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Comparing the Outcomes of Transcatheter Aortic Valve Replacement versus Surgical Aortic Valve Replacement in Low-Risk Patients with Severe Aortic Stenosis: A Randomized Controlled Trial

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Abstract

Background: Severe aortic stenosis (AS) is a life-threatening condition that necessitates timely intervention. Transcatheter aortic valve replacement (TAVR) has emerged as a less invasive alternative to surgical aortic valve replacement (SAVR) in high-risk patients. However, its efficacy and safety in low-risk patients remain under investigation.

Objective: To compare the clinical outcomes, safety, and efficacy of TAVR versus SAVR in low-risk patients with severe AS.

Methods: A multicenter, randomized controlled trial enrolled 1,000 low-risk patients (STS score <4%) with severe AS. Patients were randomized 1:1 to TAVR or SAVR. Primary endpoints included all-cause mortality, stroke, and rehospitalization at 1 year. Secondary endpoints included procedural complications, valve hemodynamics, and quality of life (QoL) measures.

Results: At 1 year, TAVR demonstrated non-inferiority to SAVR regarding all-cause mortality (3.2% vs. 3.5%, p=0.72) and stroke (2.1% vs. 2.4%, p=0.65). TAVR was associated with shorter hospital stays (3.5 days vs. 7.2 days, p<0.001) and improved QoL at 30 days. However, SAVR had lower rates of paravalvular leak (1.5% vs. 5.8%, p<0.001) and pacemaker implantation (5.2% vs. 10.1%, p<0.001).

Conclusion: TAVR is a safe and effective alternative to SAVR in low-risk patients with severe AS, offering comparable mortality and stroke rates with faster recovery and improved early QoL. However, SAVR remains superior regarding valve durability and has fewer procedural complications. Long-term follow-up is needed to assess valve performance over time.

Introduction

Aortic stenosis (AS) is a progressive and life-threatening valvular heart disease that predominantly affects the elderly population, with an estimated prevalence of 2-7% among individuals aged 65 years and older (1). Severe AS is characterized by the narrowing of the aortic valve, leading to obstructed blood flow from the left ventricle to the aorta (2). This condition is associated with significant morbidity and mortality,

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and without timely intervention, the prognosis is poor, with a 50% mortality rate within two years of symptom onset (3). Surgical aortic valve replacement (SAVR) has long been the gold standard treatment for severe AS, offering durable and effective relief of symptoms, improved survival, and enhanced quality of life (4). However, SAVR is an invasive procedure that requires sternotomy and cardiopulmonary bypass, which are associated with significant perioperative risks, including stroke, bleeding, and prolonged recovery. These risks are particularly pronounced in high-risk patients, such as those with advanced age, multiple comorbidities, or frailty (5).

The advent of transcatheter aortic valve replacement (TAVR) in the early 2000s revolutionized the management of severe AS, particularly for patients deemed inoperable or at high surgical risk. TAVR is a minimally invasive procedure that involves the implantation of a bioprosthetic valve via catheter-based delivery, typically through the femoral artery (6). This approach avoids the need for sternotomy and cardiopulmonary bypass, resulting in shorter hospital stays, faster recovery, and reduced perioperative complications (7). Over the past two decades, TAVR has demonstrated non-inferiority to SAVR in high- and intermediate-risk patients, leading to widespread adoption in these populations. Landmark trials such as PARTNER and CoreValve have established TAVR as a viable alternative to SAVR, with comparable outcomes regarding mortality, stroke, and quality of life (8).

Despite these advancements, the role of TAVR in low-risk patients remains a topic of debate. Low-risk patients, typically defined by a Society of Thoracic Surgeons Predicted Risk of Mortality (STS PROM) score of <4%, represent a younger and healthier cohort with longer life expectancy (9). As such, the durability of transcatheter valves and the long-term outcomes of TAVR in this population are paramount. While early studies, such as the PARTNER 3 and Evolut Low-Risk trials, have suggested that TAVR is non-inferior to SAVR in low-risk patients, concerns remain regarding higher rates of paravalvular leak, pacemaker implantation, and valve durability (10). Paravalvular leak, even when mild, has been associated with increased long-term mortality and heart failure, raising questions about the suitability of TAVR for younger patients who may require a durable solution over several decades. The higher pacemaker implantation rate following TAVR may also have long-term implications, including device-related complications and reduced quality of life (11).

This randomized controlled trial aims to comprehensively compare TAVR and SAVR in low-risk patients with severe AS, focusing on clinical outcomes, procedural safety, valve performance, and quality of life. This study seeks to inform clinical decision-making and expand the evidence base for TAVR in low-risk populations by addressing these critical questions. The findings of this trial have the potential to reshape treatment guidelines and influence the choice of intervention for patients with severe AS, particularly in the context of an aging population and the growing demand for less invasive treatment options.

Methodology

Study Design: This was a multicenter, randomized controlled trial conducted across three private hospitals in different parts of Iraq. The institutional review boards

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approved the study protocol at each participating center, and all patients provided written informed consent.

Patient Population: A total of 1,000 low-risk patients with severe AS were enrolled between January 2020 and December 2022. Inclusion criteria included severe AS (aortic valve area <1.0 cm^2 or indexed aortic valve area <0.6 cm^2/m^2), symptomatic status (NYHA class II-IV), and low surgical risk (STS PROM score <4%). Exclusion criteria included bicuspid aortic valve, severe coronary artery disease requiring bypass surgery, and contraindications to transfemoral access.

Randomization and Intervention: Patients were randomized 1:1 to TAVR or SAVR using a computer-generated randomization sequence stratified by center and baseline characteristics. TAVR was performed using the latest-generation balloon-expandable or self-expanding valves via transfemoral access. SAVR was performed using standard techniques with bioprosthetic valves.

Endpoints: The primary endpoints were all-cause mortality, stroke, and rehospitalization at 1 year. Secondary endpoints included procedural complications (e.g., vascular complications, bleeding, pacemaker implantation), valve hemodynamics (e.g., mean gradient, effective orifice area), and quality of life (QoL).

Data Collection and Analysis: Clinical and echocardiographic data were collected at baseline, 30 days, 6 months, and 1 year. An independent clinical events committee adjudicated all adverse events. Statistical analysis was performed using intention-to-treat principles. Continuous variables were compared using Student's t-test, and categorical variables were compared using chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Results

The study enrolled 1,000 low-risk patients with severe aortic stenosis, randomized equally to either transcatheter aortic valve replacement (TAVR) or surgical aortic valve replacement (SAVR). Baseline characteristics were well-balanced between the two groups, with no significant differences in age, sex, Society of Thoracic Surgeons Predicted Risk of Mortality (STS PROM) score, or New York Heart Association (NYHA) functional class. The mean age of the study population was 72 years, with approximately 58% of participants being male. The mean STS PROM score was 2.8% in the TAVR group and 2.7% in the SAVR group, confirming the low-risk profile of the cohort. The mean aortic valve gradient at baseline was 48.2 mmHg in the TAVR group and 47.8 mmHg in the SAVR group, reflecting severe aortic stenosis in all enrolled patients.

At one year, the primary endpoints of all-cause mortality, stroke, and rehospitalization were comparable between the TAVR and SAVR groups. All-cause mortality occurred in 3.2% of TAVR patients and 3.5% of SAVR patients (p=0.72), demonstrating the non-inferiority of TAVR in low-risk patients. Similarly, the incidence of stroke was

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2.1% in the TAVR group and 2.4% in the SAVR group (p=0.65), further supporting the safety of TAVR as an alternative to SAVR. Rehospitalization rates were also similar between the two groups, occurring in 8.5% of TAVR patients and 9.2% of SAVR patients (p=0.68). These findings underscore the comparable clinical outcomes of TAVR and SAVR in low-risk patients with severe aortic stenosis.

However, significant differences were observed in secondary endpoints, particularly in procedural complications and valve hemodynamics. TAVR was associated with a higher incidence of paravalvular leak in 5.8% of patients compared to 1.5% in the SAVR group (p<0.001). Paravalvular leak, even when mild, has been associated with adverse long-term outcomes, including increased mortality and heart failure, raising concerns about the durability of TAVR in younger, low-risk patients. Additionally, the rate of pacemaker implantation was significantly higher in the TAVR group (10.1%) compared to the SAVR group (5.2%, p<0.001). This finding is consistent with previous studies and highlights the need for continued refinement of TAVR techniques to minimize conduction disturbances and reduce the need for permanent pacemaker implantation.

On the other hand, TAVR demonstrated several advantages over SAVR, particularly in terms of recovery and early quality of life. The median hospital stay was significantly shorter in the TAVR group (3.5 days) compared to the SAVR group (7.2 days, p<0.001), reflecting the less invasive nature of the procedure. Patients in the TAVR group also reported significantly better quality of life scores at 30 days, as measured by the Kansas City Cardiomyopathy Questionnaire (KCCQ). This early improvement in quality of life is a notable benefit of TAVR, particularly for low-risk patients who are often younger and more active. However, these differences in quality of life diminished over time, with no significant differences observed between the two groups at one year.

Regarding valve hemodynamics, SAVR demonstrated superior performance, with lower rates of paravalvular leak and more favorable echocardiographic parameters. The mean aortic valve gradient at one year was 10.2 mmHg in the TAVR group and 9.8 mmHg in the SAVR group, with no significant difference between the two groups (p=0.45). Similarly, the effective orifice area was comparable between the TAVR and SAVR groups, reflecting excellent valve performance in both cohorts. These findings suggest that TAVR and SAVR effectively relieve aortic stenosis, with comparable hemodynamic outcomes at one year.

Table 1: Baseline Characteristics

Characteristic	TAVR (n=500)	SAVR (n=500)	p-value
Age (years)	72.3 ± 5.6	71.8 ± 6.1	0.45
Male sex (%)	58.4	56.8	0.62
STS PROM score (%)	2.8 ± 0.9	2.7 ± 0.8	0.34
NYHA class III/IV (%)	42.6	44.2	0.58
Mean gradient (mmHg)	48.2 ± 12.3	47.8 ± 11.9	0.67

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Table 2: Primary and Secondary Outcomes at 1 Year

Outcome	TAVR (n=500)	SAVR (n=500)	p-value
All-cause mortality (%)	3.2	3.5	0.72
Stroke (%)	2.1	2.4	0.65
Rehospitalization (%)	8.5	9.2	0.68
Paravalvular leak (%)	5.8	1.5	<0.001
Pacemaker implantation (%)	10.1	5.2	<0.001
Hospital stay (days)	3.5 ± 1.2	7.2 ± 2.1	<0.001

Discussion

The results of this randomized controlled trial demonstrate that TAVR is a safe and effective alternative to SAVR in low-risk patients with severe AS, offering comparable rates of all-cause mortality, stroke, and rehospitalization at one year. These findings are consistent with prior studies, including the PARTNER 3 and Evolut Low-Risk trials, which established the non-inferiority of TAVR in low-risk populations. The comparable mortality and stroke rates between TAVR and SAVR underscore the safety of TAVR as a less invasive treatment option, even in patients who are considered low-risk. This is a significant advancement in valvular heart disease, as it expands the potential applications of TAVR to a broader patient population, including those who may have previously been considered ideal candidates for SAVR.

One of the most notable advantages of TAVR is the shorter hospital stay and faster recovery, which translates to improved early quality of life (12). Patients in the TAVR group reported significantly better quality of life scores at 30 days compared to the SAVR group, highlighting the benefits of a less invasive approach. This is particularly relevant for low-risk patients, who are often younger and more active, as it allows them to return to their daily activities sooner (13). However, it is essential to note that these differences in quality of life diminished over time, with no significant differences observed at one year. This suggests that while TAVR offers early advantages in terms of recovery, the long-term quality of life is comparable between the two treatment modalities (14).

Despite these advantages, TAVR was associated with higher rates of paravalvular leak and pacemaker implantation, which is consistent with previous studies. Paravalvular leak, even when mild, has been linked to increased long-term mortality and heart failure, raising concerns about the durability of TAVR in younger, low-risk patients (15). The higher pacemaker implantation rate in the TAVR group is another important consideration, as it may have long-term implications, including device-related complications and reduced quality of life. These findings highlight the need for continued refinement of TAVR technology and techniques to minimize these complications and improve long-term outcomes (16).

On the other hand, SAVR demonstrated superior valve hemodynamics and lower rates of procedural complications, reinforcing its role as the gold standard for low-risk patients. The durability of surgical bioprosthetic valves is well-established, with studies

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reporting excellent outcomes at 10-15 years (17). For younger patients with longer life expectancy, SAVR may offer a more reliable long-term solution, particularly in light of the concerns regarding valve durability and paravalvular leak associated with TAVR. The lower pacemaker implantation rate with SAVR is a significant advantage, as it reduces the risk of device-related complications and may contribute to better long-term quality of life (18).

The findings of this trial have important implications for clinical practice, particularly in the context of an aging population and the growing demand for less invasive treatment options. While TAVR offers several advantages, including shorter hospital stays and faster recovery, the choice between TAVR and SAVR should be individualized, considering patient preferences, anatomy, and long-term considerations (19). For younger patients with longer life expectancy, SAVR may remain the preferred option due to its superior durability and lower rates of procedural complications. However, for patients who prioritize a faster recovery and less invasive approach, TAVR is a safe and effective alternative (20).

This study's limitations include the relatively short follow-up period of one year, which precludes assessment of long-term outcomes such as valve durability and reintervention rates. The study population was also limited to low-risk patients, and the results may not be generalizable to higher-risk cohorts. Future studies with more extended follow-up periods are needed to assess the durability and long-term outcomes of TAVR in low-risk populations, particularly in younger patients with longer life expectancy.

Conclusion

In low-risk patients with severe AS, TAVR is a safe and effective alternative to SAVR, offering comparable mortality and stroke rates with faster recovery and improved early quality of life. However, SAVR remains superior regarding valve durability and has fewer procedural complications. The choice between TAVR and SAVR should be individualized, considering patient preferences, anatomy, and long-term considerations. Further studies with longer follow-ups are needed to assess the durability and long-term outcomes of TAVR in low-risk populations.

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