Atrial Approach in Mitral Valve Surgery: Are There Differences in the Incidence of Clinically Relevant Adverse Effects? A Propensity Analysis.

Carlos Obando (drcarlosobando@yahoo.com)
Fundación Cardioinfantil Instituto de Cardiología: Fundacion Cardioinfantil Instituto de Cardiologia
Javier D Garzón
Fundación Cardioinfantil Instituto de Cardiología: Fundacion Cardioinfantil Instituto de Cardiologia
Lina M Ramirez
Fundación Cardioinfantil Instituto de Cardiología: Fundacion Cardioinfantil Instituto de Cardiologia
Andrea C Castillo
Fundación Cardioinfantil Instituto de Cardiología: Fundacion Cardioinfantil Instituto de Cardiologia
Albert F Guerrero
Fundación Cardioinfantil Instituto de Cardiología: Fundacion Cardioinfantil Instituto de Cardiologia
Tomas Chalela
Fundación Cardioinfantil Instituto de Cardiología: Fundacion Cardioinfantil Instituto de Cardiologia
Diana C Sandoval
Fundación Cardioinfantil Instituto de Cardiología: Fundacion Cardioinfantil Instituto de Cardiologia
Manuel Giraldo-Grueso
Ochsner Medical Center - New Orleans
Nestor F Sandoval
Fundación Cardioinfantil Instituto de Cardiología: Fundacion Cardioinfantil Instituto de Cardiologia
Jaime Camacho
Fundación Cardioinfantil Instituto de Cardiología: Fundacion Cardioinfantil Instituto de Cardiologia
Juan P Umaña
Fundación Cardioinfantil Instituto de Cardiología: Fundacion Cardioinfantil Instituto de Cardiologia

Research article

Keywords: mitral valve, surgical approaches, complications, postoperative

Posted Date: October 28th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-1014098/v1

Abstract

Background: The lack of evidence with respect to complications with mitral valve approaches leaves the choice of exposure to the surgeon's preference, basing it on individual experience, speed, ease, and quality of exposure.

Methods: Analysis of patients undergoing mitral valve surgery by either a superior transseptal approach or a left-atrial approach between 2006 and 2018. We included first time elective mitral valve procedures, isolated or combined, without a history of rhythm disturbances. We used propensity score matching based on 26 perioperative variables. Primary endpoint was to determine the association between the superior transeptal approach and clinically significant adverse outcomes including arrhythmias, need for permanent pacemaker, cerebrovascular events, and mortality

Results: 652 patients met the inclusion criteria, 391 received the left atrial approach and 261 superior transseptal. After matching, 96 patients were compared with 69, respectively. The distribution of the preoperative and perioperative variables was similar. There was no difference in the incidence of supraventricular tachyarrhythmias and the need for treatment. The incidence of nodal rhythm ($p = 0.008$) and length of stay in intensive care ($p = 0.04$) were higher in the superior transseptal group, however the need for permanent pacemaker implantation was the same. Likewise, there was no difference in the need for anticoagulation due to arrhythmia, the incidence of cerebrovascular events or mortality in the postoperative period, and in the long-term follow-up.

Conclusion: We did not find an association with permanent heart rhythm disorders or any other significant adverse clinical outcome, therefore we consider that the superior transeptal approach is useful and safe for mitral valve exposure.

1. Background:

Minimally invasive surgery has established itself as a first-line alternative for the treatment of mitral valve disease (1). However, the conventional open surgical approach retains a fundamental role, especially given the need for combined procedures that include revascularization, multi-valvular intervention, or both. Similarly, it is essential in the presence of anatomical or functional conditions that make a minimally invasive approach difficult or contraindicated. There are multiple surgical ways to expose the MV, but the most frequently used are the lateral left atrial and the transseptal approach or its extended superior transseptal version (2,3,4,5).

The most used incision is through the left atrium behind the interatrial groove. It provides satisfactory exposure of the valve and subvalvular apparatus. However, there are circumstances that limit the versatility of this type of access, such as the presence of a small left atrium, a deep thorax or simply the need for a greater degree of tissue dissection in the context of reoperation (6,7).

The superior transeptal (TS) approach offers optimal exposure of the MV complex, even in the presence of hostile anatomical conditions and in the event of reoperations, limits the need to extend the release of pleuropericardial, mediastinal adhesions or both, facilitating exposure and theoretically reducing the risk of bleeding. This approach has been associated with a variety of complications, especially postoperative heart rhythm disorders, but the evidence is contradictory (8,9,10,11,12,13).

The lack of evidence with respect to complications with either approach leaves the choice of exposure to the surgeon's preference, basing it on individual experience, speed, ease, and quality of exposure, as well as less need for dissection in reoperations.

The present study approaches the problem from a different perspective as it seeks to establish the association with clinically significant outcomes leading to the need for additional therapeutic interventions such as chronic anticoagulation due to arrhythmia, use of antiarrhythmic medication and either electrical cardioversion, implantation of devices for rhythm control or both. The establishment of causal relationships between the type of surgical approach used for MV exposure and the development of postoperative complications will provide objective and useful elements when planning the strategy for open MV surgery.

2. Methods:

2.1 Patients

This is a retrospective cohort analysis of adult patients (over 18 years of age) who underwent cardiac surgery for the first time for conventional open intervention of the MV between January 2006 and July 2018 at Fundación Cardioinfantil – Institute of Cardiology. MV exposure was performed through a Left Atrial (LA) or TS approach. The study included patients with MV stenosis (MVS) or insufficiency (MVI) of any etiology with indication for MV replacement (MVR) or repair (MVr) as a single procedure or combined with other types of valve surgery at the aortic, tricuspid or both, with and without coronary revascularization.

Patients who underwent other types of MV access, emergency interventions, history of cardiac arrhythmia, use of devices for rhythm control, resynchronization therapy, implantable cardioverter defibrillator (ICD) or both, were excluded from the present study.

We searched for potentially eligible patients by convenience sampling, extracting the information from the institutional electronic medical records and selected the patients who fulfilled the criteria, according to the Consort flow diagram.

2.1 Ethics Statement

The Clinical Research Ethics Committee of our institution approved the study (Act number 11-2017) and considered that there was no need for consent.

2.2 Surgical technique

Surgical procedures were performed by the Institution's group of nine cardiovascular surgeons throughout the study period. In all cases, cardiopulmonary bypass (CPB) was established with arterial cannulation in the ascending aorta and bicaval venous cannulation, with normothermia or mild hypothermia through active cooling. Cardioplegic solutions employed for myocardial protection included HTK solution (custodiol), cristaloid (St Thomas, Del Nido) or blood cardioplegia using St Thomas solution in a 4:1 ratio and Del Nido in a 1:4 ratio, administered by either antegrade and /or retrograde route. In the LA approach, access was achieved through a longitudinal incision posterior to the interatrial groove. For the TS approach a right oblique atriotomy was performed, followed by a longitudinal septal incision in the middle part of the floor of the fossa ovalis extending cranially over the roof of the left atrium.

2.3 Echocardiographic and hemodynamic data

Echocardiographic data was obtained from our institutional database. All preoperative studies were performed by our echocardiography lab, which is accredited by the Intersocietal Accreditation Commission. Variables evaluated were left ventricle ejection fraction (LVEF), pulmonary artery systolic pressure (PASP), left atrial diameter (LAD), type and severity of mitral and other types of valve dysfunction. The presence of hemodynamically significant CAD identified in the preoperative cardiac catheterization was recorded in the database. The variables were categorized to define groups of outcomes, according to the severity of the diagnosis.

2.4 Data and follow-up

Patient records were reviewed to obtain demographic data, prior medical history, and intraoperative variables including type of approach, valve interventions, coronary artery bypass grafting (CABG), myocardial protection strategy, CPB and cross-clamp times. During their hospitalization, all patients were monitored with continuous telemetry and any alteration of the rhythm was recorded in the medical records. Thirty day-postoperative follow-up was included in our database. Long-term follow-up was performed through telephone interviews and outpatient clinic visits. Patients were evaluated for the appearance of atrial fibrillation (Afib), flutter, other supraventricular arrhythmias, bradyarrhythmias or blocks, the use of antiarrhythmics, the need for electrical cardioversion, implantation of permanent pacemaker (PPM), and ICU length of stay.

2.5 Statistical analysis

All preoperative, perioperative and 30-day variables were recorded in our database, which follows the guidelines established by the Society of Thoracic Surgeons. Long-term follow-up variables were recorded by extracting data from institutional registries and by telephone survey.

Continuous variables are presented as mean ± one standard deviation (SD) or as median and interquartile range (IQR). Preoperative and postoperative data were compared using the t- test or the Mann-Whitney U test for continuous variables, according to the sample distribution of normality

(Kolmogorov-Smirnoff test) and categorical variables were expressed as the number and percentage of the cases within each category and groups compared using the Chi-square test or the Fisher's exact test. Statistical significance was assumed with $p < 0.05$. Data processing was carried out using the Statistical Package for the Social Sciences - SPSS version 25 software for Windows.

In order to control the selection bias of the sample, we performed a propensity score matching (PSM), using the Nearest Neighbor method, according to the similarities in the standardized differences between a case comparing it with 2 controls (matching 1:2), ordered from highest to lowest, without replacement of the data and setting a reference caliper of 0,2 (14).

Variables included in the calculation of the propensity score were sex, age, LVEF, PASP, LAD, preoperative creatinine, preoperative hematocrit, MVS (absent, mild, moderate, severe), MVI (absent, mild, moderate, severe), aortic valve disease (absent, stenosis, insufficiency, double injury), CAD, 3 Vessel disease and/or left main trunk compromise, TV disease (≥ moderate), Euroscore II risk (%), diabetes mellitus, hypertension, COPD, stroke, CKD, PAD, pre-surgical use of beta-blockers and statins, mitral valve surgery (valvuloplasty, bioprosthesis or mechanical prosthesis), CABG, aortic valve replacement, tricuspid valve surgery.

A secondary analysis was performed splitting the data according to the follow up time in first and second half, to check if consistent results would come up compared to the primary outcomes analysis.

The Kaplan–Meier method and log-rank test were used to estimate and compare the survival rates between the 2 matched groups.

3. Results:

Between January 2006 and July 2018, 652 patients who met the criteria to be included in the study, underwent first-time isolated or combined MV surgery. Associated procedures included CABG, aortic valve replacement (AVR) and TV repair/replacement. 391 patients received a LA approach (Group LA), and 261 patients received a TS approach (Group TS). We excluded 18 patients because the type of surgical approach (minimally invasive) and 424 patients who had uncompleted preoperative critical data such as echocardiographic measures. Graph 1.

We obtained a new sample of 96 patients to the LA group and 69 patients to the TS group after PSM. Standardized differences were obtained and an improved of the sample heterogeneity were achieved, because the post PSM Standardized differences were lower to 0,1 (14) Graph 2.

The preoperative and perioperative variables are illustrated in Table 1.

Before matching, no statistically significant differences were found except for PASP (U-Mann Whitney; *p=0,001*) and tricuspid intervention (X^2; *p=0,007*). No differences were observed in the distributions of other variables such as the type and severity of mitral valve dysfunction, aortic valve disease, comorbidity profile and intraoperative characteristics such as type of mitral intervention, type of cardioplegia solution and cross-clamp and CPB time. Of the patients who underwent simultaneous AVR, only 0,95% received a mechanical prosthesis with no differences in distribution between groups. All tricuspid valves were repaired.

In the primary analysis according to PSM, yielded 69 patients in the TS group and 96 in the LA group, with no significant differences between cohorts, except for longer ICU stay (U-Mann Whitney; *p=0,002*) and an increase prevalence of nodal rhythm in TS patients (X^2; *p=0,008*). Table 2.

There were 24 deaths along the entire follow-up time (mean time from surgery 11,6 years for LA group and 10,6 years for TS group), but no significant differences were found between the type of surgical approach in the survival analysis (Log-rank test; *p=0,073*). Graph 3.

In the secondary analysis, we divided the sample according to the mean follow-up time into 2 groups. The first sub analysis included patient's date of surgery from January 2006 to July 2011 and the second subgroup from July 2011 to December 2016. No significant differences were found between patients, except for longer ICU stay (U-Mann Whitney; *p=0,04*) and an increase prevalence of nodal (X^2; *p=0,023*) and other SV arrhythmias (X^2; *p=0,045*) in TS patients for the first sub analysis group. Table 3.

For the second sub analysis group no significant differences were found between patients, except for longer ICU stay (U-Mann Whitney; *p=0,04*) and an increase cross-clamp (U-Mann Whitney; *p=0,024*) and CPB time (U-Mann Whitney; *p=0,049*) in TS patients. Table 4.

No significant differences in the perioperative and overall mortality were found in neither group. Although a noticeable difference is observed in the mortality figures in each of the intervention groups, between the two periods.

4. Discussion:

Since the description of the TS approach by Guiraudon and colleagues in 1991 (4,9), there has been controversy regarding its relationship with postoperative heart rhythm disorders, need for PPM, and postoperative bleeding. Available evidence comes mainly from retrospective studies and from a few randomized prospective studies without adequate power, which explains why it’s contradictory and not widely applicable (15).

Our study addresses this problem using a cohort model in which the differences in prognosis of MV surgery are analyzed after the use of the left atrial vs superior transseptal approach. Given that there is a non-random distribution between groups, conditions that could influence the selection of the technique, such as reoperations or emergency surgeries, were excluded from the analysis; Similarly, patients with a history of arrhythmia, chronic anticoagulation or PPM were excluded, since the objective of this study is precisely to elucidate the effect of the use of the two main mitral approach strategies in the development of rhythm disturbances, the need for PPM, use of postoperative anticoagulation and antiarrhythmic medication, among others. Finally, we used propensity score matching (PSM) to further minimize biases inherent to retrospective analyses.

After matching with propensity scores, no significant differences were observed in the postoperative incidence of Afib/flutter or other types of supraventricular arrhythmias between groups. There was a higher incidence of nodal rhythm ($p = 0.008$) and length of stay in ICU ($p = 0.04$) in those patients undergoing a TS approach. However, these rhythm disorders were mostly transitory. Therefore, they did not result in a significant difference in the need for PPM implantation. Similar findings have been reported in other studies and seem to reflect a benign behavior of early rhythm disorders related to the TS approach (16,17). Since we found no difference in the incidence of Afib/flutter, use of anticoagulation, antiarrhythmic medication, and the need for postoperative electrical cardioversion was the same between groups. Our results are consistent with the observations of the prospective randomized study by Gaudino et al, who did not identify significant differences in the incidence of cardiac rhythm disturbances in patients whose preoperative rhythm was normal sinus rhythm (18). On the contrary, Rezahosseini et al, in a retrospective cohort analysis done through pairing with propensity scores that gathered 815 patients, observed a significant increase in the prevalence of postoperative Afib in patients with TS mitral approach (36.8% vs 27.5%, $p = 0.019$), with no differences in the need for a perioperative temporary pacemaker between the groups. Although it was essentially a transient dysfunction, our higher early incidence of nodal rhythm contributes in part to the longer stay observed in the ICU with the TS approach. However, it is clear that the definition of this outcome is due to a multifactorial origin. Turkyilmaz and Kavala, in a retrospective analysis using propensity scores, identified a significant increase in ICU stay ($p<0.001$) and hospitalization ($p<0.001$) associated with the TS approach, despite not having observed significant differences in the prevalence of postoperative rhythm disturbances. They instead identified perioperative bleeding as the main factor influencing this outcome ($p<0.001$) (17).

Rhythm disturbances correlated to the TS approach can be explained because of the proximity of the sinus node artery which can be easily injured, leading to ischemia and resultant nodal dysfunction. Additionally, the incision can cause internodal pathway disruption and scar formation can block impulses getting from the sinus node. (19).

Nienabber et al, in a retrospective analysis of 531 patients comparing the LA approach with the so-called mini-transseptal access, limited to the interatrial septum without extension to the atrial roof, observed a significant increase in the incidence of junctional rhythm (8.7% vs. 4.2%, $p = 0.035$) and in the need for PPM (10.5% vs 5.1%, $p = 0.025$). However, multivariate analysis showed that TS access was not an independent predictor for the development of rhythm alterations or the need for PPM, and the latter is specifically related to the presence of redo sternotomy (20). Lukac et al, also identified a greater need for PPM in their retrospective cohort analysis of 577 patients ($p = 0.010$) undergoing TS approach, mainly related to a higher incidence of sinus node dysfunction ($p = 0.017$) (21). In the long-term follow-up of our cohorts, clinical stability was evidenced without significant differences in the incidence of arrhythmias, the need for antiarrhythmic medication, the use of oral anticoagulation in non-carriers of mechanical valves, and the incidence of cerebrovascular events. Likewise, the need for late PPM implantation was similar between groups.

We didn`t observe a significant difference in perioperative (p = 0.204) and late (p=0.211) mortality, associated with the use of a TS approach. Similarly, the studies by Gaudino et al (18) and Aydin et al (16) specifically evaluated the outcome of mortality without being able to establish a relationship with the type of atrial approach. Nor do we have evidence from prospective studies showing an association between the use of the ST approach and an increase in mortality (15). The recent meta-analysis by Harky et al. compared the outcomes in MV surgery of these two types of approach, although it included limited transseptal access and superior transseptal access in the TS group. 4537 patients were included and evaluated as primary outcomes, operative mortality and PPM implantation. The mortality outcome was similar between the groups, unlike the need for PPM implantation and the incidence of new onset AF, which were higher in the TS group. Analysis of the isolated MV surgery subgroup did not show any significant difference. Unlike our study, the distribution of other concomitant valve procedures was not symmetrical and this could influence the higher incidence of postoperative rhythm disorders and the need for PPM (22)

The high mortality rate observed in both intervention groups is striking. However, it should be taken into account that both isolated mitral procedures and procedures combined with valve interventions in other locations and / or with coronary revascularization have been included in the present analysis. The secondary analysis in different periods shows that such high mortality values are mainly conditioned by the results obtained in the initial period. Important factors that may have influenced the improvement of the postoperative prognosis probably include improvement in surgical technique and anesthesia, advances in cardiopulmonary bypass technology and intensive care management, among others.

5. Conclusions:

In this study, no association was identified between the ST approach and a higher incidence of tachyarrhythmias, although there was evidence of a greater risk of developing transitory postoperative nodal rhythm and a longer stay in intensive care. Similarly, there are no differences in clinically significant short-term and long-term adverse outcomes, such as the need for antiarrhythmic medication, electrical cardioversion, anticoagulation, permanent pacemaker implantation, cerebrovascular event, or mortality. Therefore, the superior transseptal approach is shown as a useful and safe alternative for mitral valve exposure in cardiac surgery.

List Of Abbreviations:

Afib Atrial Fibrillation

AV Atrioventricular

AVR Aortic Valve Replacement

CABG Coronary Artery Bypass Grafting

CAD Coronary Artery Disease

COPD Chronic Obstructive Pulmonary Disease

CKD Chronic Kidney Disease

CPB Cardiopulmonary Bypass

EF Ejection Fraction

LA Left Atrial

ICD Implantable Cardioverter Defibrillator

ICU Intensive Care Unit

LAD Left Atrial Diameter

LVEF Left Ventricle Ejection Fraction

MV Mitral Valve

MVI Mitral Valve Insufficiency

MVr Mitral Valve repair

MVR Mitral Valve Replacement

MVS Mitral Valve Stenosis

PASP Pulmonary Artery Systolic Pressure

PPM Permanent Pacemaker

PSM Propensity Score Matching

SV Supraventricular

TS Superior Transseptal Approach

TV Tricuspid Valve

Declarations:

Ethics approval and consent to participate: The institutional review board approved this study. (Act number 11-2017) there was no need for consent since the data collection was done in a retrospective manner.

Institutional Review Board: Comité de Ética en Investigación Clínica

Consent for publication: Yes

Availability of data and material: Database collected in the study is available from the corresponding author on reasonable request

Competing Interests: Dr Juan P. Umana is a consultant for Edwards Lifesciences.

Funding: No

Authors Contributions: CO: Conceptualization, data curation, investigation, methodology, project administration, supervision, validation, visualization, writing-original draft, writing-review and editing. JD: Conceptualization, data curation, investigation, methodology.LR: Data curation, formal analysis, software.AC: Data curation, investigation, methodology.AG, TC, DS, MGG: Data curation. NS, JC, JU: Supervision, visualization, writing-review and editing.

Acknowledgments: Special thanks to Juan David Obando Cardenas for his collaboration in language editing of this manuscript.

References:

1. Goldstone AB, Woo YJ. Alternative approaches for mitral valve repair. Ann Cardiothorac Surg 2015; 4:469-473.
2. Sultan I, Trivedi I, Machiraju V. Surgical approaches to the mitral valve: variable paths to the same destination. Indian J Thorac Cardiovasc Surg 2017;34(S2):105-112. Doi 10.1007/s12055-017-0598-7
3. Jouan J. Mitral valve repair over five decades. Ann Cardiothorac Surg 2015; 4:322-334.
4. Guiraudon GM, Ofiesh JG, Kaushik R. Extended vertical transatrial septal approach to the mitral valve. Ann Thorac Surg 1991; 52:1058-1062.
5. Pezzella AT, Utley JR, Vander Sam TJ. Operative approaches to the left atrium and mitral valve: an update. Operat. Techn Thorac Cardiovasc Surg 1998; 3:74-94.
6. Goldstone AB, Woo YJ. Alternative approaches for mitral valve repair. Ann Cardiothorac Surg 2015; 4:469-473.
7. Urso S, Sadaba JR. Invasiveness in cardiac surgery: a question of age. Interact Cardiovasc Thorac Surg 2013; 17:413-415.
8. Garcia-Villarreal OA. Superior septal approach for mitral valve surgery: Letter 2. Ann Thorac Surg 2007; 84:1073.

9. Berreklow E, Ercan H, Schönberger JP. Combined superior-transseptal approach to the left atrium. Ann Thorac Surg 1991; 51:293-295.
10. Kon ND, Tucker WY, Mills SA, Lavender SW, Cordell AR. Mitral valve operation via an extended transseptal approach. Ann Thorac Surg 1993; 55:1413-1417.
11. Smith CR. Efficacy and safety of the superior-septal approach to the mitral valve. Ann Thorac Surg1993; 55:1357-1358.
12. Kovács GS, Szabados S. Superior-septal approach to the mitral valve. Ann Thorac Surg 1994; 57:571-522.
13. Misawa Y, Tenpanku H. Sick sinus syndrome after superior septal approach for mitral valve surgery (letter). Japan J Thorac Cardiovasc Surg 2001; 49:542-543
14. Zhang Z, Kim H J, Lonjon G, Zhu, Y. Balance diagnostics after propensity score matching. Ann Transl Med 2019;7(1):16
15. Boulemdem A, Nadarajah D, Szafranek A, Richens D. Atrial approaches to the mitral valve: is there a difference in postoperative rhythm disturbance and permanent pacemaker implantation? Interact CardioVasc Thorac Surg 2018; 27:536-542.
16. Aydin E, Arslan A, Oskokeli M. Comparison of superior septal approach with left atriotomy in mitral valve surgery. Rev Bras Cardiovasc 2014;29(3):367-373.
17. Turkyilmaz S, Kavala A. Comparison of left atriotomy and superior transseptal approaches in mitral valve surgery. The Heart Surgery Forum (#2017-1997) 2018; 21(4): E318-E321.
18. Gaudino M, Alessandrini F, Glieca F, Martinelli L, Santarelli P, Bruno P, et al. Conventional left atrial versus superior septal approach for mitral valve replacement. Ann Thorac Surg 1997; 63:1123-1127.
19. Berdajs D, Patonay L, Turina M. The clinical anatomy of the sinus node artery. Ann Thorac Surg 2003; 76:732-735.
20. Nienaber J, Glower D. Minitransseptal versus left atrial approach to the mitral valve: a comparison of outcomes. Ann Thorac Surg 2006; 834-839.
21. Lukac P, Hjortdal V, Pedersen A, Mortensen P, Jensen H, Hansen P, Superior transseptal approach to mitral valve is associated with a higher need for pacemaker implantation than the left atrial approach. AnnThorac Surg 2007; 83:77-82.
22. Harky A, Kusu-Orkar TE, Chan JSK, Noshirwani A, Savarimuthu S, Pousios D, et al. Left Atrial or Transeptal Approach for Mitral Valve Surgery: A Systematic Review and Meta-analysis. Curr Probl Cardiol 2020;00:100602. https://doi.org/10.1016/j.cpcardiol.2020.100602

Tables:

Table 1. Propensity score matching (PSM) of both groups, for pre and intraoperative variables.

Pre-operative	**Comparisons before matching**				**Comparisons after matching 1:2**			
Variables	LA	TS	*p value*	SD	LA	TS	*p value*	SD
	n=107	n=103			n=96	n=69		
Sex (male)	65 (60,7)	67 (65)	*0,519*	0,09	59 (61,5)	41 (59,4)	*0,792*	-0,045
Age (years)	62 (53 - 72)	65 (54 - 72)	*0,851*	-0,016	64 (53 - 72)	64 (54 - 72)	*0,939*	0,001
LVEF (%)	41 (30 - 58)	50 (30 - 60)	*0,33*	0,119	42 (34 - 60)	50 (30 - 60)	*0,762*	0,01
PASP (mmHg)	38 (30 - 55)	50 (35 - 65)	***0,001***	0,421	40 (30 - 56)	43 (30 - 60)	*0,375*	0,027
Left atrial diameter (mm)	44 (39 - 50)	44 (39 - 48)	*0,946*	0,041	44 (39 - 50)	44 (38 - 48)	*0,962*	0,016
Creatinine (mg/dL)	1 (0,9 - 1)	1 (0,9 - 1)	*0,207*	-0,042	1 (0,9 - 1)	1 (1 - 1,1)	*0,169*	0,005
PreOP hematocrit (%) *	41,1 (3,5)	40,9 (4,3)	*0,706*	-0,056	40,9 (3,3)	41 (4,2)	*0,984*	0,042
Mitral stenosis			*0,632*				*0,83*	
Absent	92 (86)	89 (86,4)		-	83 (86,5)	60 (87)		-
Moderate	7 (6,5)	9 (8,7)		0,007	7 (7,3)	6 (8,7)		0
Severe	8 (7,5)	5 (4,9)		-0,121	6 (6,3)	3 (4,3)		-0,067
Mitral regurgitation			*0,608*				*1*	
Absent	2 (1,9)	4 (3,9)		-	2 (2,1)	2 (2,9)		-
Mild	8 (7,5)	11 (10,7)		0,103	8 (8,3)	6 (8,7)		0
Moderate	67 (62,6)	57 (55,3)		-0,146	60 (62,5)	42 (60,9)		0
Severe	30 (28)	31 (30,1)		0,045	26 (27,1)	19 (27,5)		0
Aortic valve disease			*0,89*				*0,924*	

Absent	63 (64,5)	61 (59,2)			61 (63,5)	41 (59,4)		
Stenosis	6 (5,6)	7 (6,8)		-	6 (6,3)	6 (8,7)		-
Insufficiency	23 (21,5)	25 (24,3)		0,064	21 (21,9)	16 (23,2)		0,034
Double injury	9 (8,4)	10 (9,7)		0,044	8 (8,3)	6 (8,7)		-0,049
Tricuspid valve disease > moderate	43 (40,2)	51 (49,5)	*0,174*	0,186	39 (40,6)	31 (44,9)	*0,581*	0,014
Coronary disease	55 (51,4)	51 (49,5)	*0,785*	-0,038	47 (49)	34 (49,3)	*0,968*	0,029
3 Vessel disease and left main trunk	19 (17,8)	28 (27,2)	*0,101*	0,211	19 (19,8)	16 (23,2)	*0,599*	0,032
Euroscore II risk (%)	3,5 (2,6 - 7,6)	4,3 (3,1 - 8,1)	*0,213*	-0,087	3,5 (2,6 - 7)	4,2 (3,2 - 7,7)	*0,133*	0,043
Diabetes mellitus	26 (24,3)	25 (24,3)	*0,996*	-0,001	23 (24)	16 (23,2)	*0,909*	0
Arterial hypertension	73 (68,2)	62 (60,2)	*0,225*	-0,163	66 (68,8)	46 (66,7)	*0,777*	-0,029
COPD	14 (13,1)	18 (17,5)	*0,376*	0,115	14 (14,6)	10 (14,5)	*0,987*	0
Stroke	5 (4,7)	7 (6,8)	*0,508*	0,084	5 (5,2)	5 (7,2)	*0,743*	0,057
CKD	13 (12,1)	11 (10,7)	*0,738*	-0,047	13 (13,5)	9 (13)	*0,926*	0,047
PAD	3 (2,8)	3 (2,9)	*1*	0,006	3 (3,1)	3 (4,3)	*0,695*	0,043
Beta-blockers	65 (60,7)	55 (53,4)	*0,282*	-0,147	57 (59,4)	38 (55,1)	*0,633*	-0,043
Statins	62 (57,9)	52 (50,5)	*0,278*	-0,148	54 (56,3)	37 (53,6)	*0,738*	-0,014
Mitral intervention			*0,189*				*0,683*	
Mitral valve repair	56 (52,3)	41 (39,8)		-	49 (51)	31 (44,9)		-
Biological prosthesis	44 (41,1)	54 (52,4)		0,225	41 (42,7)	32 (46,4)		0,014
Mechanical prosthesis	7 (6,5)	8 (7,8)		0,046	6 (6,3)	6 (8,7)		0,054

CABG	53 (49,5)	51 (49,5)	*0,998*	0	46 (47,9)	33 (47,8)	*0,991*	0,014
Aortic valve replacement	22 (20,6)	32 (31,1)	*0,082*	0,226	21 (21,9)	19 (27,5)	*0,403*	0,078
Tricuspid intervention	8 (7,5)	21 (20,4)	***0,007***	0,319	7 (7,3)	6 (8,7)	*0,741*	-0,036
Cardioplegia			*0,535*				*0,726*	
St Thomas Solution	32 (29,9)	25 (24,3)			29 (30,2)	15 (21,7)		
Del nido	25 (23,4)	22 (21,4)		-	22 (22,9)	15 (21,7)		-
HTK Solution	15 (14)	13 (12,6)		-	12 (12,5)	10 (14,5)		-
Sanguineous	22 (20,6)	32 (31,1)		-	21 (21,9)	20 (29)		-
Others	13 (12,1)	11 (10,7)		-	12 (12,5)	9 (13)		-

* Mean (standard deviation)

Data are presented as frequencies and percentages (%) or as medians and interquartile range (IQR), unless otherwise specified

PAD: peripheric arterial disease.

Standardized difference (SD): it is the difference in the means divided by the standard error; an excellent balance between groups was defined as an absolute value less than 0.1 and up to 0.25 (corresponding to a small effect size)

Table 2. Postoperative and post-discharge outcomes after propensity score matching.

Post-operative	LA	TS	*p value*
Variables after PSM	n=96	n=69	
Cross-clamp time (minutes)	108 (74 - 130)	109 (70 - 141)	*0,38*
CPB time (minutes)	128 (98 - 156)	142 (100 - 170)	*0,14*
ICU stay (days)	3 (1 - 6)	4 (2 - 10)	***0,002***
Atrial fibrillation	33 (34,4)	25 (36,2)	*0,805*
Atrial flutter	5 (5,2)	4 (5,8)	*1*
Nodal rhythm	10 (10,4)	18 (26,1)	***0,008***
AV Block	5 (5,2)	7 (10,1)	*0,228*
Sick sinus syndrome	1 (1)	0 (0)	*1*
Other SV arrhythmias	5 (5,2)	7 (10,1)	*0,228*
Antiarrhythmic medication	27 (28,1)	19 (27,5)	*0,934*
Electrical cardioversion	5 (5,2)	4 (5,8)	*1*
Device placement	7 (7,3)	7 (10,1)	*0,516*
Blood transfusion	54 (56,3)	48 (69,6)	*0,082*
Creatinine (mg/dL)	1,3 (1,1 - 1,6)	1,3 (1 - 1,6)	*0,543*
Oral anticoagulation	28 (29,2)	15 (21,7)	*0,284*
Perioperative mortality	4 (4,2)	7 (10,1)	*0,204*
Post-discharge			
SV arrhythmia	6 (6,2)	3 (4,3)	*0,595*
Device placement	5 (5,2)	3 (4,3)	*0,799*
Stroke	2 (2,1)	1 (1,4)	*1*
Valve Reintervention	3 (3,1)	4 (5,8)	*0,366*
Chronic oral anticoagulation	29 (30,2)	16 (23,2)	*0,318*
Overall Mortality	8 (8,3)	10 (14,5)	*0,211*

Data are presented as frequencies and percentages (%) or as medians and interquartile range (IQR), unless otherwise specified.

AV Block: advanced atrioventricular block.

Table 3. Postoperative and post-discharge outcomes between the years 2006 and 2011.

Outcomes 2006-2011	LA	TS	*p value*
Variables after PSM	n=60	n=53	
Euroscore II risk (%)	3,5 (3,5 - 8)	4,7 (3,5 - 8,5)	*0,235*
Cross-clamp time (minutes)	106 (61 - 134)	100 (69 - 140)	*0,739*
CPB time (minutes)	123 (93 - 160)	135 (96 - 160)	*0,372*
ICU stay (days)	3 (1 - 6)	4 (2 - 10)	***0,04***
Atrial fibrillation	19 (31,7)	19 (35,8)	*0,639*
Atrial flutter	2 (3,3)	2 (3,8)	*1*
Nodal rhythm	6 (10)	14 (26,4)	***0,023***
AV Block	1 (1,7)	4 (7,5)	*0,185*
Sick sinus syndrome	0 (0)	0 (0)	-
Other SV arrhythmias	0 (0)	4 (7,5)	***0,045***
Antiarrhythmic medication	17 (28,3)	14 (26,4)	*0,82*
Electrical cardioversion	2 (3,3)	4 (7,5)	*0,417*
Device placement	2 (3,3)	5 (9,4)	*0,25*
Blood transfusion	36 (60)	39 (73,6)	*0,127*
Creatinine (mg/dL)	1,3 (1,1 - 1,6)	1,3 (1 - 1,6)	*0,666*
Oral anticoagulation	15 (25)	9 (17)	*0,298*
Perioperative mortality	4 (6,7)	6 (11,3)	*0,511*
Post-discharge			
SV arrhythmia	1 (1,7)	3 (5,7)	*0,466*
Device placement	1 (1,7)	3 (5,7)	*0,466*
Stroke	2 (3,3)	1 (1,9)	*1*
Valve Reintervention	3 (5)	4 (7,5)	*0,597*
Chronic oral anticoagulation	15 (25)	10 (18,9)	*0,433*
Overall Mortality	6 (10)	9 (17)	*0,275*

Data are presented as frequencies and percentages (%) or as medians and interquartile range (IQR), unless otherwise specified.

AV Block: advanced atrioventricular block.

Table 4. Postoperative and post-discharge outcomes between the years 2012 and 2016.

Outcomes 2012 - 2016	LA	TS	*p value*
Variables after PSM	n=36	n=16	
Euroscore II risk (%)	2,9 (2,2 - 5,1)	3 (2 - 4,4)	*0,874*
Cross-clamp time (minutes)	110 (87 - 130)	133 (105 - 149)	***0,024***
CPB time (minutes)	130 (108 - 154)	155 (129 - 172)	***0,049***
ICU stay (days)	3 (1 - 6)	7 (4 - 13)	***0,007***
Atrial fibrillation	14 (38,9)	6 (37,5)	*0,924*
Atrial flutter	3 (8,3)	2 (12,5)	*0,637*
Nodal rhythm	4 (11,1)	4 (25)	*0,231*
AV Block	4 (11,1)	3 (18,8)	*0,662*
Sick sinus syndrome	1 (2,8)	0 (0)	*1*
Other SV arrhythmias	5 (13,9)	3 (18,8)	*0,689*
Antiarrhythmic medication	10 (27,8)	5 (31,3)	*1*
Electrical cardioversion	3 (8,3)	0 (0)	*0,544*
Device placement	5 (13,9)	7 (10,1)	*1*
Blood transfusion	18 (50)	9 (56,3)	*0,677*
Creatinine (mg/dL)	1,3 (1,2 - 1,6)	1,3 (1,1 - 1,6)	*0,959*
Oral anticoagulation	13 (36,1)	6 (37,5)	*0,924*
Perioperative mortality	0 (0)	1 (6,3)	*0,308*
Post-discharge			
SV arrhythmia	5 (13,9)	0 (0)	*0,308*
Device placement	4 (11,1)	0 (0)	*0,299*
Stroke	0 (0)	0 (0)	-
Valve Reintervention	0 (0)	0 (0)	-
Chronic oral anticoagulation	14 (38,9)	6 (37,5)	*0,924*
Overall Mortality	2 (5,6)	1 (6,3)	*1*

Data are presented as frequencies and percentages (%) or as medians and interquartile range (IQR), unless otherwise specified.

AV Block: advanced atrioventricular block.

Figures

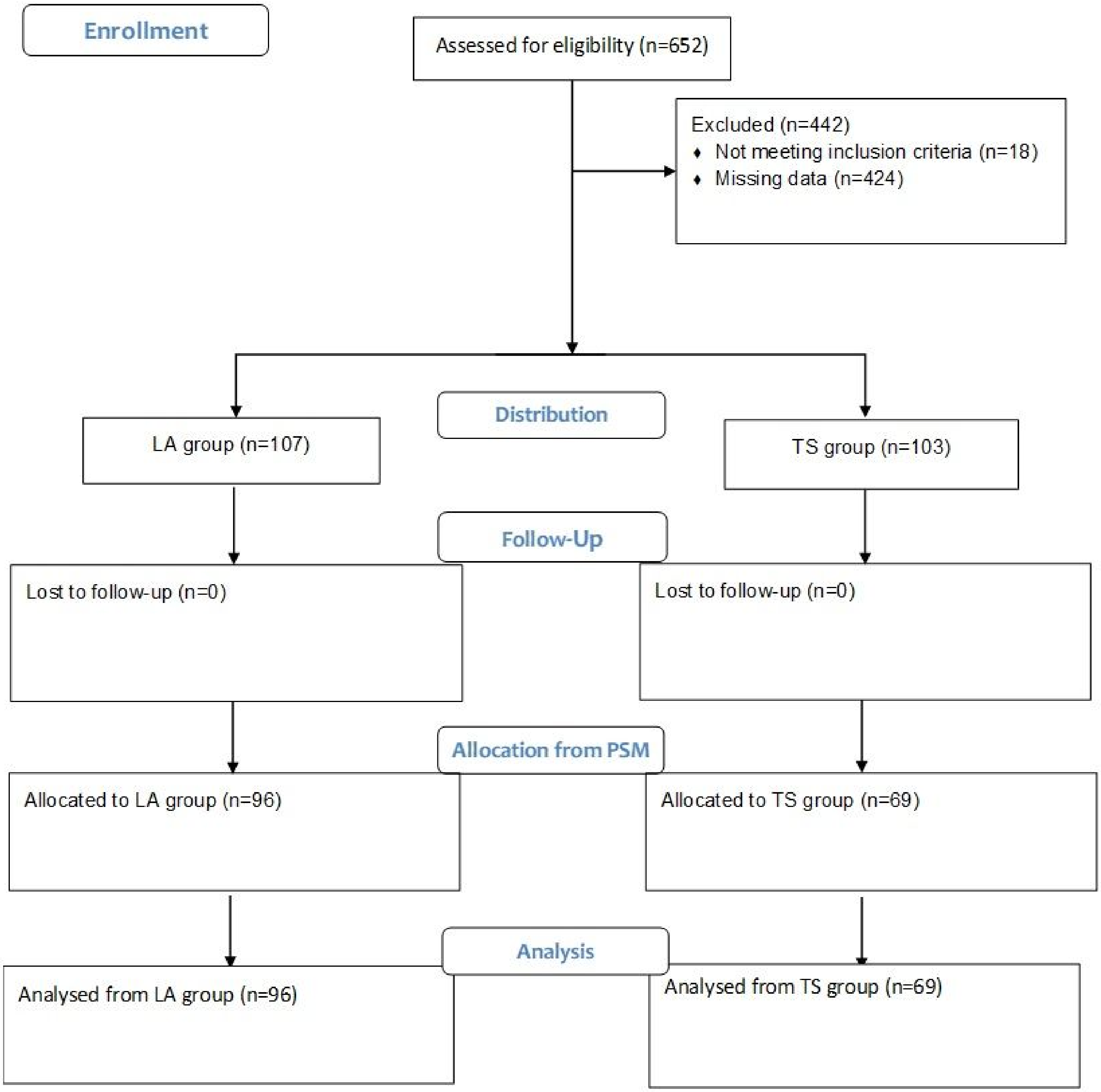


Figure 1

Consort 2010 flow diagram.

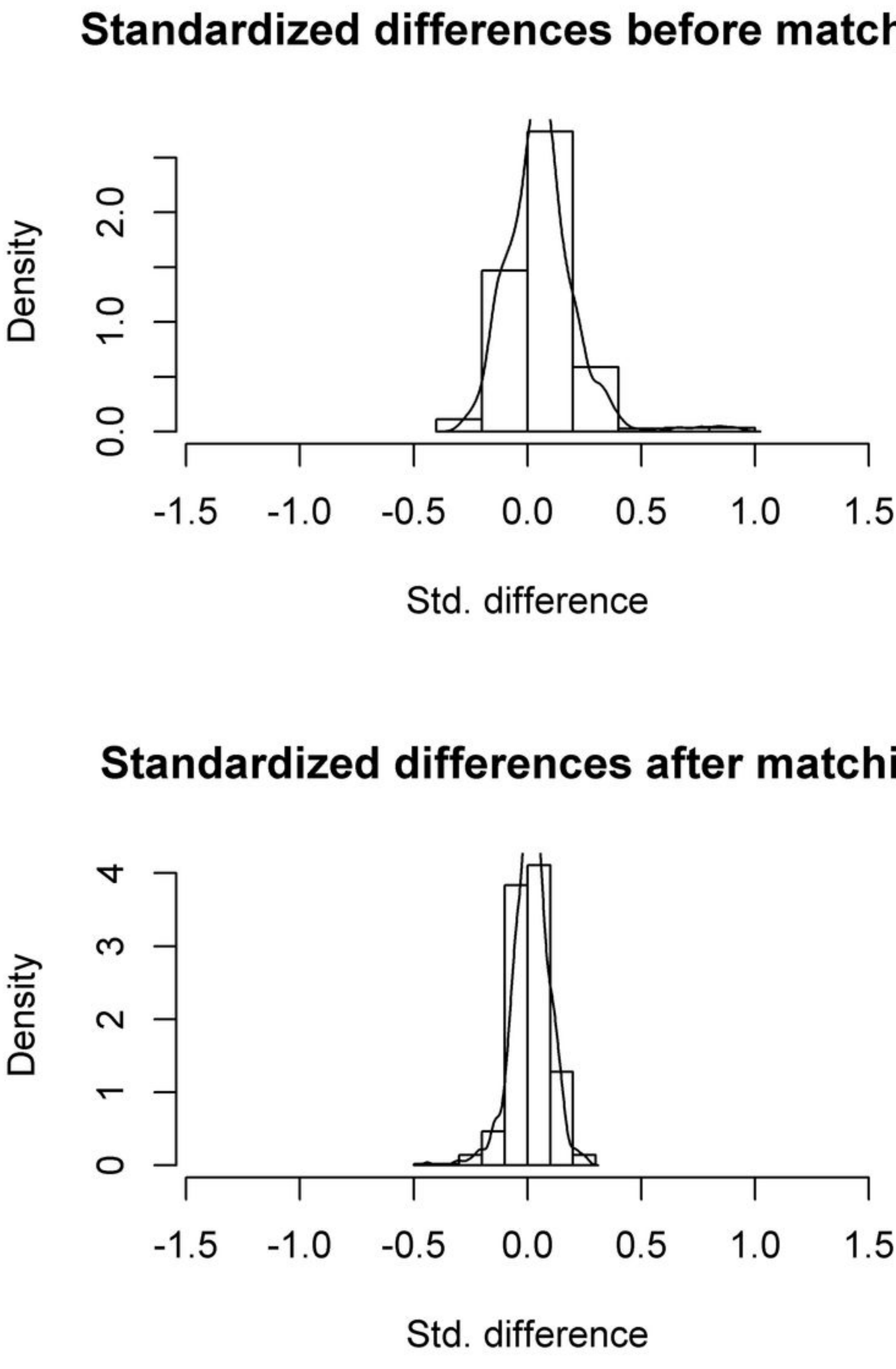
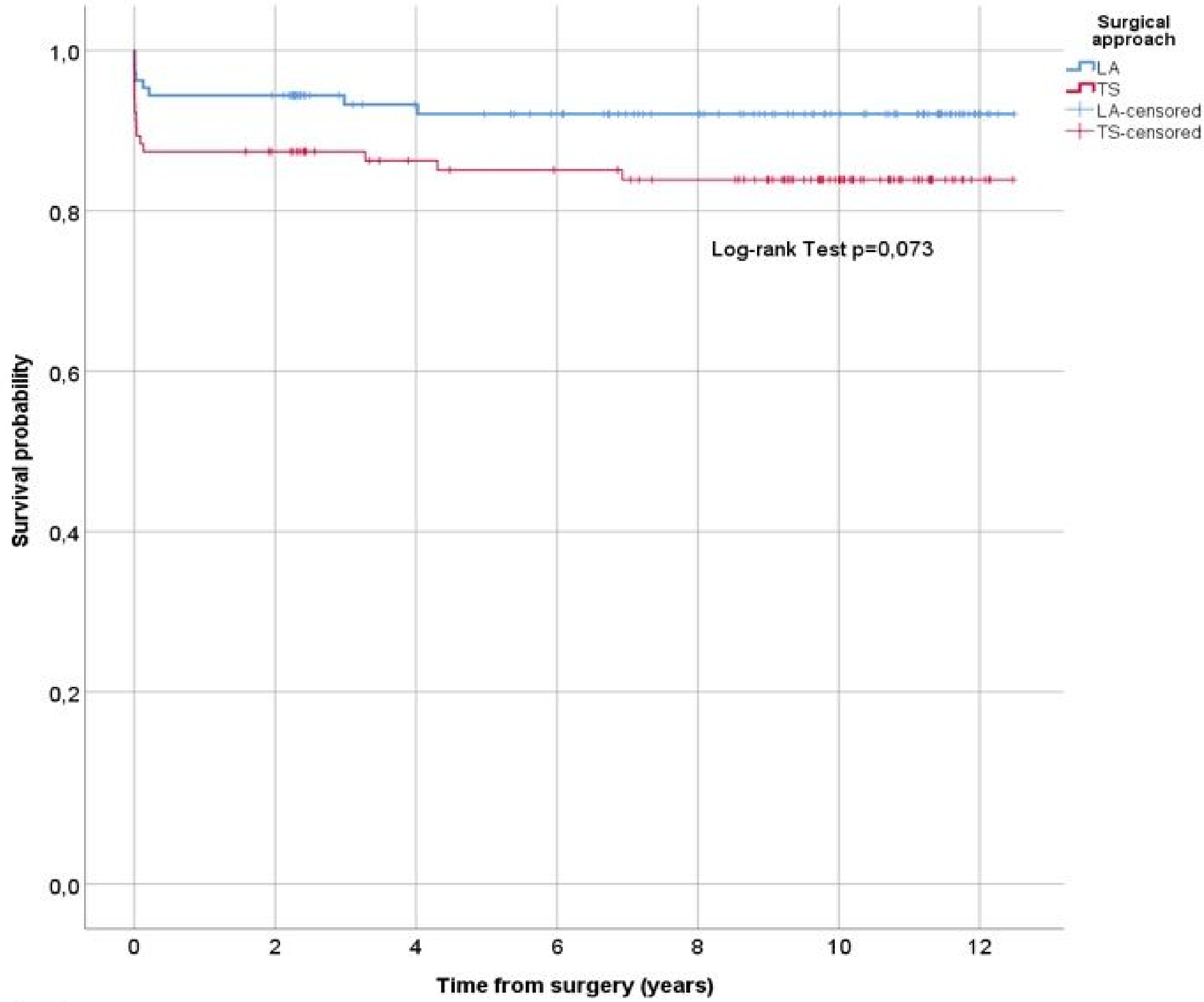


Figure 2

Standardized differences of the preoperative and perioperative variables before and after pairing by propensity scores.



Number at risk

LA	107	101	100	99	99	99	99
TS	103	90	89	88	87	87	87

Figure 3

Kaplan-Meier curves of survival.