International Journal of Social Science and Economic Research

ISSN: 2455-8834

Volume:09, Issue: 12 "December 2024"

Comparative Analysis of TAVR and SAVR for Treatment of Aortic Valve Disease: Innovations and Implications

Bao Le

Lake Forest Academy Vietnam

DOI: 10.46609/IJSSER.2024.v09i12.042 URL: https://doi.org/10.46609/IJSSER.2024.v09i12.042

Received: 18 November 2024 / Accepted: 20 December 2024 / Published: 31 December 2024

ABSTRACT

Aortic valve disease (AVD) encompasses significant pathologies such as aortic valve stenosis (AVS) and regurgitation, primarily affecting the elderly population. This review examines four prevalent treatments for AVD: Surgical Aortic Valve Replacement (SAVR), Transcatheter Aortic Valve Replacement (TAVR), Sutureless Aortic Valve Replacement (SuAVR), and Balloon Aortic Valvuloplasty (BAV). We explore the epidemiology, etiology, and global impact of AVD, highlighting the economic burden associated with untreated cases. A comparative analysis of SAVR and TAVR reveals differences in risk profiles, cost-effectiveness, and survival rates. While SAVR offers superior long-term outcomes, TAVR provides a less invasive option with favorable short-term results, particularly for high-risk patients. Technological advancements continue to pave the way for better treatments of AVD.

Keywords: Translational Medical Sciences; Disease Treatment and Therapies; Cardiovascular; Aortic Valve Disease; S/TAVR

1. Introduction

Heart valves are vital in maintaining effective blood circulation within the cardiovascular system. When these valves undergo calcification, their ability to open properly is compromised, leading to a condition known as valve stenosis. The aortic valve, which connects to the aorta and withstands the highest blood pressure in the body, is particularly susceptible to damage and, consequently, is the site of the most prevalent valve disorder: Aortic Valve Disease (AVD). This condition is prevalent among the elderly, making it a significant public health concern as aging populations continue to grow.

AVD includes two conditions: aortic valve stenosis (AVS) and regurgitation. AVS leads to a constricted aortic valve, resulting in impaired blood flow.[1] In contrast, aortic regurgitation entails

ISSN: 2455-8834

Volume:09, Issue: 12 "December 2024"

the backward flow of blood into the heart, causing it to become overloaded and ultimately cause heart failure. A thorough understanding of these conditions is essential, as they contribute to the burden of cardiovascular disease and highlight the need for effective treatment.

This review focuses on found key treatment availabilities for AVD: Surgical Aortic Valve Replacement (SAVR), Transcatheter Aortic Valve Replacement (TAVR), Sutureless Aortic Valve Replacement (SuAVR), and Balloon Aortic Valvuloplasty (BAV). Each of those presents benefits and shortcomings. Historically, SAVR has been regarded as the benchmark treatment, providing long-lasting results, whereas TAVR has revolutionized care, especially for high-risk medical record patients to apply traditional open-heart surgery. Meanwhile, SuAVR and BAV are more recent approaches that still need to be more widely applied but hold immense potential.

We delve into the epidemiology, etiology, and global repercussions of AVD, especially the economic burden of the treatments' expense. Nowadays, more and more younger patients are diagnosed with AVD, which brings the urgent need for spreading awareness of this modern global health crisis.

A detailed comparison of SAVR and TAVR illustrates differences in patient risk profiles, economic viability, and survival outcomes. Grasping these distinctions is essential for healthcare providers in selecting the most suitable treatment for each patient's unique situation. Although SAVR entails a greater risk of surgical complications, it generally yields excellent long-term results, making it ideal for younger or less comorbid patients. Conversely, TAVR, which tends to carry lower immediate risks, has gained popularity among older patients and those with significant health challenges. However, its long-term efficacy remains a subject of ongoing investigation.

While SAVR is associated with better long-term results, TAVR offers a less invasive approach that reduces the short-term mortality rate, particularly with high-risk profile patients. This contrast treatment method underscores the importance of personalized patient care. As advancements in medical technology continue to emerge, new techniques and strategies are being developed to enhance the safety and efficacy of AVD interventions.

1.2 Aortic valve disease

Aortic valve disease (AVD) consists of 2 major aortic valve pathologies: valve stenosis or regurgitation. Aortic Valve Stenosis (AVS) is a condition where a patient's valve cannot be fully open, limiting the blood flow. It is often associated with the calcification of the valves.[1] This then pushes the heart to work harder to pump the same amount of blood. As a result, the heart might be overworked leading to heart failure and stroke. In addition to AVS, there are three additional types of valve stenosis as demonstrated in (Table 1).[2]

ISSN: 2455-8834

Volume:09, Issue: 12 "December 2024"

Table 1: Four types of valve stenosis

Types of Valve Stenosis	Definition	Distribution (%)
Aortic Valve Stenosis	Narrowing of the Valve between the heart's left ventricle and the aorta. As shown in Figure 1(B), the aortic stenosis valve could not fully close or open. Thus, reducing the blood flow efficiency.	46%
Mitral Valve Stenosis	Narrowing of the valve between the left atrium and the left ventricle	12.5%
Pulmonary Valve Stenosis	Narrowing of the valve between the left atrium and the left ventricle	1.5%
Tricuspid Valve Stenosis	Narrowing of the valve between the right atrium and the left atrium	0.5%

The table displays the distribution of 4 valve stenosis types in Japanese cases of heart valve calcification. The data were collected from a population with a high risk of atherosclerosis, so the distribution of aortic and mitral valves could have been higher than the past data set. Adapted from.[29]

The majority of patients diagnosed with Valve Stenosis fall into the AVS category (Table 1). This is due to the aorta's role in pumping a great volume of blood to the whole body, which is challenging for the valve (f1-i). Furthermore, AVD is more common and more alerting, so more research has been focused on improving AVS.

Recent studies indicate a growing number of aortic stenosis, particularly among the elderly population.[3] A recent analysis highlights that a significant number of patients remain undiagnosed or untreated, emphasizing the need for increased awareness and early intervention.[4] Specifically, among the six main risk factors that cause AVD, none of them have a percentage of patients with an intervention that is more than 50% (Table 3.). As a result, the economic burden associated with AVD is substantial, driven by hospitalizations and long-term treatment expenses.[5]

However, many younger patients with AVD reported little to no symptoms for years.[6] This is in part due to the circulation system, specifically, the heart works at its optimal during the early

ISSN: 2455-8834

Volume:09, Issue: 12 "December 2024"

years of life and it can work more to compensate for the blood deficit by the gap.[7] The heart, just like our skin, gets older and less productive. Thus, the common age reported for valve stenosis patients is bimodal: one either gets it during the newborn period or at the later period at 60 or 70.[6]

Severe AVD that can no longer be treated with medicine broad on dietary, exercise changes, or genetic predisposition may lead to aortic valve replacement. Currently, the primary treatment is SAVR, which requires open-heart surgery. However, recent technological advancements in the management of AVD have transformed treatment protocols. TAVR is a minimally invasive procedure that has gained popularity due to its favorable outcomes compared to traditional surgical methods.[8] Innovations in valve design, delivery systems, or cardiac modeling have enhanced procedural success rates and patient recovery times.[9]

AVD is a multifaceted condition, with links to genetic and epigenetic factors playing critical roles.[10] A study in 2016 shows that changes in DNA regulation in the H19 gene are linked to higher levels of a molecule that promotes bone-like changes(calcifying and narrowing the valves).[10-11] This finding highlights the complex interplay between genetic and epigenetic factors in valve disease.

Table 2: Main causes of AVD. Adapted from Table 3.[30]

causes	Aortic stenosis(n=1197)	Aortic regurgitation(n=369)	AVD(n=1197+369=)
Degenerative(%)	81.9	50.3	74.4
Rheumatic(%)	11.2	15.2	12.1
Endocardities(%)	0.8	7.5	2.4
Inflammatory(%)	0.1	4.1	1.0
Congenital(%)	5.4	15.2	7.7
Ischaemic(%)	0	0	0
Other(%)	0.6	7.7	2.3

The result was collected from the Euro Heart Survey, which was conducted from April to July 2021 across 92 centers in 25 countries, enrolling 5,001 adults with moderate to severe valve disease.

ISSN: 2455-8834

Volume:09, Issue: 12 "December 2024"

Table 3: Risk Factors of AVD. Adapted from Table 4.[30]

Risk Factors	Percentage(n=5001)	% with intervention(n=1269)
smoking(current or former)	38.7	37.2
Hypertension	49.2	47.6
Hyperlipidemia	35.5	39.7
Diabetes	15.3	14.1
Family history	25.7	26.3

The chart displays six main causes of AVD from the Euro Heart Survey, which was conducted from April to July 2021 across 92 centers in 25 countries, enrolling 5,001 adults with moderate to severe valve disease.

The major cause of AVD is a degenerative valve with 81.9% for AS, while only 50.3% in the AR categories (Table 2). There is an equal split of 15.2% for both rheumatic and Congenital causes in AR. Major cardiovascular risk factors are smoking, Hypertension, Hyperlipidemia, Diabetes, and Family History.[12] The risk factors are relatively evenly distributed, with hypertension as the highest risk factor at 49.2% (Table 3).

1.3 TAVR vs. SAVR: A Comparative Analysis

SAVR (Surgical Aortic Valve Replacement) remains the most fundamental treatment for valve stenosis, particularly in patients with severe symptoms. The procedure involves the surgical excision of the diseased valve and replacement with a prosthetic valve.[2] Outcomes from SAVR are well-documented, demonstrating effective symptom relief and long-term survival rates.[13] However, it is the most dangerous option for patients since it carries the risk of infection, blood clots, stroke, and irregular heartbeats.[5]

In very high-risk patients study from Emory University, the mean age of all patients is 76.1 years old (11.2 margin of error, the in-hospital mortality is 16.4%, and the midterm survival rate also does not surpass 70.9% in one year post-surgery. After three and five years, the survival rate drops to 56.8% and 47.4%, respectively.[5]

In more recent years, TAVR (Transcatheter Aortic Valve Replacement) has emerged as a viable alternative to SAVR, particularly for high-risk patients.[5] The procedure utilizes a catheter to

ISSN: 2455-8834

Volume:09, Issue: 12 "December 2024"

implant a prosthetic alternative valve, which reduces the need for open heart surgery. Recent studies have shown that TAVR is associated with shorter recovery times and comparable outcomes to SAVR, prompting its increasing adoption.[14]

As a less intrusive method, TAVR is a good alternative for elderly patients or patients at higher surgical risks who may not tolerate open-heart surgery.[15] Similarly, patients with a history of heart, liver, kidney, or Lung Disease, diabetes, and hemophilia would benefit from this alternative approach because it would prevent creating damage to other organs during the surgery (Transcatheter Aortic Valve Replacement (TAVR)).

Recovery time is generally shorter than SAVR. Many patients can return home within a few days. TAVR can significantly improve the conditions of valve stenosis if implanted successfully. A recent study involving patients with a mean age of 84.4 years.[8] 100% of patients who had the valve implanted were deemed successful with no instances of valve embolization, misplacement, or additional valve procedures. All repositioning (26 cases) and retrieval (6 cases) efforts were successful, and 34 patients (28.6%) received a permanent pacemaker. The primary performance goal was achieved, with the mean pressure gradient improving from 46.4 ± 15.0 mm Hg to 11.5 ± 5.2 mm Hg. At the 30-day mark, the mortality rate was 4.2%, with a disabling stroke rate of 1.7%.[8]

1.4 Exploring beyond TAVR and SAVR

Balloon Aortic valvuloplasty (BAV) is a less common intervention for AVD. It is primarily used as a palliative measure in patients who are not candidates for surgical options. The procedure involves inflating a balloon within the stenotic valve to improve blood flow, although long-term outcomes remain limited.[16] There are two main available approaches for Balloon Valvuloplasty: balloon commissurotomy, and metallic commissurotomy.[17]

Suture-less AVR (SuAVR) is a more rare surgical option. While outcomes vary, the procedure aims to relieve obstructive symptoms effectively and enhance the quality of life for selected patients.[18] There are several key differences between the implantation of a sutureless valve and a traditional stented aortic prosthesis. First, since there are no actual anatomical changes, this method can not be applied in severe cases. Surgery is often required later despite the seldom need for urgent surgery (within 24 hours).[17] Second, sutureless valves eliminate the need for extensive suturing, as they require only a few locking sutures—typically no more than three—to secure them to the aortic root after the diseased valve is removed.[19] This streamlined process may lead to shorter operation times, particularly when utilizing minimally invasive approaches.[19] Minimally invasive techniques have been considered more complex and associated with longer surgical durations due to their learning curve.[20]

ISSN: 2455-8834

Volume:09, Issue: 12 "December 2024"

A detailed comparison of TAVR and SAVR is essential in guiding treatment decisions. While both procedures aim to alleviate the symptoms of AVD, their approaches differ significantly. TAVR is generally associated with fewer complications and shorter recovery times, particularly in older patients or those with comorbidities.[21-22] However, SAVR is still preferred for younger patients or those with lower surgical risks due to its established long-term outcomes. [23]

The reason behind the age-orientated preferences is due to the open-chest surgery (cut through the rib cage and breastbone- dangerous for high-risk patients) that is required in SAVR. SAVR requires open-chest surgery and the doctor can alter the old valve precisely with the artificial valve, which eventually serves as the biggest advantage of this conventional approach.[24] In a recent study the short term-30 days mortality rates were slightly higher for TAVR (0.4% vs 0.2%), in the long run, 5-year, the survival rate of SAVR was significantly larger (98% vs 86%).[25] The secondary outcomes (reoperation, infective endocarditis, stroke, and heart failure) in both groups recorded no significant differences as p>0001.[25]

Understanding survival rates across different methods for aortic valve disease is also essential for optimizing treatment outcomes. Each method presents distinct survival profiles influenced by patient risk factors. The average age of TAVR is higher than all three other methods (Table 4). TAVR in patients with an intermediate to high-risk profile was associated with a significant decrease at both short and mid-term survival rates when compared with conventional surgery, BAV, or suture-less valve implantation.

In treating aortic valve disease, different methods yield varying survival outcomes. Surgical Aortic Valve Replacement (SAVR), though the most invasive, has the highest one-month survival rate, showcasing its effectiveness in severe cases. Transcatheter Aortic Valve Replacement (TAVR) offers a slightly better 30-day survival rate than SAVR (Table 4) but struggles with long-term survival, ranking just above Balloon Aortic Valvuloplasty (BAV).

Surprisingly, BAV, despite its lower risk profile, has the lowest long-term survival rate, even though it achieves the best short-term results. In contrast, Sutureless Aortic Valve Replacement (SuAVR) stands out with the highest long-term survival rate and a strong short-term rate of 94.2% (Table 4). As the newest technique available, SuAVR suggests promising advancements in the management

1.5 Technological Advancements and Future Outlook

The future and landscape of Aortic Valve Disease (AVD) is evolving rapidly. This is driven by significant technological advancements, such as the development of stem cell therapies aimed at regenerating heart valves.[26] While these therapies hold potential, they must be approached with caution, as they may not be able to fully replace the original methods like Transcatheter Aortic

ISSN: 2455-8834

Volume:09, Issue: 12 "December 2024"

Valve Replacement (TAVR) and Surgical Aortic Valve Replacement (SAVR), which currently provide reliable and effective solutions for severe AVD.[27-28]

Recent innovations in TAVR and SAVR have transformed how clinicians approach valve diseases. TAVR benefits as a less invasive option, with statistically proven from clinical trials in many countries further validating its efficacy and safety, specifically in the elderly or with background illnesses.[26] This minimally invasive approach allows quicker recovery times, positioning TAVR as an attractive alternative for high-risk patients.

Meanwhile, SAVR remains the golden standard for most cases, particularly in younger patients or those with fewer comorbidities. Regardless, integrating advanced materials and techniques in valve design will likely enhance outcomes for both TAVR and SAVR procedures.[28] Continued exploration into stem cells when used in combination with other therapeutic methods will be crucial as the field aims to refine and personalize treatment options for AVD patients, ensuring that each individual's needs are met effectively.

The future of AVD treatment will likely blend these innovations, enhancing patient treatments while addressing the economic implications of managing this prevalent condition. By bridging the gap of traditional surgical techniques with emerging technologies, patient outcomes and quality of life will improve significantly in the near future.

1.6 Conclusion

Aortic valve disease (AVD) remains a critical health concern, particularly among the elderly population, necessitating timely intervention and effective treatment strategies. The four available approaches are TAVR, SAVR, SuAVR, and BAV, whereas TAVR and SAVR take the majority. While SAVR is associated with higher long-term survival rates, TAVR offers a minimally invasive alternative that is particularly beneficial for elderly or high-risk patients. The comparative analysis of these methods emphasizes the need for a nuanced understanding of patient medical profiles. Furthermore, ongoing technological advancements such as stem cell therapies promise to enhance post-surgical outcomes and survival rates. Future research should focus on integrating innovative therapies to ensure comprehensive and personalized care for AVD patients. Looking forward, a multidisciplinary approach will be crucial in addressing both clinical and economic challenges associated with this health crisis.

2. Authors' information

Bao Le is a 12th-grade Vietnamese international student at Lake Forest Academy(IL). She is passionate about biomedical engineering, particularly cardiovascular and stem cell research. In college, she intends to major in Biomedical Engineering and a minor in Biostatistics.

ISSN: 2455-8834

Volume:09, Issue: 12 "December 2024"

3. Acknowledgments

I would like to thank and acknowledge my mentor Dr. Xavier Portillo for his expert advice and guidance in this research paper.

References

1. Freeman, R. V. & Otto, C. M. Spectrum of Calcific Aortic Valve Disease. *Circulation* **111**, 3316–3326 (2005).

2. Foroutan, F. *et al.* Prognosis after surgical replacement with a bioprosthetic aortic valve in patients with severe symptomatic aortic stenosis: systematic review of observational studies. *BMJ* i5065 (2016) doi:10.1136/bmj.i5065.

3. Lindroos, M., Kupari, M., Heikkilä, J. & Tilvis, R. Prevalence of aortic valve abnormalities in the elderly: An echocardiographic study of a random population sample. *J. Am. Coll. Cardiol.* **21**, 1220–1225 (1993).

4. Guerbaii, R.-A. *et al.* Asymptomatic aortic stenosis: An assessment of patients' and of their general practitioners' knowledge, after an indexed specialized assessment in community practice. *PLOS ONE* **12**, e0178932 (2017).

5. Thoenes, M. *et al.* Patient screening for early detection of aortic stenosis (AS)—review of current practice and future perspectives. *J. Thorac. Dis.* **10**, 5584 (2018).

6. Aortic Stenosis Overview. *www.heart.org* https://www.heart.org/en/health-topics/heart-valve-problems-and-disease/heart-valve-problems-and-causes/problem-aortic-valve-stenosis.

7. Overview: Heart valve diseases. in *InformedHealth.org [Internet]* (Institute for Quality and Efficiency in Health Care (IQWiG), 2019).

8. Meredith Am, I. T. *et al.* Transcatheter Aortic Valve Replacement for Severe Symptomatic Aortic Stenosis Using a Repositionable Valve System. *J. Am. Coll. Cardiol.* **64**, 1339–1348 (2014).

9. Redaelli, A. & Cooper-White, J. Bioengineering of the heart. *APL Bioeng.* **4**, 010402 (2020).

10. Hadji, F. *et al.* Altered DNA Methylation of Long Noncoding RNA H19 in Calcific Aortic Valve Disease Promotes Mineralization by Silencing NOTCH1. *Circulation* **134**, 1848–1862 (2016).

ISSN: 2455-8834

Volume:09, Issue: 12 "December 2024"

11. Pathogenesis of Calcific Aortic Valve Disease | Arteriosclerosis, Thrombosis, and Vascular Biology. https://www.ahajournals.org/doi/full/10.1161/01.ATV.0000227513.13697.ac.

12. Iung, B. *et al.* A prospective survey of patients with valvular heart disease in Europe: The Euro Heart Survey on Valvular Heart Disease. *Eur. Heart J.* **24**, 1231–1243 (2003).

13. S, á M. P. B. O. *et al.* Valve-in-Valve Transcatheter Aortic Valve Replacement Versus Redo Surgical Aortic Valve Replacement. *JACC Cardiovasc. Interv.* **14**, 211–220 (2021).

14. Komosa, A. *et al.* Transcatheter Aortic Valve Replacement Is Associated with Less Oxidative Stress and Faster Recovery of Antioxidant Capacity than Surgical Aortic Valve Replacement. *J. Clin. Med.* **8**, 1364 (2019).

15. Smith, C. R. *et al.* Transcatheter versus Surgical Aortic-Valve Replacement in High-Risk Patients. *N. Engl. J. Med.* **364**, 2187–2198 (2011).

16. Nishimura, R. A. *et al.* 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation* **129**, e521-643 (2014).

17. Vahanian, A. VALVE DISEASE: Balloon valvuloplasty. *Heart* **85**, 223–228 (2001).

18. Phan, K., Zhou, J. J., Niranjan, N., Di Eusanio, M. & Yan, T. D. Minimally invasive reoperative aortic valve replacement: a systematic review and meta-analysis. *Ann. Cardiothorac. Surg.* **4**, 15–25 (2015).

19. Lee, J. W., Lee, S. K., Choo, S. J., Song, H. & Song, M. G. Routine minimally invasive aortic valve procedures. *Cardiovasc. Surg. Lond. Engl.* **8**, 484–490 (2000).

20. Christiansen, S. *et al.* Minimally-invasive versus conventional aortic valve replacement--perioperative course and mid-term results. *Eur. J. Cardio-Thorac. Surg. Off. J. Eur. Assoc. Cardio-Thorac. Surg.* **16**, 647–652 (1999).

21. Goel, K. & Holmes, D. R. J. Transcatheter Aortic Valve Replacement: OPTIMIZING OUTCOMES FOR HEALTHY RECOVERY. *J. Cardiopulm. Rehabil. Prev.* **38**, 1 (2018).

22. Clinical Outcomes at 1 Year Following Transcatheter Aortic Valve Replacement | Valvular Heart Disease | JAMA | JAMA Network. https://jamanetwork.com/journals/jama/fullarticle/2190986.

ISSN: 2455-8834

Volume:09, Issue: 12 "December 2024"

23. Tarro Genta, F. *et al.* Cardiac rehabilitation after transcatheter aortic valve implantation compared to patients after valve replacement. *J. Cardiovasc. Med.* **18**, 114 (2017).

24. Shah, K. K. *et al.* Transcatheter Aortic Valve Implantation (TAVI) Versus Surgical Aortic Valve Replacement for Aortic Stenosis (SAVR): A Cost-Comparison Study. *Heart Lung Circ.* **30**, 1918–1928 (2021).

25. Muneretto, C. *et al.* A comparison of conventional surgery, transcatheter aortic valve replacement, and sutureless valves in "real-world" patients with aortic stenosis and intermediate- to high-risk profile. *J. Thorac. Cardiovasc. Surg.* **150**, 1570–1579 (2015).

26. Mendelson, K. & Schoen, F. J. Heart Valve Tissue Engineering: Concepts, Approaches, Progress, and Challenges. *Ann. Biomed. Eng.* **34**, 1799–1819 (2006).

27. Brown, J. M. *et al.* Isolated aortic valve replacement in North America comprising 108,687 patients in 10 years: Changes in risks, valve types, and outcomes in the Society of Thoracic Surgeons National Database. *J. Thorac. Cardiovasc. Surg.* **137**, 82–90 (2009).

28. Al-Adhami, A. & Al-Attar, N. Recent advances in aortic valve replacement for aortic stenosis. *F1000Research* **5**, F1000 Faculty Rev (2016).

29. Kamo, Y. *et al.* A study on the prevalence, distribution and related factors of heart valve calcification using coronary CT angiography. *IJC Heart Vasc.* **29**, 100571 (2020).

30. Iung, B. A prospective survey of patients with valvular heart disease in Europe: The Euro Heart Survey on Valvular Heart Disease. *Eur. Heart J.* **24**, 1231–1243 (2003).

ISSN: 2455-8834

Volume:09, Issue: 12 "December 2024"

Appendix

Figures

Figure 1: Normal aortic valve vs. aortic stenosis. Schematic of the human heart including four valves (A). The difference between a healthy aortic valve and the aortic stenosis valve (B)