Patient Prosthesis Mismatch: Has it Made a Comeback?

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Patient–prosthesis mismatch (PPM) was first described by Rahimtoola in 1978 and was considered to be present when the effective prosthetic valve area is less than that of a normal human valve.¹ This is actually true for every aortic valve replacement with a mechanical or bioprosthetic valve because their orifice can not be as large as the native annulus. Today, PPM is assumed when the effective orifice area (EOA), determined echocardiographically with the continuity equation, of a normally functioning prosthesis is too small in relation to the patient’s body size and results in increased transprosthetic pressure gradients during hemodynamic states of higher cardiac output.² PPM is routinely determined by calculating the indexed EOA, which is the EOA of the prosthesis divided by the patient’s body surface area.³ ⁴

Table 1 shows the threshold values of indexed EOA that are routinely used to identify PPM and to quantify its severity. The incidence of severe PPM after surgical aortic valve replacement (AVR) ranges from 2% to 11% and of moderate PPM 20% to 70% and is related to adverse clinical outcome. Similar incidences have been reported for the mitral position. Of interest, transcatheter aortic valve implantations (TAVI) seems to be associated with a similar risk for the occurrence of PPM: in a recent study from Europe, moderate PPM was found in 76 out of 278 patients (27.3%) and severe PPM in 21 out of 278 patients (7.6%).⁵ Following TAVI, severe mismatch appears to be accompanied by high early mortality, especially when combined with increased pressure gradients. Given the overall increase of percutaneous valve replacements, this indeed warrants further investigation and may indeed represent an area where PPM has made a comeback.

**Table 1:**

<table>
<thead>
<tr>
<th>Position</th>
<th>Mild (cm²/m²)</th>
<th>Moderate (cm²/m²)</th>
<th>Severe (cm²/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic position</td>
<td>&gt; 0.85 (0.8–0.9)</td>
<td>≤ 0.85 (0.8–0.9)</td>
<td>≤ 0.65 (0.6–0.7)</td>
</tr>
<tr>
<td>Mitral position</td>
<td>&gt; 1.2 (1.2–1.3)</td>
<td>≤ 1.2 (1.2–1.3)</td>
<td>≤ 0.9 (0.9)</td>
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Modified from⁶
Aortic PPM is associated with limited improvement in both symptoms and functional class, and decreases the likelihood of recovery of exercise capacity and improvement in coronary flow reserve, while ultimately leading to more adverse cardiac events and increased mortality. The negative impact of PPM can best be explained by the added hemodynamic burden, which is poorly tolerated by a compromised ventricle. Of interest, younger patients appear to be more significantly impacted by PPM than older patients. This might be best explained by the fact that younger patients generally depend on higher cardiac output requirements. Further, it appears to be similarly important to avoid moderate PPM in patients undergoing AVR with preexisting LV dysfunction and an age of 65 to 70 years, that are intending to maintain a decent level of physical activity. Mitral PPM is independently associated with increased mortality after MVR, persisting pulmonary hypertension, and increased incidence of congestive heart failure.

Given the published evidence, surgeons have attempted to avoid severe PPM when replacing aortic or mitral valves. To assist surgeons in this task, the cardiologist and perioperative echocardiographer is tasked with providing the surgeon with accurate and precise information in regards to native valve, the annular size, the diameter of the left ventricular outflow tract and body surface area. In addition, the echocardiographer can assist the surgeon in choosing an appropriate valve and consider or plan any additionally required procedures. Besides accurate imaging and utilization of a multi-modal approach to imaging, the projected indexed EOA of the selected prosthesis needs to be determined. If in doubt, alternatives to the initially selected valve should be discussed. The hemodynamic profile of current prosthetic valves varies significantly and careful selection paired with surgical skills (e.g enlargement of the aortic root) may lead to improved results. Surgical options in the mitral position are limited (the MV annulus can not be enlarged and stentless valves do not exist here) which means that the prevention of PPM in the mitral position is more challenging than in the aortic position.

When selecting a prosthesis, the surgeon needs to consider a number of important options: mechanical versus bioprosthetic, long-term durability (bioprosthesis) versus low thrombogenicity (mechanical prostheses). Similarly important is the correct selection of a valve with an optimized hemodynamic performance to prevent PPM by reducing postoperative transprosthetic gradients. Aortic valve homografts have the advantage that they cause very little if any obstruction to flow because they have no stents that occupy the orifice. If in doubt, one should preferably select
the model that provides the largest valve effective orifice area (EOA) in relation to the patient’s annulus size. The resulting hemodynamics of a selected valve depend on the size of prosthesis that fits the patient’s annular dimensions and total cross-sectional area of that valve available for forward flow. In addition, the hemodynamic profile tends to be superior in newer compared to older prostheses, in stentless compared with stented bioprosthetic valves, in supra-annular compared with intra-annular stented bioprostheses,\textsuperscript{18} and in mechanical compared with stented bioprosthetic valves.\textsuperscript{19}

Patients with a small aortic root present a particular challenge to the surgeon and his or her experience plays a crucial role in the outcome. A small patient population will even present with an anatomically small aortic annulus of <18 mm and/or a narrow left ventricular outflow tract (<15 mm). There are no commercially available prosthetic heart valves that will fit in an aortic annulus that small. Even if the surgeon implants a stentless biological valve, the residual gradient will be unacceptable and eventually leads to a poor outcome.

References:
dysfunction: effect on survival, freedom from heart failure, and left ventricular mass regression. The Journal of thoracic and cardiovascular surgery 2006;131:1036-44.