SHORT COMMUNICATION

Patient-prosthesis mismatch after minimally invasive aortic valve replacement

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INTRODUCTION

Compared to conventional aortic valve replacement (con-AVR, sternotomy), minimally invasive aortic valve replacement (mini-AVR) is associated with lower morbidity and mortality in high-risk patients. However, mini-AVR is technically challenging and more demanding. Limited access to the heart and a smaller operative field may lead to incorrect prosthesis size selection with greater risk of postoperative patient-prosthesis mismatch (PPM).

Patient-prosthesis mismatch occurs when the indexed effective orifice area (EOAi) of the implanted valve prosthesis is too small compared to the patient's body surface area (BSA). PPM is a strong and independent predictor of cardiac events, left ventricular overload, and mortality [1, 2]. To date, the literature on PPM after mini-AVR is very limited.

The aim of our study was to analyse the prevalence of PPM after mini-AVR and the effect of PPM on post-operative transvalvular gradient.

METHODS

A total of 150 patients were enrolled in the study; 74 patients who underwent mini-AVR and 76 patients who underwent con-AVR. In each group all procedures were performed by a group of four experienced surgeons who decided which method to use as well as which prosthesis type and size. Patients were similar in terms of age, body mass index, sex, and comorbidities.

The EOAi was calculated by dividing the corresponding EOA of each valve type and size (registered in vitro values published by each manufacturer) by each patient's BSA. BSA was calculated using methods described in a similar study [3]. PPM was defined as not clinically significant if the projected EOAi was > 0.85, moderate if it was > 0.65 and ≤ 0.85, and severe if it was ≤ 0.65 cm²/m² [4].

RESULTS

Patients-prosthesis mismatch

Mean EOAi of all AVR patients was 0.97 cm²/m², with PPM present in 31% (n = 46). Mean EOAi in the PPM group was 0.73 ± 0.8 cm²/m² versus 1.07 ± 0.15 cm²/m² in the group without PPM (p < 0.001). Severe PPM (EOAi ≤ 0.65 cm²/m²) was present in 3.3% (n = 5), and moderate PPM (0.65 cm²/m² $<$ EOAi ≤ 0.85 cm²/m²) was present in 27.3% of all AVR patients.

In mini-AVR, the incidence of PPM was 39%, with mean EOAi 0.91 ± 0.16 cm²/m² and was higher compared to con-AVR, where the incidence of PPM was 22%, with mean EOAi 1.02 ± 0.23 cm²/m² (p = 0.04 for PPM and p = 0.003 for EOAi).

Postoperative transprosthetic gradient

In all AVR patients, there was a significantly higher peak/mean postoperative transprosthetic gradient in the PPM group in comparison to the group without PPM (27.9/16.6 mmHg vs. 23.5/13.6 mmHg, p < 0.007 and p < 0.001). This was not the case in mini-AVR, where there was no difference in peak/mean postoperative transprosthetic gradient between the two groups (26.7/15.6 mmHg vs. 26.1/14.7 mmHg, p > 0.05). However, there was a significantly higher postoperative peak/mean transprosthesis gradient in con-AVR patients

Table 1. Relationship between the incidence of patient-prosthesis mismatch (PPM), mean effective orifice area index (EOAi), peak aortic valve gradient, and mean aortic valve and the prosthesis size

Aortic prosthesis size	Mini-AVR (n = 74)		Con-AVR (n = 76)		p
	No-PPM	PPM	No-PPM	PPM	
Small size [19 mm]:	33% (n = 1)	67% (n = 2)	40% (n = 2)	60% (n = 3)	> 0.05
EOAi [cm²/m²]	0.99	0.75 ± 9.65	0.95	0.81 ± 0.01	> 0.05
Peak AVG [mmHg]	74	27 ± 0.71	36 ± 1.41	36 ± 11.53	> 0.05
Mean AVG [mmHg]	38	17 ± 1.41	18 ± 2.82	21 ± 5.29	> 0.05
Medium size [21 and 23 mm]:	58% (n = 37)	42% (n = 27)	79% (n = 46)	21% (n = 12)	> 0.05
EOAi [cm²/m²]	1.01 ± 0.09	0.74 ± 0.09	1.09 ± 0.19	0.7 ± 0.7	0.007
Peak AVG [mmHg]	25.61 ± 14.18	26.6 ± 13.84	21.6 ± 8.95	29.56 ± 8.99	> 0.05
Mean AVG [mmHg]	15.47 ± 8.04	14.61 ± 4.67	12.6 ± 5.87	18.11 ± 6.17	> 0.05
Large size [27 mm]:	100% (n = 7)	0% (n = 0)	85% (n = 13)	15% (n = 2)	> 0.05
EOAi [cm²/m²]	1.08 ± 0.11	–	1.18 ± 0.13	0.77 ± 0.03	> 0.05
Peak AVG [mmHg]	20.5 ± 3.27	–	18.01 ± 5.86	21	> 0.05
Mean AVG [mmHg]	11.71 ± 3.46	–	11.74 ± 5	15	> 0.05

Data are shown as mean ± standard deviation. AVG — aortic valve gradient; AVR — aortic valve replacement; con — conventional; mini — minimally invasive

with PPM compared to those without PPM (30.4/18.5 mmHg vs. 21/12.7 mmHg, p < 0.002 and p < 0.001).

Aortic prosthesis size

In medium aortic prosthesis size a significantly lower mean EOAi was found in patients with mini-AVR in comparison to con-AVR patients (0.9 ± 0.16 cm²/m² vs. 1.01 ± 0.24 cm²/m², p = 0.007). There was no significant differences in mean EOAi, peak aortic valve gradient, or mean aortic valve gradient in other prosthesis sizes (Table 1).

DISCUSSION

Globally, the incidence of PPM after median sternotomy is estimated at between 20% and 70% [1]. Our study results are similar: overall moderate PPM was observed in about 27.3% of patients, and 3.3% of patients had severe PPM [5, 6]. In contrast to a previous study [5], we found that the incidence of PPM was higher in mini-AVR compared to con-AVR. This may be due to several reasons (**Supplementary Figure 1 — see journal website**).

The risk of PPM is strongly related to the size of implanted prosthetic valves [7, 8], with larger valves resulting in PPM less often than smaller valves. Differences in PPM prevalence were observed only in patients with medium-sized prostheses, where higher EOAi was observed in mini-AVR patients with PPM. Based on the mean value of EOAi in those patients, PPM may be categorised as moderate. A recent large meta-analysis found that severe PPM was associated with higher mortality [9]. It is possible that in mini-AVR surgeons were more often able to avoid implanting larger valves in favour of a medium-sized prosthesis, with acceptable postoperative haemodynamic parameters. In our study, postoperative transprosthetic

gradients were slightly lower in mini-AVR. There were also no differences in transprosthetic gradients in mini-AVR patients with PPM compared to those without PPM, in contrast to con-AVR, where higher gradients were observed in the PPM group. Therefore, the higher prevalence of PPM in mini-AVR had no impact on postoperative haemodynamic parameters.

The effective orifice area can be measured in a variety of ways, and may change over time. EOAi can be calculated using the manufacturer's charts or echocardiographic data [5]. Due to the retrospective design of this analysis, the former method was used, which has been described elsewhere [4]. The EOAs reported by the manufacturer are based on in vitro models and their size may be overestimated in comparison with in vivo EOAs [5].

There are several surgical options to reduce the risk of PPM [10]. The first one involves aortic root enlargement procedures, which were not used in our study. Magruder et al. [5] show that aortic root enlargement procedures may also be successfully performed in mini-AVR patients to prevent PPM. The second option is the use of stentless bioprostheses, which present a better haemodynamic performance, but they are more challenging and increase the risk to the patient. New generation of stented bioprostheses is characterised by similar haemodynamic performance and an easier implanting technique [11]. There is no general recommendation for the preference of stentless bioprostheses. Most surgeons tend to implant stented valves in complicated cases and octogenarians because operative mortality and the stent durability are not worse than in stentless AVR [10]. In our analysis, no stentless bioprostheses were implanted.

At the time of publication, no standard objective patient selection criteria applied in our clinic for mini-AVR. The surgical approach was chosen by the individual surgeon. Therefore,

it is possible that the higher frequency of PPM in mini-AVR is related to the surgeon learning the procedure.

Mini-AVR is associated with lower morbidity and mortality in high-risk patients (e.g. obese and elderly) [12]. On the other hand, studies on PPM showed decreased survival rates in patients < 70 years of age and those with body mass index < 30 kg/m^2, but not in elderly or obese patients [13]. This may mean that there is an even stronger need to monitor mini-AVR procedures for PPM, because the benefits of this approach may be outweighed by the risk of worsened haemodynamics due to incorrect valve size.

This is a single-centre, non-randomised, retrospective study with a small patient sample size. The decision on the adopted method and the type and size of the implanted valve was a reflection of the individual surgeon's preference.

In conclusion, the incidence of PPM was found to be higher in patients undergoing mini-AVR compared to those undergoing conventional sternotomy.

Conflict of interest: *none declared*

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