecedented time, a robust evidence base to inform best clinical practice does not exist. Therefore, the recommendations presented are based on the opinions and experience of the authors in an attempt to best manage patients with AS in a resource constrained healthcare system.

OUTPATIENT SURVEILLANCE AND RISK STRATIFICATION

Prompt referral and evaluation for AVR is normally paramount for patients with symptomatic severe AS, leading to the adoption of "wait-time" as a quality-metric in the management of AS.(8) **(Table 1)** Even small delays in AVR are associated with increased morbidity and mortality with the highest risk patients having up to a 20% mortality at 3 months.(2,9,10) In the COVID-19 era, however, risks of delayed AVR need to be balanced against resource constraints and risks of patient exposure to infection, which carries a 10-20% mortality rate in the elderly.(3) **(Figure 1)** Despite the urgency normally assigned to any form of symptomatic severe AS, we and others recommend stratifying patients based on symptom severity as follows: (11,12) **(Table 2)**

Mild, stable symptoms include generalized fatigue, stable exertional dyspnea (allowing for ≥1 flight of stairs), or New York Heart Association (NYHA) Class II congestive heart failure (CHF) symptoms. Virtual or telephone assessments every 1-3 months are prudent to screen for evidence of disease progression. Deferral of AVR referral until the COVID-19 pandemic abates is warranted if symptoms remain stable.

Moderate, stable symptoms include mild, stable angina, stable NYHA Class II/III CHF symptoms, reduced exertional capacity, exertional dyspnea permitting activities of daily living, or symptoms with chronic, stable left ventricular (LV) systolic dysfunction. These patients may be monitored virtually every 1-2 weeks or treated urgently based on local resource availability during the COVID-19 pandemic.(13)

Severe or unstable symptoms apply to patients with NYHA Class III/IV CHF symptoms, progressive weight gain, rapidly decreasing exertional capacity or with minimal exertion, progressive or severe angina, syncope, or new onset pre-syncope. In-person assessments and repeat trans-thoracic echocardiographic (TTE) may be required to assess for new LV dysfunction. Urgent AVR is prudent despite COVID-19 related risks.

Those with asymptomatic severe AS should be monitored every 6 months by virtual visit with TTEs only performed in response to new-onset symptoms or other change in clinical status.(14) All patients should be counseled to maintain a consistent activity level and to promptly communicate changes in their functional capacity or new-onset symptoms, including dyspnea, decreased exertional capacity, lower extremity or abdominal edema, orthopnea, angina, progressive fatigue, or pre-syncope. Caregiver and family member involvement in virtual visits can facilitate home-monitoring of potential symptoms and improved understanding of the clinicians' decision making during this unusual time.

Guidance: Risk stratification for patients with symptomatic severe AS during the COVID-19 pandemic should:

- Use virtual visits to remotely assess patient symptoms and progression
- Classify symptom status as mild, moderate, or severe/unstable as outlined in Table 2
- Trigger prompt AVR evaluation for patients with severe or unstable symptoms
- Remotely surveil patients with mild, stable symptoms every 1-3 months

EVALUATION FOR AVR

When symptom severity or progression mandate prompt AVR evaluation (**Figure 2**), medical urgency and institutional resources should guide whether an inpatient or outpatient evaluation strategy should be employed.

Echocardiographic Evaluation

New or progressive heart failure symptoms may necessitate urgent TTE with the appropriate precautions to minimize contamination of staff, patients, and equipment.(15) There is concern for prolonged COVID-19 viability on plastics, making TTE equipment highly-susceptible to acting as a fomite without thorough cleaning techniques.(16) Sonographers may typically spend up to an hour in close proximity of the patient for full TTE studies, placing them at high risk of COVID-19 exposure.(15) Strategies to prevent equipment contamination and minimize exposure risk for patients and sonographers include deferring unnecessary tests; shortening studies to focus on AS severity, LV systolic function, and exclusion of other severe valve lesions; using smaller machines (i.e. point-of-care ultrasound) which are easier to clean; and using disposable plastic covers for machines and probes.(15) Transesophageal echocardiography, which can aerosolize viral particles, should be avoided.

Inpatient Assessment Strategy

Direct admission to a cardiac or telemetry inpatient bed should be favored over referral to the emergency department in order to minimize interaction with other patients and to reduce the burden on front-line providers and emergency department resources. Pre-admission COVID-19 testing should be obtained if possible. Inpatient services should be carefully orchestrated to facilitate consultative evaluate and necessary testing, imaging, and procedures expeditiously.

Outpatient AVR Assessment Strategy

Multi-disciplinary visits with valve team members and the treatment coordinator can be performed virtually and should focus on the stratification of cardiac symptoms, risk assessment, counselling regarding the natural history of AS, and the comparative risks and benefits of available treatment strategies. A shared decision-making approach should be employed to determine the selection of transcatheter and surgical AVR (TAVR and SAVR, respectively). Activities of daily living should be assessed, and if possible, a virtual frailty walk test (i.e. visualize patient standing from a chair and timed while walking 15 feet).(17)

Guidance: AVR evaluation for patients with symptomatic severe AS during the COVID-19 pandemic should:

- Minimize interpersonal contacts and COVID-19 exposure risk.
- Invoke direct hospital admission and facilitated assessment for acute illness
- Utilize virtual health platforms to predict operative risk, assess frailty, and counsel patients regarding AS and treatment options.
- Perform focused trans-thoracic echocardiography for new or progressive heart failure symptoms at facilities using COVID-19 exposure risk mitigation.

TREATMENT STRATEGIES (TAVR vs. SAVR)

The choice of transcatheter AVR (TAVR) versus surgical AVR (SAVR) should continue to be made by a Heart Team using evidence-based and individualized patient criteria in the COVID-19 era. SAVR should remain the favored approach in younger low-risk patients, especially for those in whom mechanical AVR is being considered or with aortic dilatation, complex root anatomy, or an additional indication for cardiac surgery. As TAVR usually

requires a shorter hospital length of stay and less resource utilization compared to SAVR, it should be preferred for patients who would receive a bioprosthetic valve.(18–20) TAVR may be performed in the cardiac catheterization laboratory with fewer staff using monitored anesthesia or conscious sedation, eliminating the need for operating room resources.(21) Furthermore, procedural recovery after TAVR often occurs in a standard telemetry bed, as opposed to an intensive care unit bed after SAVR. To the extent possible, patient and provider preference for TAVR or SAVR should be determined at the time of the virtual visit in order to inform further customization of subsequent testing.

Guidance: In consideration SAVR vs TAVR for patients with symptomatic severe AS during the COVID-19 pandemic:

- SAVR should remain the favored approach in younger patients in whom mechanical AVR being considered, who have unfavorable anatomy for TAVR, or with additional indication for cardiac surgery
- TAVR should be preferred in elderly patients and in those being considered for a bioprosthetic valve
- Patient and provider preference for TAVR or SAVR should be determined early in the evaluation to inform to inform customization of subsequent testing.
- The Society for Thoracic Surgery Resource Utilization Tool can be used to inform heart team decisions in locales where COVID-19 has limited resources (22)

When SAVR is the preferred strategy, the initial surgical visit should be completed virtually. Cardiac catheterization should be obtained either on an outpatient basis or via direct admission

with plans for SAVR on the following day. Prolonged in-patient wait-times prior to SAVR should be avoided. Dental panorex x-ray, carotid imaging, and pulmonary function tests (PFTs) are commonly performed prior to SAVR, but in the COVID-19 era, diagnostic testing should be minimized or eliminated. PFTs should be deferred in patients without a smoking history and only performed if severe pulmonary disease is suspected. Dental evaluation should similarly be triaged based on the presence of gross dental symptoms or pathology. Rapid testing for COVID-19 prior to admission should be considered when available. If concomitant coronary revascularization is being considered, venous mapping should be obtained in the inpatient setting immediately prior to SAVR or foregone.

Guidance: In evaluation for surgical AVR for patients with symptomatic severe AS during the COVID-19 pandemic:

- Obtain dental panorex x-ray, carotid imaging, vein mapping, and pulmonary function tests only when results will change critical management decisions.
- Cardiac catheterization should be obtained either on an outpatient basis or via direct admission with plans for SAVR on the following day.

A consolidated and prioritized diagnostic testing approach similar to that in the SAVR strategy may be adopted for TAVR. The TAVR-protocol computed tomography angiography (CTA) is a crucial component of TAVR-eligibility and should be performed early in the AVR evaluation to inform management. TAVR CTA imaging protocols can be adapted to excluded proximal CAD and severe carotid artery disease in order to maximize the information obtained and reduce the need for additional testing. Hallmark features of COVID-19 infection on chest CTA should also

be used to supplement COVID-19 testing given its variable sensitivity.(23) PFTs can be deferred unless anticipated to change management. If high-risk for heart block, a virtual visit with an electrophysiologist can be considered prior to the procedural admission for discussion of pacemaker placement. Following the TAVR evaluation, a virtual multi-disciplinary Heart Team meeting should be convened with review of the pertinent data to finalize the appropriate treatment strategy.

If accepted for TAVR, coronary angiography with percutaneous coronary intervention as needed may be performed at the time of TAVR. Using moderate sedation and TTE image guidance rather than general anesthesia and transesophageal echocardiography avoids particle aerosolization with esophageal and tracheal intubation and should be the favored approach when appropriate. The adoption of monitored anesthesia and the "minimalist TAVR approach" may also contribute to reduced length of stay, decreased mortality, and more frequent discharge to home compared to general anesthesia.(21)

Guidance: In evaluation for transcatheter AVR for patients with symptomatic severe AS during the COVID-19 pandemic:

- TAVR-protocol CTA should include coronary and carotid artery assessment.
- TAVR-protocol CTA should be completed early in the evaluation process given its critical role in determining anatomic TAVR candidacy.
- Virtual Heart Team meetings should be conducted after completion of assessment to weigh treatment strategies
- In patients with suspected proximal obstructive CAD, invasive coronary angiography and revascularization may be performed at the time of TAVR.

- Perform TAVR under monitored anesthesia care and TTE image guidance when possible to avoid aerosol generation.

Post-procedural Care

After SAVR, early extubation and mobilization can facilitate shorter length of stay.(24) Transfer out of the intensive care unit within 24 hours should be routinely accomplished barring medical complexity or instability. (18,25)

Hospital discharge within 24-48 hours after TAVR is feasible without significant increases in mortality, poor outcomes, or readmission rates.(25) Teams should strive to remove femoral and upper extremity lines at the completion of the case.(25) In addition, assessments for pacemaker-needs should be expedited. Consideration should be given to immediate implantation of permanent pacemakers at the time of TAVR for patients with atrioventricular block and high-risk features such as slow or absent escape rhythms or hemodynamic instability.(25) Mobile cardiac telemetry monitoring should be utilized for continued outpatient monitoring beyond 24-48 hours for patients with new or increased bundle branch block or atrioventricular block.(25,26)

For both TAVR and SAVR, expedited attention from services including physical, occupational, and speech-language therapy are critical in the COVID-19 era. Nursing and care-coordinators can assist with rapid discharge planning prioritizing discharges to patients' homes rather than to rehabilitation facilities where infection risk may be higher. Rapid COVID-19 screening for visitors may allow for greater presence of family members at the bedside which may in turn improve safety upon discharge.

The Society of Thoracic Surgery (STS) / American College of Cardiology (ACC) Transcatheter Valve Therapy (TVT) Registry typically mandates 30-day clinical follow-up

including post-TAVR TTE, but have recommended deferral of TTE in the absence of clinical concerns. (27) Virtual clinical assessment should be performed and quality of life questionnaires and additional data requested by the TVT Registry should be collected.

Guidance: Post-procedural care after AVR during the COVID-19 pandemic should:

- Accelerate extubation and transfer out of the intensive care unit after SAVR.
- Focus attention on accelerated physical therapy, occupational therapy, and speech-language therapy to support rapid mobilization and diet advancement.
- Target hospital discharge within 24 hours after TAVR.
- Utilize mobile cardiac telemetry monitors over prolonged hospitalization for patients with conduction disturbances not meeting indication for permanent pacemaker implantation.
- Defer routine follow-up echocardiographic assessment in the absence of clinical concerns

PATIENTS WITH SEVERE AS WHO CONTRACT COVID-19

We are likely to care for patients who have severe AS with concurrent COVID-19 infection. In the critically ill patient, the immediate focus should be on the management of COVID-19 illness. However, the robust inflammatory response caused by COVID-19 infection may result in complicated hemodynamics for those with severe or critical AS. In the setting of severe COVID-19 infection, balloon aortic valvuloplasty or emergent TAVR may be considered if cardiac decompensation hinders clinical recovery.(28) SAVR should be undertaken only in extreme cases given the risk of the inflammatory response and pulmonary dysfunction commonly seen after cardiopulmonary bypass. Management and evaluation of severe AS should be deferred in patients with active COVID-19 infection in the absence of an emergent need for

AVR. Similarly, persons under investigation for possible COVID-19 infection should be managed conservatively until cleared with negative COVID-19 testing unless there is an emergent need for AVR; however, decisions in such situations must be guided by local infection control policies, PPE availability, and the population prevalence of COVID-19 infection, and should evolve in conjunction with the state of the pandemic.

AREAS FOR INNOVATION

Although many novel technologies to facilitate continued medical care in the COVID-19 era exist, dissemination, operationalization, and incorporation into existing clinical platforms remain barriers. These barriers are not insurmountable for rapid uptake: states expanded telehealth early in the pandemic which resulted in rapid uptake of telemedicine.(29) The duration of this public health emergency remains uncertain and thus investment in innovative healthcare technologies is critical. Improved virtual platforms that allow for transmission of blood pressure readings, tracking of physical activity, and wide-spread use of home-electrocardiogram (ECG) platforms or digital stethoscopes with recordable audio would allow for a more complete remote clinical assessment. **(Figure 3)**

Innovative protocols that expedite discharge without significant sacrifices in outcomes or that move virtual recovery services to the patients' home would also facilitate care in the COVID-19 era. For example, a caregiver may be instructed in physical therapy techniques, and engage in virtual physical therapy sessions.(30) In addition, cardiac rehabilitation could be made virtual with wearable devices for transmission of hemodynamics, ECG monitoring during structured exercise, and activity levels.(31) Virtual post-operative visits may allow for more timely follow-up after discharge, improve medication reconciliation, and ease patient anxiety about appropriate activity and expectations.

CONCLUSIONS

Patients with severe AS pose a challenge during the COVID-19 pandemic due to their high-resource utilization and increased mortality from delays in care but substantial risk of poor outcomes from COVID-19 infection.(2,4) Our proposed strategies for monitoring, treating patients with severe AS based on current epidemiology and testing patterns strive to minimize the risk of COVID-19 exposure and infection while also providing a high level of clinical care to patients with severe AS.

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FIGURE LEGENDS

Figure 1. Risks of treating severe aortic stenosis (AS) balanced with risks of delayed treatment. (Intensive Care Unit (ICU); Personal Protective Equipment (PPE))

Figure 2. Suggested treatment strategies for patients with severe symptomatic aortic stenosis (AS). (Transcatheter Aortic Valve Replacement (TAVR); Surgical Aortic Valve Replacement (SAVR); Pulmonary Function Tests (PFTs); Computed Tomography Angiography (CTA))

Figure 3. Areas of innovation to facilitate care of patients with severe AS. (Blood Pressure (BP); Electrocardiogram (ECG))

Table 1. Typical care of the patient with symptomatic severe AS vs. COVID-19 era care of the patient with symptomatic severe AS

Typical Care	COVID-19 Era Care
Patient Assessment by Primary Cardiologist	
• In-person detailed assessment and physical examination • Routine outpatient echocardiography	• Virtual or telephone assessment to screen for symptoms. • Outpatient TTE only if uncertain about AS severity or other cardiac concerns
Patient Assessment by Consulting Providers	
• In-person consultation with cardiac surgery, interventional cardiology, and/or other Heart Team providers • Heart Team discussion	• Virtual or telephone assessment by cardiac surgery, interventional cardiology, and/or other Heart Team providers • Virtual Heart Team discussion
Testing	
• Dental panorex X-Ray and clearance • Pulmonary function test • Carotid Doppler ultrasound • Invasive coronary angiography • TAVR protocol CT angiography of chest, abdomen, and pelvis (if TAVR candidate)	• Dental panorex X-Ray only for known dental pathology/caries • Defer pulmonary function test unless required for decision-making • Defer carotid Doppler ultrasound • Coronary angiography performed in the same admission pre-SAVR or during TAVR • TAVR protocol CT angiography extended to include neck, chest, abdomen, and pelvis and coronary screen (if TAVR candidate)
Post-procedurally	
• Rapid mobilization • Patient observed for 24 to 72 hours post TAVR • Patient observed inpatient for 5 to 7 days post SAVR • Home PT and/or inpatient rehabilitation • Outpatient cardiac rehabilitation	• Rapid mobilization • Emphasis on discharge within 24-48hrs post-TAVR • Expedited discharge post-SAVR if feasible • Avoid home PT and inpatient rehabilitation • Virtual outpatient physical therapy and cardiac rehabilitation.

Table 2. Severe AS treatment priorities during the COVID-19 era

Urgent AVR
• Severe or unstable symptoms o *Progressive or severe heart failure symptoms (NYHA class III or IV) including weight gain, rapidly decreasing exertional capacity, or dyspnea with minimal exertion* o *Progressive or severe angina* o *Syncope of new onset pre-syncope* o *New decline in left ventricular ejection fraction*
Consider AVR Based on Local Resources
• Moderate, stable symptoms o *Heart failure symptoms (NYHA class II or III) including weight gain, reduced exertional capacity, or exertional dyspnea that have remained stable and allow for routine daily activities* o *Stable, mild angina* o *Chronic, stable left ventricular systolic dysfunction*
Defer AVR During COVID-19 Pandemic
• Mild, stable symptoms o *Generalized fatigue* o *NYHA Class II heart failure symptoms including stable exertional dyspnea (allowing for at least 1 flight of stairs)*