

Transcatheter Aortic Valve Implantation in Nonagenarians: In-Hospital Complications and One-Year Follow-Up Mortality

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Abstract

Background: Aortic Stenosis (AS) is prevalent among elderly individuals and is associated with high mortality when untreated. Transcatheter Aortic Valve Implantation (TAVI) has emerged as a viable therapeutic alternative, particularly for patients with surgical contraindications. However, its application in nonagenarians remains controversial due to limited data in this very elderly population.

Objective: To evaluate clinical outcomes in nonagenarian patients undergoing TAVI at a private quaternary hospital, with emphasis on mortality and in-hospital as well as one-year complications.

Methods: A retrospective cohort study with prospective follow-up was conducted between 2009 and 2023. A total of 265 patients with symptomatic severe AS who underwent TAVI were included, of whom 40 were nonagenarians (≥ 89 years). Data were obtained from an institutional database and from the Brazilian Registry of Aortic Bioprosthesis Implantation by Catheter – New Technologies (RIBAC-NT). Comparisons between nonagenarians and younger patients were performed using the Student's t-test for continuous variables and the chi-square (χ^2) test for categorical variables. A p-value < 0.05 was considered statistically significant.

Results: Among nonagenarians, 55% were female, 72.5% had hypertension, and 95% had chronic kidney disease. The technical success rate was 55%. Major complications included permanent pacemaker implantation (35%) and adverse events (45%). In-hospital mortality was 7.9%, with no statistically significant differences at 30 days ($p = 0.40$), 6 months ($p = 0.35$), and one year ($p = 0.06$) compared to younger patients.

Conclusion: TAVI proved to be a safe and effective therapeutic option in nonagenarians, showing clinical outcomes comparable to those of younger individuals.

Keywords: Aortic Valve Stenosis; Transcatheter Aortic Valve Replacement; Hospital Mortality; Nonagenarians; Postoperative Complications.

Introduction

Aortic Stenosis (AS) is the most prevalent valvular heart disease among older adults, affecting 3% to 5% of individuals over 75 years of age.¹ It is characterized by progressive obstruction of the left ventricular outflow tract due to stiffening and calcification of the aortic valve. Once symptoms develop, untreated AS is associated with high mortality, exceeding 50% within two years.² Surgical aortic valve replacement

remains the gold-standard treatment. However, in many patients, particularly those of advanced age or with multiple comorbidities, the surgical risk is considered prohibitive.³

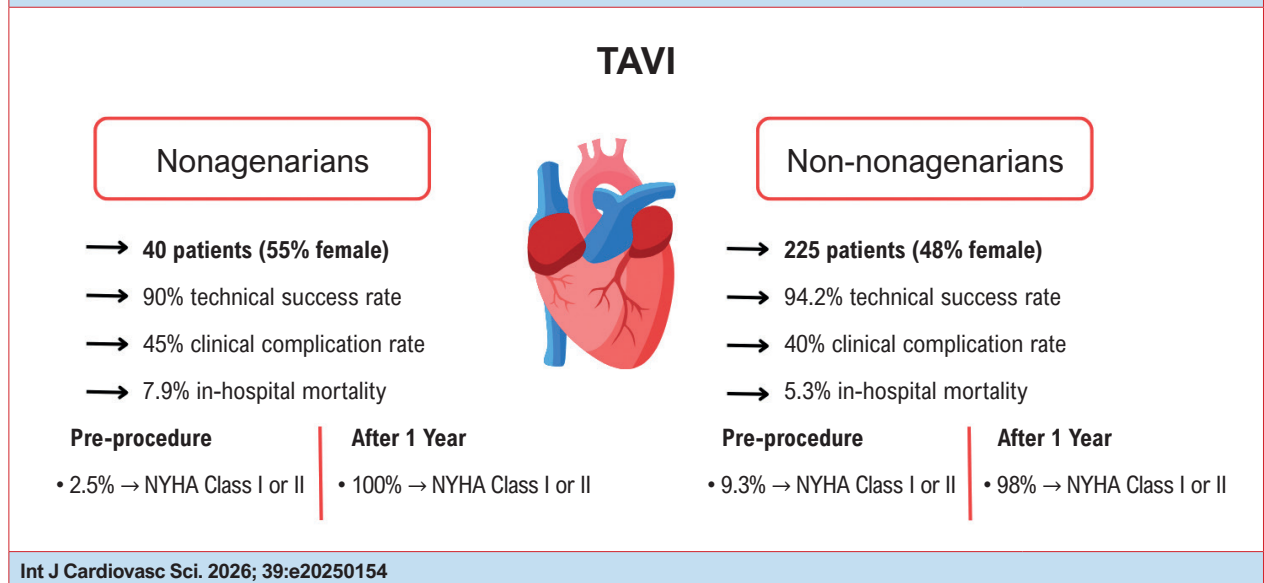
In this context, TAVI has emerged as a minimally invasive therapeutic alternative for the treatment of AS. Initially indicated for patients deemed inoperable, TAVI is now also widely used in patients at intermediate and even low surgical risk.⁴⁻⁶ Landmark trials such as PARTNER and SURTAVI demonstrated the efficacy and safety of TAVI in elderly populations.^{7,8} However, data regarding its use in patients aged 89 years or older, the so-called nonagenarians, remain scarce. As life expectancy continues to increase in Brazil and worldwide, there is a growing need for robust clinical evidence to guide therapeutic decision-making for very elderly patients, who may benefit particularly from this treatment strategy.

The Brazilian literature evaluating the impact of TAVI in nonagenarians is limited,⁹ making it difficult to establish protocols and specific clinical guidelines for this age

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Central Illustration: Transcatheter Aortic Valve Implantation in Nonagenarians: In-Hospital Complications and One-Year Follow-Up Mortality



TAVI: Transcatheter Aortic Valve Implantation.

group. Therefore, the present study aims to contribute to the understanding of clinical outcomes following TAVI in nonagenarians by evaluating in-hospital complications and mortality during up to one year of follow-up.

Methods

This was a retrospective cohort study with prospective follow-up based on the analysis of an institutional database. Consecutive patients who underwent transcatheter aortic valve implantation (TAVI) between December 2009 and December 2023 at a private quaternary care hospital in Rio de Janeiro, Brazil, were included. The study was approved by the local Research Ethics Committee (approval No. 5,183,540) and is linked to the Brazilian Registry of Transcatheter Aortic Bioprosthesis Implantation – New Technologies (RIBAC-NT).

The study population comprised 265 patients diagnosed with symptomatic severe AS who had a contraindication to or were considered at elevated risk for conventional surgical aortic valve replacement. Patients were divided into two groups: nonagenarians (age $\geq$ 89 years) and non-nonagenarians (age < 89 years).

Inclusion Criteria:

- Age $\geq$ 89 years at the time of the procedure (study group);
- Symptomatic severe AS, defined as an aortic valve area $\leq$ 1.0 cm² and/or a mean transvalvular gradient $\geq$ 40 mmHg and/or a peak aortic jet velocity $\geq$ 4.0 m/s;
- Formal contraindication to conventional surgical aortic valve replacement, as determined by the Heart Team;

- Favorable anatomy for the transcatheter procedure, with suitable vascular access;
- Provision of written informed consent in accordance with Brazilian National Health Council Resolution No. 466/12.

Exclusion Criteria:

- Significant congenital heart disease;
- Valvular heart disease other than predominant AS (e.g., isolated aortic regurgitation);
- Previous valve surgery requiring a valve-in-valve procedure;
- Cognitive impairment precluding clinical follow-up;
- Incomplete data for outcome assessment.

Procedures

The TAVI procedure was performed in a hybrid catheterization laboratory under general anesthesia or conscious sedation, as determined by the treating team. The prosthetic valve type (self-expanding or balloon-expandable) and the access route (preferably transfemoral) were selected on a case-by-case basis. Procedural success was defined according to the Valve Academic Research Consortium-3 (VARC-3) criteria.

Statistical analysis

Categorical variables are presented as absolute and relative frequencies. Continuous variables are expressed as mean $\pm$ standard deviation after assessment of normality using the Shapiro-Wilk test. Comparisons between groups

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(nonagenarians and non-nonagenarians) were performed using the unpaired Student's t-test for body mass index (BMI), the only continuous variable with a normal distribution between groups, and the chi-square (χ^2) test for categorical variables. A two-sided p-value < 0.05 was considered statistically significant. Statistical analyses were performed using GraphPad Prism version 8.0 (GraphPad Software, San Diego, CA, USA).

Results

A total of 265 patients with severe symptomatic AS who underwent TAVI between 2009 and 2023 were included. Of these, 40 patients (15.1%) were nonagenarians (≥ 89 years), whereas 225 patients (84.9%) comprised the comparison group (non-nonagenarians) (Central Illustration).

The nonagenarian group consisted predominantly of women (55.0%), patients with hypertension (72.5%), non-diabetic individuals (65.0%), patients with chronic kidney disease (95.0%), and patients without coronary artery disease (61.5%). No significant differences were observed between non-nonagenarians and nonagenarians ($p > 0.05$) regarding anthropometric characteristics and comorbidities, except for BMI (Table 1).

Among nonagenarians, the proportion of patients with previous myocardial infarction was lower among those without prior coronary artery bypass graft surgery (12.5% vs. 17.5%).

Regarding cardiac rhythm, 62.5% of nonagenarians were in sinus rhythm at baseline, and 22.5% reported angina.

Procedural characteristics and clinical outcomes are presented in Table 2. General anesthesia was used more frequently in nonagenarians (85% vs. 60%), and all patients in this group underwent surgical vascular access with direct-vision arterial puncture (100% vs. 90%). The most frequently implanted prosthesis in this group was the CoreValve (67.5%). According to the VARC-3 criteria, the technical success rate was 90% among nonagenarians compared with 94.2% in younger patients ($p = 0.510$).

Complications occurred in 45% of nonagenarians, with permanent pacemaker implantation required in 35%. In-hospital mortality in this group was 7.9%, with no statistically significant difference compared with the control group. Likewise, no significant differences were observed in mortality at 30 days ($p = 0.40$), 6 months ($p = 0.35$), or 1 year ($p = 0.06$) between the two groups (Figure 1).

Improvement in functional status following the procedure, according to the New York Heart Association (NYHA) classification, demonstrated a marked reduction in the proportion of patients classified as NYHA functional class III and IV, accompanied by an increase in the proportion of patients classified as NYHA class I and II in both nonagenarians and non-nonagenarians (Graphs 1 and 2, respectively). No statistically significant differences were observed between the two groups (Table 3).

Table 1 – Clinical, comorbidity, and electrocardiographic characteristics of patients undergoing TAVI according to age group

Variable	Nonagenarians (n = 40)	Non- nonagenarians (n = 225)	P-Value
Female	22 (55.0%)	108 (48.0%)	0.519
Systemic arterial hypertension	29 (72.5%)	153 (68.0%)	0.704
Chronic kidney disease	38 (95.0%)	187 (83.0%)	0.090
BMI (SD)	24.4 (3.9)	26.5 (5.0)	0.009
Previous myocardial infarction	5 (12.5%)	34 (15.0%)	0.851
Previous coronary revascularization	7 (17.5%)	45 (20.0%)	0.880
Sinus rhythm on baseline ECG	25 (62.5%)	158 (70.0%)	0.431
Presence of angina	9 (22.5%)	41 (18.0%)	0.676

TAVI: transcatheter aortic valve implantation; ECG: electrocardiogram; SD: standard deviation; BMI: body mass index.

Table 2 – Procedural characteristics and clinical outcomes of patients undergoing TAVI according to age group

Variable	Nonagenarians (n = 40)	Non- nonagenarians (n = 225)	P-Value
General anesthesia	34 (85.0%)	135 (60.0%)	0.004
Surgical access	40 (100.0%)	203 (90.0%)	0.079
Use of self-expanding prosthesis (CoreValve)	27 (67.5%)	158 (70.0%)	0.874
Technical success (VARC-3 criteria)	36 (90.0%)	212 (94.2%)	0.510
Permanent pacemaker implantation	14 (35.0%)	56 (25.0%)	0.253
Occurrence of clinical complications	18 (45.0%)	90 (40.0%)	0.676
In-hospital mortality	3 (7.9%)	12 (5.3%)	0.861

TAVI: transcatheter aortic valve implantation; VARC-3: Valve Academic Research Consortium-3.

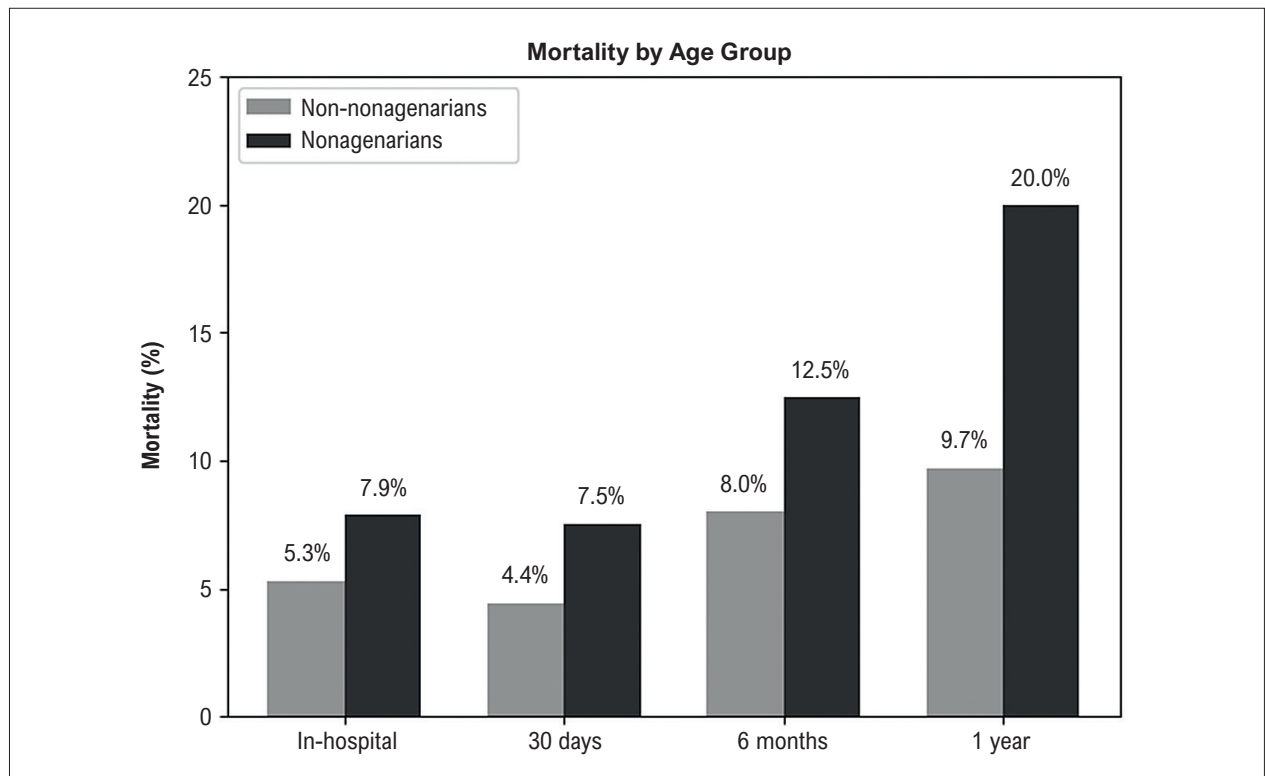


Figure 1 – In-hospital, 30-day, 6-month, and 1-year mortality following TAVI in non-nonagenarians ($n = 225$) and nonagenarians ($n = 40$).

Discussion

The present study demonstrates substantial, sustained, and clinically meaningful improvement in patients with symptomatic AS undergoing TAVI, regardless of age. Favorable outcomes were observed in both younger and older patients in the short, intermediate, and long term, extending up to one year after the procedure. These findings further support the safety and effectiveness of TAVI, including in a very elderly population.

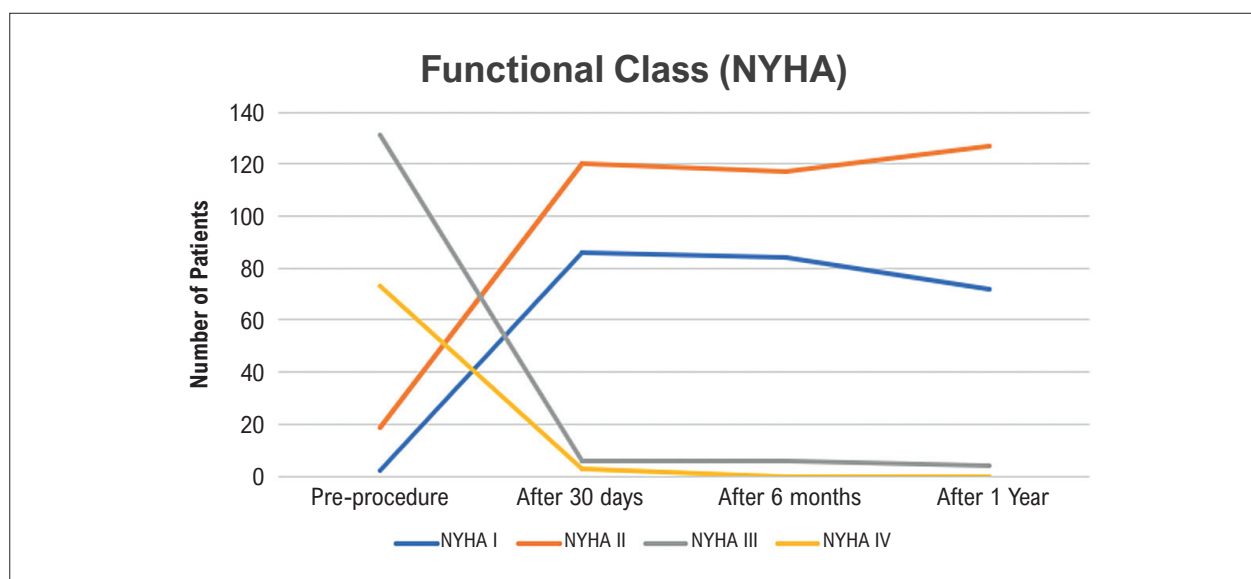
With ongoing advances in transcatheter valve technologies, TAVI has become an established therapeutic option, particularly for patients at intermediate or high surgical risk.^{6,7} The adoption of less invasive techniques has further expanded its clinical use, reflecting the broader trend toward minimizing procedural invasiveness. However, it is important to recognize that most previously published studies have included populations with shorter life expectancy, limiting our understanding of long-term outcomes following the procedure. This gap highlights the need for studies evaluating outcomes in very elderly patients, such as nonagenarians, to support safer and more individualized therapeutic decision-making.

Regarding anthropometric characteristics, BMI differed significantly between nonagenarians and younger patients, with higher values observed among patients aged 89 years or older. This finding may be related to physiological changes associated with aging, including sarcopenia and progressive alterations in body composition commonly observed in this population.¹⁰ In addition, the analysis of chronic comorbidities

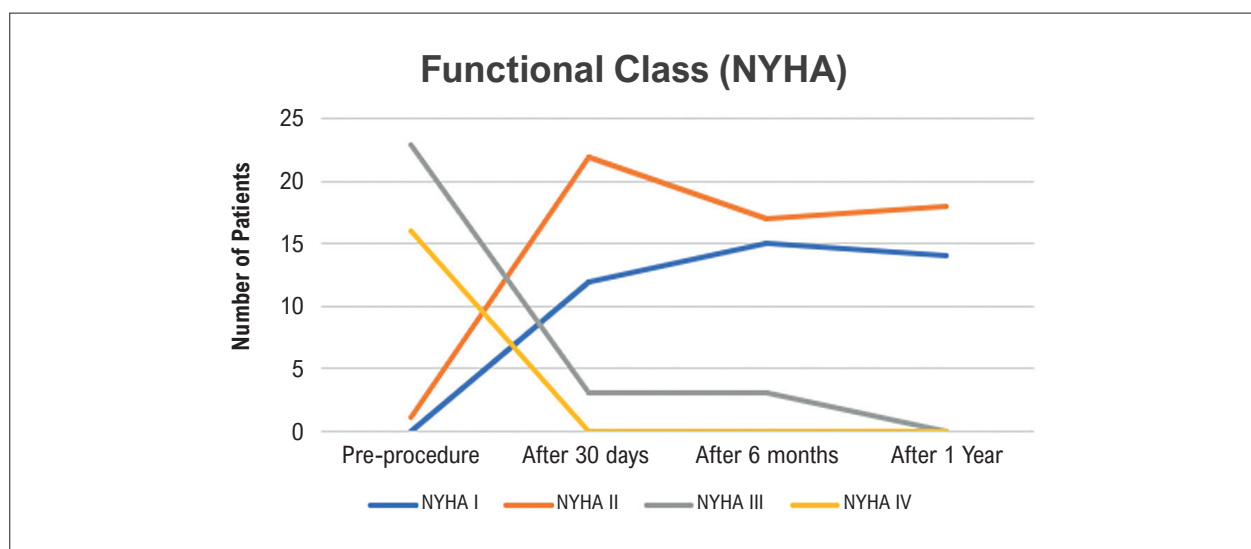
demonstrated that hypertension and chronic kidney disease were highly prevalent in both age groups, underscoring their clinical relevance in the geriatric population and the importance of appropriate therapeutic management.

Although general anesthesia was used significantly more frequently in nonagenarians undergoing TAVI than in younger patients ($p = 0.004$), this difference did not translate into differences in most procedural or clinical outcomes evaluated. Specifically, no significant differences were observed in technical success according to the VARC-3 criteria, the need for permanent pacemaker implantation, or the incidence of clinical complications. Furthermore, in-hospital mortality among nonagenarians was statistically comparable to that observed in younger patients and was consistent with rates reported in international registries for this age group.^{11,12} These findings further support broader use of this valve implantation strategy in appropriately selected elderly patients. Although relatively high mortality rates were observed among patients aged 89 years or older, particularly during long-term follow-up, these findings should be interpreted within the context of the inherently high baseline mortality expected in this age group due to advanced age and the high prevalence of comorbid conditions such as coronary artery disease and chronic kidney disease. Therefore, the observed mortality rates should not necessarily be interpreted as evidence of procedural failure.

Overall, these findings suggest that, despite differences in perioperative management strategies, such as the choice of anesthetic technique, nonagenarians may derive benefits from TAVI comparable to those observed in patients younger



Graph 1 – Evolution of NYHA functional class in non-nonagenarians before the procedure, 30 days after the procedure, 6 months after the procedure, and 1 year after the procedure. NYHA: New York Heart Association.



Graph 2 – Evolution of NYHA functional class in nonagenarians before the procedure, 30 days after the procedure, 6 months after the procedure, and 1 year after the procedure. NYHA: New York Heart Association.

than 90 years, with similar safety and efficacy profiles. This observation further supports the growing recognition that advanced chronological age alone should not preclude consideration of TAVI, provided that patients undergo comprehensive individualized assessment and optimization of coexisting medical conditions.

The results of the present study indicate that TAVI is feasible in nonagenarians, with technical success rates and clinical outcomes comparable to those observed in younger patients. Moreover, comparisons between nonagenarians and non-nonagenarians revealed no statistically significant differences in short- or intermediate-term mortality. These

findings are consistent with those reported by the U.S. STS/ACC TVT Registry, which demonstrated a 30-day mortality rate of 8.8% among nonagenarians undergoing TAVI and a one-year survival rate of 74%, similar to that observed in octogenarian patients.¹³

The higher use of general anesthesia (85%) and surgical vascular access (100%) among nonagenarians may reflect a more conservative institutional approach toward patients with greater anatomical complexity or frailty. Nevertheless, more recent studies have demonstrated favorable outcomes with the preferential use of conscious sedation and image-guided transfemoral access.^{14,15}

Improvement in NYHA functional class following TAVI was evident in both nonagenarians and younger patients, with sustained clinical benefits observed at 30 days, 6 months, and 1 year after the procedure. These findings indicate progressive improvement in functional capacity and sustained enhancement of quality of life. The absence of significant differences between age groups further supports the comparability of outcomes between nonagenarians and younger patients.

Conclusion

Despite the limitations inherent to its retrospective design, including the potential for selection bias and heterogeneity in clinical follow-up, this study provides important evidence

regarding the applicability of TAVI in a very elderly Brazilian population that remains underrepresented in both national and international registries.

These findings reinforce the importance of individualized evaluation by the Heart Team, considering not only chronological age but also the patient's functional, cognitive, and social status. As life expectancy continues to increase and percutaneous technologies continue to evolve, expanding access to TAVI for appropriately selected nonagenarians is likely to become increasingly important.

Author Contributions

Conception and design of the research and analysis and interpretation of the data: Mattos NDFG, Oliveira RL, Feijó ALF, Souza ALS, Salgado CG, Castello Branco RV, Mattos GZ, Secco JCP, Carvalho LAF, Rey HC; acquisition of data: Mattos NDFG, Oliveira RL, Feijó ALF, Souza ALS, Salgado CG, Castello Branco RV, Carvalho LAF; statistical analysis: Mattos NDFG, Oliveira RL, Salgado CG, Mattos GZ, Secco JCP, Carvalho LAF, Rey HC; obtaining financing: Mattos NDFG; writing of the manuscript: Mattos NDFG, Salgado CG, Mattos GZ, Secco JCP, Rey HC; critical revision of the manuscript for intellectual content: Mattos NDFG, Salgado CG, Mattos GZ, Secco JCP, Carvalho LAF, Rey HC.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This article is part of the thesis submitted by Nelson Durval Ferreira Gomes de Mattos, from the Instituto Nacional de Cardiologia (INC).

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the Comitê de Ética em Pesquisa Local (Rio de Janeiro) under the protocol number CAEE 54137821.6.0000.5533, approval number 5.183.540, on December 15, 2021. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Availability of Research Data

The underlying content of the research text is contained within the manuscript.

Table 3 – Evolution of functional class in nonagenarians and non-nonagenarians following TAVI

Variable	Age		P-value
	< 89 years	≥ 89 years	
Pre-procedural NYHA class	n = 225	n = 40	0.4799
I	2 (0.9)	0 (0)	
II	19 (8.4)	1 (2.5)	
III	131 (58.2)	23 (57.5)	
IV	73 (32.4)	16 (40.0)	
NYHA class at 30 days	n = 215	n = 37	0.102
I	86 (40.0)	12 (32.4)	
II	120 (55.8)	22 (59.5)	
III	6 (2.8)	3 (8.1)	
IV	3 (1.4)	0	
NYHA class at 6 months	n = 207	n = 35	0.2122
I	84 (40.6)	15 (42.8)	
II	117 (56.5)	17 (48.6)	
III	6 (2.9)	3 (8.6)	
IV	0	0	
NYHA class at 1 year	n = 203	n = 32	0.6867
I	72 (47.5)	14 (43.7)	
II	127 (47.5)	18 (56.3)	
III	4 (3.3)	0	
IV	0	0	

NYHA: New York Heart Association.

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