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LETTER TO THE EDITOR
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Transcatheter mitral valve repair in nonagenarians

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Given the increase in life expectancy in developed countries, nonagenarian population will become clinically and numerically relevant in our daily routine practice in the near future. Age has been observed to exert a profound influence on the prevalence of severe mitral regurgitation (MR) in the population.[1] Mitral valve surgery remains the gold standard of care for patients with symptomatic severe MR. Nevertheless, older adults are often deemed to be a high-risk group for surgery, especially in the presence of comorbidities and frailty.[2] Over the past decade, transcatheter mitral valve repair (TMVR) with edge-to-edge device has been established as a minimally invasive alternative in individuals with clinically relevant MR who are considered not candidates to mitral valve surgery.[3,4] This technique has improved the prognosis of untreated patients with severe MR in whom mortality rates could reach 50%.[5] However, data of TMVR in some specific segments of the population such as nonagenarians is scarce and limited to case reports or small series of patients. Considering the increasing prevalence of nonagenarians, there is an unmet need of "real life" data to assess the impact of TMVR on this high-risk population. The aim of our study is to evaluate to efficacy and safety of TMVR in patients aged 90 years and older.

This multi-centre observational study included all consecutive patients aged ≥ 90 years who underwent TMVR with "edge-to-edge" systems at eleven institutions between 2017 and January 2021. The indication for TMVR was agreed upon by Heart Team at each centre. Prospectively collected data from each institution were transferred to a dedicated database. The study was approved by the Ethics Committee of each centre and adhered to the principles outlined in the Declaration of Helsinki. All procedures were performed in a cardiac catheterization laboratory, and patients were under general anesthesia using transesophageal echocardiogram and fluoroscopic guidance. Preprocedural transthoracic

and transesophageal echocardiography were performed in all patients for semiquantitative MR analysis and to assess morphologic suitability for edge-to-edge device implantation. Demographics, baseline, and procedural characteristics as well as clinical and echocardiographic outcomes at follow-up were collected. Procedural and clinical adverse events during follow-up were defined according to the Mitral Valve Academic Research Consortium.[6] Technical success was defined as correct implantation of at least one clip and the absence of procedural mortality or emergent cardiovascular intervention related to the device or the access site. The primary efficacy endpoint was successful implantation, and the primary safety endpoint was procedure-related serious adverse events. Secondary outcomes included heart failure rehospitalization, change in New York Heart Association functional (NYHA) class, MR reduction and all-cause mortality during the follow-up. Clinical follow-up was carried out by patient visit and phone contact. Categorical variables are presented as frequencies (percentages), and Friedman's test was used to compare paired nominal data. Continuous variables are presented as a mean ± SD or as a median (interquartile range). The Kolmogorov-Smirnov test was applied to ensure normal distribution. Follow-up was considered to terminate at the date of the last follow-up. Analyses were performed using STATA software (V 14.0, StataCorp LP, College Station, TX).

Among a total of 1 035 patients, 16 patients (1.5%) aged ≥ 90 years underwent TMVR with edge-to-edge systems between 2017 and January 2021. Median age was 90 years (range between 90 and 94) and men were predominant (72%). The main baseline, heart failure and echocardiographic characteristics are presented in Table 1. Preoperative risk was high (median EUROSCORE II = 5.05, interquartile range (IQR) = 3.63–6.97) with a moderate burden of comorbidities (Charlson Comorbidity Index = 6.67 ± 1.35). All patients presented severe MR with a high impact in quality of life according to the baseline NYHA class (all patients in NYHA class ≥ III) and hospitalizations for heart failure in the previous year (median = 1, IQR = 1–3). Technical success was obtained in 100% of cases with a median of one clip per case (IQR = 1–1.5). Procedural and clinical events are shown in Table 1. Two patients presented a procedure-related serious adverse event: a vascular complication related to femoral access without need for surgery and an in-hospital death because of acute kidney injury. The median length of stay after the procedure was 4 (3–5) days. Successful implantation of the clip with at least one grade reduction in MR severity at discharge was achieved in all patients (Figure 1A). At the maximum follow-up (median follow up = 389.5 days, IQR = 114.5–533), NYHA class showed significant improvement, with most of patients being in class II (75%) (Figure 1B). The number of hospitalizations was also reduced compared to the pre-procedure period (median = 0, IQR = 0–1). Four patients died during the follow-up, two of them by worsening of heart failure.

Population ageing is a growing and global phenomenon. The world is experiencing a sustained and unprecedented shift in its population pyramid, driven by increasing life expectancy. As life expectancy increases, the population of nonagenarians (≥ 90 years) is growing exponentially. Hence, the nonagenarian population will soon become clinically and numerically relevant in daily practice. In recent years, TMVR became an alternative to mitral surgery in patients with severe MR that, due to a high-risk profile, were denied for surgery.[7] This fact has allowed widening the spectrum of patients who are referred to mitral repair and were not considered in the past such as nonagenarians. Our report describes the outcomes of 16 nonagenarian patients undergoing TMVR for symptomatic severe MR. Despite their high-risk profile and advanced stage of the disease (94% in NYHA class ≥ III), TMVR showed as an effective and safe procedure in this population. Mitral regurgitation was reduced in all cases and the incidence of complications was low. In fact, Christidi, *et al*.[8] reported no difference in major complications in between nonagenarians and younger groups in a single center cohort. Our multi-centre study confirms the low rate of procedural MAEs in this high-risk population. In addition, follow-up data showed the benefit of the procedure at long-term, reducing the symptoms and the number of hospitalizations for heart failure. The concept to "add life to years" rather than "add years to life", is a remarkable aspect in the elderly setting and is particularly appropriate in minimally invasive interventions such as "edge-to-edge" TMVR. Simil-

Table 1 Baseline clinical and procedural characteristics.

Characteristics	All patients (*n* = 16)
Demographics	
Age, yrs	90 (90–94)
Women	6 (38%)
Medical history	
Mean creatinine clearance, mL/min	51.24 ± 10.43
Previous atrial fibrillation	10 (63%)
EUROSCORE II	5.05 (3.63–6.97)
Frailty characteristics	
Barthel score	90 (90–95)
Charlson comorbidity index	6.67 ± 1.35
Heart failure and echocardiography characteristic	
NYHA class	
I	0
II	1 (6%)
III	9 (56%)
IV	6 (38%)
Number of hospitalizations for heart failure in the last year	1 (1–3)
NT proBNP type natriuretic peptide level	5893 ± 4051
Severity of mitral regurgitation	
Moderate-to-severe, grade 3+	0
Severe, grade 4+	16 (100%)
Left ventricular ejection fraction	55.5 (39.5–63)
Procedural characteristics	
Technical success rate	16 (100%)
Patients with procedure- or device-related SAEs	2 (12%)
Vascular complication	1 (6%)
Atrial septum lesion	0
Cardiogenic shock resulting in intravenous inotropic support	0
Cardiac embolism	0
Cardiac tamponade	0
Urgent conversion to hear surgery	0
In-hospital death	1 (6%)
Admission days related to procedure	4 (3–5)
Severity of mitral regurgitation prior hospital discharge	
Mild, grade 1+	8 (54%)
Moderate, grade 2+	5 (34%)
Moderate-to-severe, grade 3+	2 (12%)
Severe, grade 4+	0
Clinical events (median follow-up = 389.5 days, IQR =144.5–533)	
All-cause death	4 (25%)
Number of heart failure rehospitalization	0 (0–1)
NYHA class	

Continued

Characteristics	All patients (n = 16)
I	0
II	9 (75%)
III	3 (25%)
IV	0

Values are n (%), mean ± SD or median (IQR). IQR: interquartile range; NYHA: New York Heart Association; SAEs: serious adverse events.

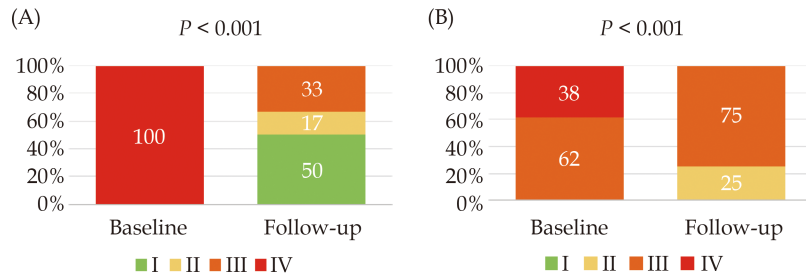

Figure 1 MR reduction and NYHA functional class improvement from baseline to maximum follow-up. (A): MR reduction; (B): NYHA functional class improvement. MR: mitral regurgitation.

arly, Buzzatti *et al*. reported similar results in patients ≥ 80 years-old undergoing TMVR with the MitraClip™ device,[9] achieving this benefit with a low acute impact in terms of procedural risk and postoperative complications, despite the high-risk profile. To achieve these results and avoid futility, a careful patient selection is mandatory, including special considerations as patient's expected quality of life and patient preference, with regards to comorbidities and general condition.[10] The final goal is palliation of heart failure symptoms and improvement in quality of life, something that TMVR might reach in this population.

We acknowledge several major limitations: First, the sample size was small and, due to absent of a control group, our results should be interpreted with caution. However, our aim was to show the effectiveness and safety in this high-risk population. Second, the procedures were performed at very experienced centers, with a careful patient selection by an experienced Heart Team which might have an impact in the positive outcomes of our cohort.

In selected nonagenarian patients with severe MR, TMVR is a feasible and safe option with a clinical benefit to long-term follow-up.

CONFLICT OF INTERESTS

Dr. Nombela-Franco has served as a proctor for Abbott; and has received speaker fee from Edwards Lifesciences Inc and Boston Scientific. Dr. Freixa has served as a proctor for Abbott. Dr. Estevez-Loureiro speaker fees from Abbott, Boston Edwards Lifesciences and P&F. Dr. Melica has served as a proctor for Abbott.

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