Minimally invasive mitral valve reconstruction: is it an "all-comers" procedure?

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Abstract

Background and aim of the study - The debate on the usefulness of the minimally invasive approach in mitral valve surgery is still open. The aim of this study is to describe a single-center case series of all comers undergoing minimally invasive mitral valve reconstruction. Methods - From 2010 to 2019, all the data recorded in the medical records of 893 consecutive patients undergoing mitral valve reconstruction through a right mini-thoracotomy were retrospectively collected. All patients were contacted by telephone for remote evaluation and integration of echocardiographic information on surgical results. Results - Mean age was 62.2±14.5; 447 (50%) were female and mean log EuroSCORE was 2.5±2.8%. At a mean follow-up of 4.1 ± 2.2 years (median 3.9), a total of 24 deaths (2.68%) were recorded. Twenty-four patients required rehospitalization for cardiac causes, 13 (1.4%) patients had at least moderate mitral insufficiency on follow-up echocardiography and, of these, 7 patients underwent reoperation (0.8%). The cumulative hazard showed that 8.3% of patients experienced at least one event at 5 years. NYHA class improved significantly with 874 patients in NYHA class I, 13 in NYHA class II, 6 in NYHA class III, and 0 in NYHA class IV at last follow-up (p <0.001 from baseline as reference point). Conclusions – In a high-volume center, mitral valve surgery using a minimally invasive approach is a feasible treatment option for all-comers and is associated with excellent results that are maintained at clinical and echocardiographic follow-up.

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Running Title: *Minimally invasive mitral valve surgery*

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Conclusions – In a high-volume center, mitral valve surgery using a minimally invasive approach is a feasible treatment option for all-comers and is associated with excellent results that are maintained at clinical and echocardiographic follow-up.

Introduction

Minimally invasive mitral valve surgery is a valid and well-established alternative to a conventional approach (1). In case series comparing minithoracotomy to conventional sternotomy, better results were achieved in patients treated with a minimally invasive approach in terms of a faster and complication-free postoperative course (2,3). Notwithstanding this, several doubts remain about its feasibility, learning curve and outcomes (4). This is because the duration of the procedure, especially in the learning phase, would be longer than that obtained using a sternotomy approach. Other authors argue, however, that the minimally invasive approach allows, paradoxically, a better visualization of the mitral valve, resulting in "simpler" repairability of the valve itself (5).

Furthermore, some authors suppose that the advantage for patients undergoing a minimally invasive approach would be only of an esthetic nature, therefore the procedure should be favored only in young and anatomically suitable patients (6). Conversely, for other authors, precisely in patients most at risk, the minimally invasive approach, reducing surgical trauma, can achieve a better postoperative outcome (5).

In summary, the debate on the usefulness of the minimally invasive approach in mitral surgery and in which patients it should be performed is still open. The purpose of our study is to show an extensive single-center case series of minimally invasive reconstructions of the mitral valve which, by institutional policy, are performed in all patients who come with an indication for isolated mitral valve surgery.

Materials and Methods

From December 2010 to December 2019, all the data recorded in the computerized medical records of patients undergoing mitral valve reconstruction in a single cardiac surgery center were retrospectively collected. All of these consecutive patients (n=893) were contacted by telephone, directly or through contact with their referring cardiologist for a remote clinical evaluation and integration of remote echocardiographic information on the result of mitral surgery. The GVM Care&Research ethics board approved the study (jan 2020) and, due to the nature of the study, a written informed consent for the procedure and study enrollment was waived.

Surgical technique

All surgeries were performed under general anesthesia, oro-tracheal intubation with simple tube or double-lumen tube for the selective exclusion of the right lung. The surgical incision was for all through a cut in the third intercostal space, right anterior mini-thoracotomy (Figure 1). A soft tissue retractor and a rib retractor were used in all patients. A surgical mini-exposure of the femoral artery and vein was performed in all patients, with cannulation of the same and retrograde perfusion through the femoral vessels and combined venous drainage (femoral vein + jugular vein with percutaneous cannulation). Venous drainage was also supported by the use of vacuum. The puncture, the advancement of the Seldinger guide and the cannulae were always performed under trans-esophageal echo guidance. All patients underwent trans-esophageal control for cannulation, control of the mitral reconstruction, control of the cardiac contractile function and the cardiac chamber filling, especially during the infusion of cardioplegic solution and weaning from extracorporeal circulation. In all patients, CO_2 was insufflated during the entire surgical phase with open heart cavities. The aortic clamping was external with Cygnet clamp and cardioplegic infusion via antegrade at regular intervals as normothermic blood cardioplegia.

The mitral repair technique has already been described for complex valve reconstructions (7). In summary, in case of posterior flap prolapse (with or without flail), the head of P2 is relocated to the base of P1, with a resection and sliding at the base of P2 (7). At the end of the procedure, a ring for the stabilization of the reconstruction was carried out in all cases using a complete Memo 3D ring (Livanova PRT, London UK) (Figure 2).

The telephone interview was performed by cardiologists or cardiac surgeons in order to better identify and understand the possible complications, the physical status (NYHA class) and read directly or electronically the echocardiographic checks and clinical documents (e.g. hospital discharge letters) showed by the patients.

Results

The characteristics of the patients are presented in Table 1. The average age of patients is highly variable with a minimum value of 12 years and a maximum of 86 years.

From the immediate postoperative period to the entire follow-up, which had a mean duration of 4.1 $\pm$ 2.2 years (median 3.9), a total of 24 deaths (2.68%) were recorded (see Kaplan-Meier curve, Figure 3).

Furthermore, 24 patients required rehospitalization for cardiac causes, 13 (1.4%) patients at follow-up echocardiography had at least moderate mitral insufficiency and, of these, 7 patients underwent reoperation (0.8%). The cumulative hazard showed that 8.3% of patients experienced at least one event at 5 years (Figure n6

At a mean follow-up of 4.1 years, there was no difference in survival between men and women. At 6 and 8 years, survival rates were 90% vs 91% and 89% vs 91% in female vs male patients, respectively ($p = 0.71$) (Figure 5). NYHA class improved significantly during follow-up, with 874 patients in NYHA class I, 13 in NYHA class II, 6 in NYHA class III, and 0 in NYHA class IV at last follow-up ($p < 0.001$ from baseline as reference point) (Figure 6). No significant differences in deaths from cardiac and non-cardiac causes were recorded at follow-up ($p = 0.9$) (Figure 7).

Discussion

Mitral valve surgery represents an important frontier for cardiovascular medicine that needs a surgical approach since trans-catheter implantation valve models are still in their "start" and the results with the "clip" procedures have recorded contrasting results (8). Despite a simple design, our study aims to demonstrate that, in our cardiac surgery center, a policy focused on the use of a minimally invasive approach in all comers is effective in providing satisfactory clinical and echocardiographic results, even at long-term follow-up.

Our results are consistent with recent data from the United States: successful surgical mitral valve repair is necessarily associated with the volume of interventions that can be performed annually in a cardiac surgery center (9).

Routinely practicing a minimally invasive mitral valve procedure allows speeding up technical preparation times for the patient, as well as cardiac ischemia time, making the procedure as a whole "less invasive". This aspect has an impact on the patient's postoperative outcome due to reduced surgical times (10). We previously showed in complex valve reconstructions that surgical time, with a rapid learning curve, could be reduced to less than 1 hour of aortic clamping (7). Obviously, this advantage in terms of lower surgical time was made possible by the simplification of the surgical technique which, despite its simplicity of application, also proved to be effective in maintaining good valve continence at follow-up (7).

However, minimally invasive surgery of the mitral valve was not shown to be superior a superiority to complete sternotomy (6)., This could also be due to patient selection. In selected populations of low-risk patients, except an outcome improvement with the minimally invasive approach was limited the esthetic result or a shorter hospital stay. It is our belief, however, that in more "frail" and higher risk patients, avoid opening the sternum and performing a "complete" minimally invasive approach that also includes "minimally invasive" anesthesia and "minimally invasive" extracorporeal circulation can be an important advantage.

In our study, only age affected long-term mortality, which is physiological in a study population that included elderly patients (Figure 8). However, the most relevant data consisted in the better quality of life of these patients, as demonstrated by a significant improvement in NYHA class which was maintained at follow-up (Figure 6).

One of the limitations of our study is that we were unable to demonstrate the reproducibility of the procedure being a "single surgeon" case series, but our study is in line with what has recently been reported as a vision for the future by Dreyfus and Windecker: the results are good only if the procedure is done in a center with highly specialized surgeons on a specific procedure (11). Perhaps in a speculative sense, it would be necessary to think of "heart" facilities that focus more on the type of pathologies treated rather than the treated apparatus: a center with highly trained specialists, for example, to which all patients with heart valve disease can refer to (11).

In conclusion, our study wants to be an example for this type of specialization path. In a center with high qualitative and quantitative capabilities, minimally invasive mitral valve surgery can be performed in all patients with surgical indication, with excellent clinical and valve continence results that are maintained at follow-up.

Author contributions

Giuseppe Speziale: Concept/design

Giuseppe Santarpino: Drafting article

Marco Moscarelli: Data analysis/interpretation

Nicola Di Bari: Data collection

Flavio Fiore: Approval of article

Ignazio Condello: Data collection

Francesco Bartolomucci: Approval of article

Maria Consiglia Bellino: Data collection

Giuseppe Nasso: Critical revision of article

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Table 1. Baseline characteristics

Patients, n		893
Age (years), mean±SD		62.2±14.5
Female sex, n (%)		447 (50)
Log EuroSCORE (%), mean±SD	Log EuroSCORE (%), mean±SD	2.5±2.8)
Hypercholesterolemia, n (%)	Hypercholesterolemia, n (%)	163 (18.2)
Hypertension, n (%)	Hypertension, n (%)	128 (14.3)
COPD, n (%)		11 (1.2)
Coronary artery disease, n (%)	Coronary artery disease, n (%)	30 (3.3)
LVEF (%), mean±SD		54.4±11.1

Patients, n	893
NYHA class, mean±SD	2.6±1.3

COPD: chronic obstructive pulmonary disease; LVEF: left ventricular ejection fraction; NYHA: New York Heart Association; SD: standard deviation.

Figure legends

Figure 1. Surgical setting.

Figure 2. Implanted Memo 3D ring.

Figure 3. Kaplan-Meier survival curve.

Figure 4. Cumulative hazard curve.

Figure 5. Gender-based pooled analysis.

Figure 6. NYHA class, preoperative vs follow-up.

Figure 7. Regression coefficient analysis.

Figure 8. Competing risk analysis.

Figure 1.

Figure 2.

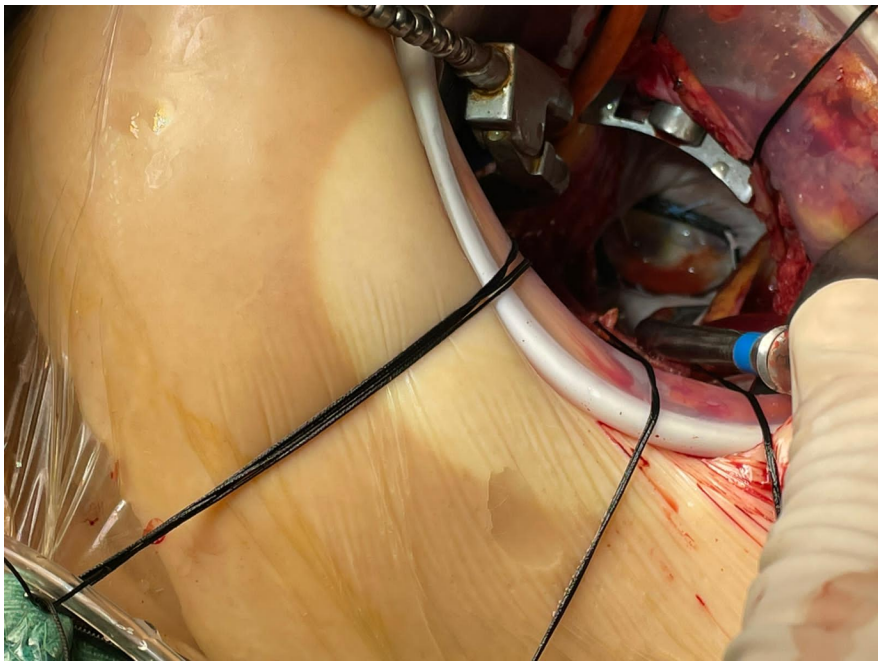


Figure 3.

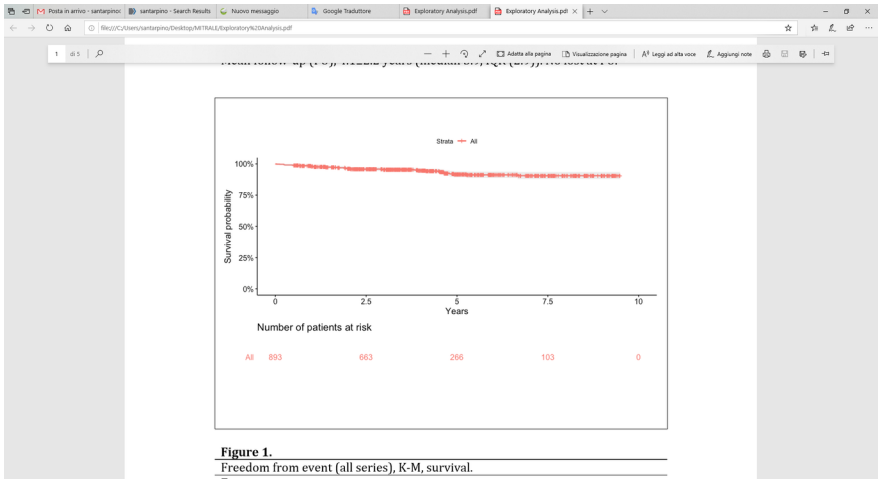
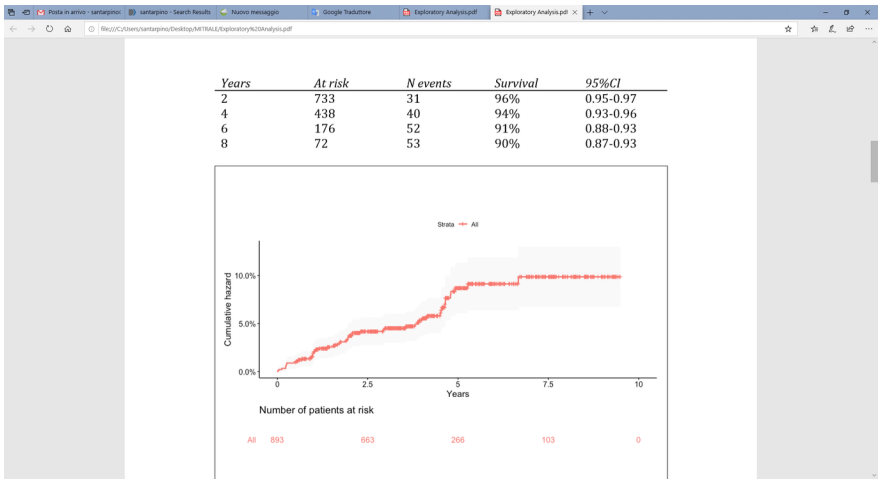


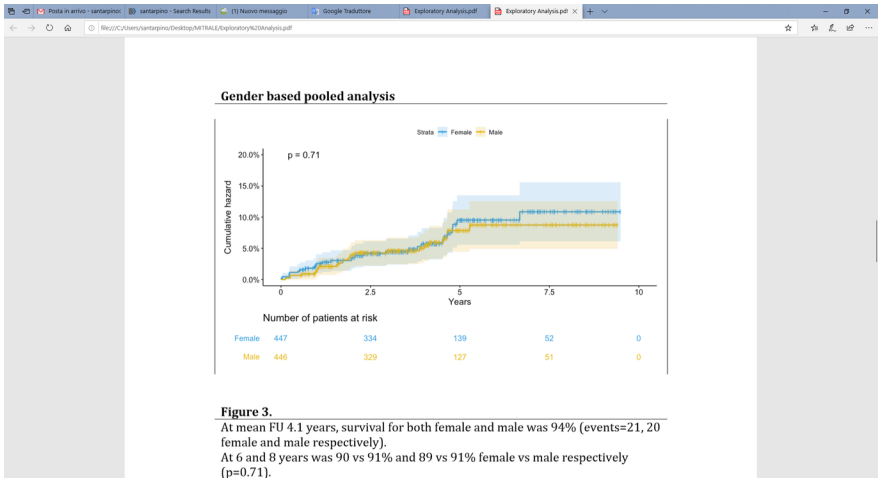
Figure 1.
Freedom from event (all series), K-M, survival.

Figure 4.



Years	*At risk*	*N events*	*Survival*	*95%CI*
2	733	31	96%	0.95-0.97
4	438	40	94%	0.93-0.96
6	176	52	91%	0.88-0.93
8	72	53	90%	0.87-0.93

Figure 5.



Gender based pooled analysis

Figure 3.
At mean FU 4.1 years, survival for both female and male was 94% (events=21, 20 female and male respectively).
At 6 and 8 years was 90 vs 91% and 89 vs 91% female vs male respectively (p=0.71).

Figure 6.

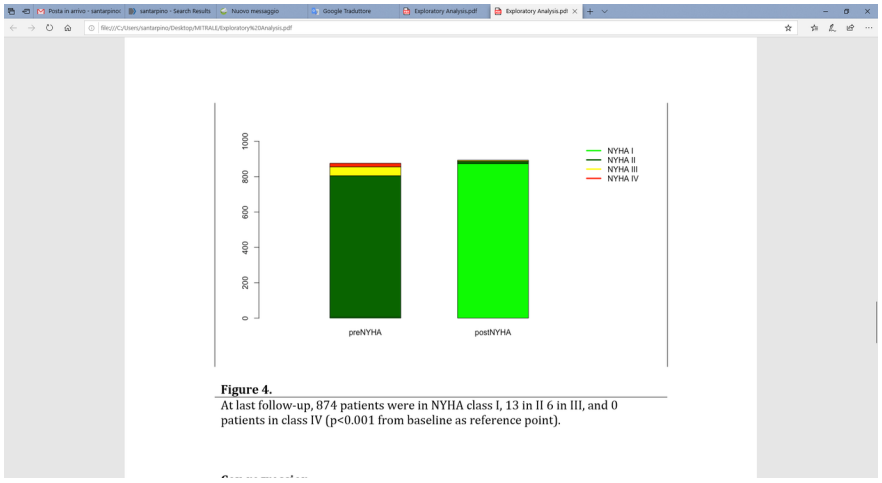


Figure 4.
At last follow-up, 874 patients were in NYHA class I, 13 in II 6 in III, and 0 patients in class IV (p<0.001 from baseline as reference point).

Figure 7.

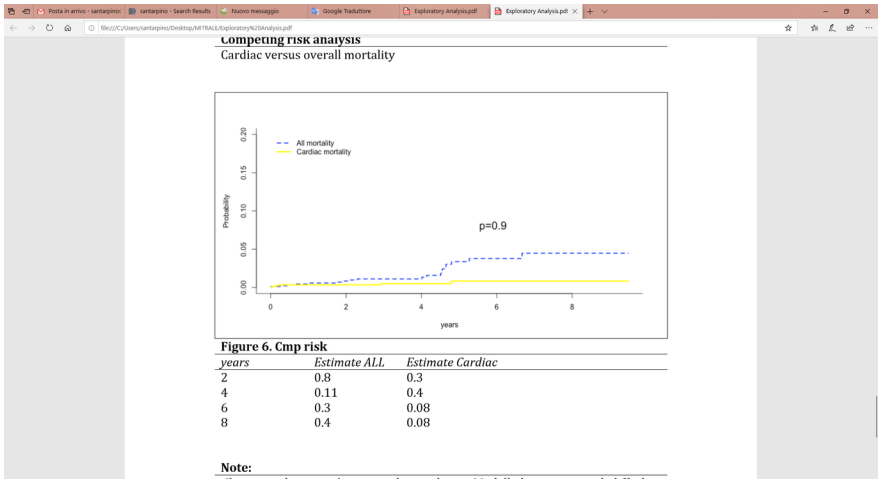
Cox-regression

Proportional test (distribution of age among sex)

Age	p=0.82
Sex	p=1

Figure 5. Regression coefficient

	coef	p
Age	0.05	<0.01
Sex	0.08	0.76



Competing risk analysis

Cardiac versus overall mortality

Figure 6. Cmp risk

years	*Estimate All.*	*Estimate Cardiac*
2	0.8	0.3
4	0.11	0.4
6	0.3	0.08
8	0.4	0.08

Note:

Figure 8.