

## Patient-Prosthetic Aortic Valve Mismatch: Role of the Echocardiographer

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Patient-prosthetic aortic valve mismatch (PPM) is a clinical diagnosis in which an aortic prosthetic valve is normal structurally, but hemodynamically functions as aortic stenosis, with higher prosthetic valve gradients than would be expected for that particular valve.<sup>1,2</sup> The prosthetic valve functions as designed but hemodynamics are less than ideal compared with a native valve. The predominant hemodynamic consequence of PPM is generation of an abnormally high mean pressure gradient (MPG), which may become evident only during or after exercise. The MPG is related to flow (Q) and prosthetic effective orifice area (EOA) by the following relationship:

$$\text{MPG} = Q^2 / \text{EOA}^2 \quad (1)$$

Flow (Q) is proportional to cardiac output, which in turn is proportional to body surface area (BSA). Therefore, the MPG is increased (and PPM is evident) when the EOA of the prosthetic valve is too small relative to the size of the patient.<sup>3</sup> An EOA indexed to BSA (iEOA) of  $\leq 0.85 \text{ cm}^2/\text{m}^2$  is considered as moderate PPM, and  $\leq 0.65 \text{ cm}^2/\text{m}^2$  as severe PPM. Likewise, an iEOA of  $>0.85 \text{ cm}^2/\text{m}^2$  is associated with a low MPG and is thought to be clinically insignificant.<sup>4-6</sup> The iEOA is obtained by the following:

$$\text{iEOA} = \text{EOA} / \text{BSA} \quad (2)$$

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where

$$\text{BSA} = (\text{Weight})^{0.425} \times (\text{Height})^{0.725} \times 0.007184 \quad (3)$$

Weight is in kg and height in cm, with BSA resulting in units of  $\text{m}^2$ .<sup>7</sup>

Operative insertion of a relatively small valve is predictive of an elevated prosthetic valve gradient and development of clinical PPM.<sup>8</sup> This has deleterious effects for both the short- and long-term. Postoperatively, there is a diminished cardiac index noted<sup>5,6,9</sup> and an increased mortality.<sup>10,11</sup> Short-term mortality relative risk as related to PPM is shown in Table I.

Long-term effects of PPM include a diminished quality of life<sup>6</sup> and functional class,<sup>5</sup> persistence of left ventricular hypertrophy,<sup>5,6,12</sup> an increased late mortality<sup>11</sup>, and also an increased incidence of sudden death.<sup>9</sup>

To prevent implantation of an inappropriately small-sized valve for a particular patient, the following procedure may be followed:

1. Calculate the BSA (Equation 3) of the patient.
2. Multiply this BSA value by the desired iEOA (e.g.,  $0.85 \text{ cm}^2/\text{m}^2$ ). By rearranging Equation (2), this is:

$$\text{EOA} = (\text{iEOA}) \times \text{BSA} \quad (4)$$

and substituting  $(0.85 \text{ cm}^2/\text{m}^2)$  for iEOA

$$\text{EOA} = (0.85 \text{ cm}^2/\text{m}^2) \times \text{BSA} \quad (5)$$

This is the minimum size EOA of a prosthetic valve that should be implanted to avoid PPM.

**Table I**

Short-Term (30-Day) Risk in Patients With PPM. Values for Severity of PPM Are the iEOA<sup>10</sup>

Severity of PPM (iEOA) cm <sup>2</sup> /m <sup>2</sup>	Risk Ratio	Risk Ratio With LVEF <40%
Nonsignificant PPM (>0.85)	1.0×	2.7×
Moderate PPM (0.65–≤0.85)	2.1×	7.1×
Severe PPM (≤0.65)	11.4×	77.1×

LVEF: Left ventricular ejection fraction.

3. Use a “lookup” table (Table II) to see the in vivo (as opposed to in vitro measurements or use of internal diameter or geometric area) EOAs of valves for implantation. The desired valve must have an EOA that is at least as large as the calculated desired EOA from step #2.

For example, if the BSA of a patient is 1.8 m<sup>2</sup>, then the minimum-sized EOA of a prosthetic valve that may be implanted (from Equation (5)) to avoid PPM is

$$EOA = (0.85 \text{ cm}^2/\text{m}^2) \times (1.8 \text{ m}^2)$$

$$EOA = 1.53 \text{ cm}^2$$

The minimum EOA of the desired prosthetic valve must be ≥1.53 cm<sup>2</sup> for this patient. In general, a mechanical valve tends to have a larger EOA than a bioprosthesis (Table II), but a stent-

**Table II**

In Vivo Effective Orifice Area (EOA) of Several Aortic Valve Prostheses, in Units of cm<sup>2</sup>. One Should Use This Data Preoperatively for a Desired Valve and Size, to Assess for Risk of Postoperative PPM (Listed EOA Values May Vary Among Investigator Reports)

Prosthetic valve size (mm)	19	21	23
Stented bioprosthetic valves			
Carpentier-Edwards Perimount <sup>13</sup>	1.10	1.30	1.50
Hancock II <sup>6</sup>	NA	1.18	1.33
Medtronic Mosaic <sup>14</sup>	1.20	1.22	1.38
Stentless bioprosthetic valves			
Medtronic Freestyle <sup>6</sup>	1.15	1.35	1.48
Prima Edwards <sup>15</sup>	0.80	1.10	1.50
St. Jude Medical Toronto SPV <sup>6</sup>	NA	1.30	1.50
Mechanical valves			
CarboMedics <sup>16</sup>	0.90	1.30	1.40
Medtronic-Hall <sup>17</sup>	1.10	1.10	1.10
St. Jude Medical Standard <sup>6</sup>	1.04	1.38	1.52
St. Jude Medical Regent <sup>18</sup>	1.70	2.00	2.50

NA: Not available.

less bioprosthesis may have an EOA as large or larger than a mechanical valve.

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