Best evidence topic - Cardiac general

In patients undergoing aortic valve replacement, what factors predict the requirement for permanent pacemaker implantation?

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Summary

A best evidence topic in cardiac surgery was written according to a structured protocol. The question was to determine what preoperative, periprocedural and postoperative factors influence the requirement for permanent pacemaker (PPM) implantation postisolated aortic valve replacement (AVR). Transcatheter aortic valve intervention was not included in this analysis. Using the reported search method outlined below, 705 papers were found. No randomised controlled trials, meta-analyses or registries were identified. Seven single-centre retrospective observational studies represent the best evidence on the subject. The author, journal, date and country of publication, level of evidence, patient group studied, study type, outcomes and results were tabulated. The incidence of PPM implantation following AVR varied from 3.0% to 11.8% (mean 7.0%, median 7.2%). Current best available evidence suggests that baseline evidence of conducting system disease – first degree atroventricular block (AVB), left anterior hemiblock, right bundle branch block (RBBB) or left bundle branch block (LBBB) is the most powerful independent predictor of PPM requirement following AVR. Other important predictors are surgery for aortic regurgitation, preoperative myocardial infarction and longer perioperative cardiopulmonary bypass time. No consistent postoperative factors were identified. The mean time to PPM implant postAVR ranged from 6 to 13 days in the four studies that reported it. Current European Society of Cardiology guidelines recommend a period of seven days of persistent AVB postsurgery prior to PPM implantation.

Keywords: Aortic valve replacement; Permanent pacemaker; Outcome; Predictors; Conducting system disease

1. Introduction

A best evidence topic was constructed according to a structured protocol. This protocol is fully described in ICVTS [1].

2. Clinical scenario

A 72-year-old male is listed for isolated aortic valve replacement (AVR) for severe aortic stenosis (AS). He tells you that he has heard that he might require a pacemaker after his operation. He asks you the likelihood of this and if there is anything that can be done to minimise this risk. You feel unable to quote him accurate estimates and decide to investigate further.

3. Three-part question

In patients undergoing aortic valve replacement, what factors predict the requirement for permanent pacemaker implantation?

4. Search strategy

An English language literature review was performed on MEDLINE using the Ovid interface from 1980 to April 2010:

[heart valve prosthesis implantation/OR heart valve prosthesis/OR prosthesis implantation/OR aortic valve/OR aortic valve surgery/OR aortic valve implantation.mp] AND [pacemaker, artificial/OR cardiac pacing, artificial/OR heart block/OR postoperative complications/OR permanent pacemaker.mp/OR permanent pacemaker implantation.mp].

EMBASE was searched using the Ovid interface from 1980 to April 2010:

[heart valve replacement/OR heart valve surgery/OR heart valve prosthesis/OR aorta valve/OR aortic valve implantation.mp] AND [pacemaker/OR artificial heart pacemaker/OR postoperative complication/OR heart block/OR permanent pacemaker.mp/OR permanent pacemaker implantation.mp].

Additionally, the CINAHL (Cumulative Index to Nursing and Allied Health Literature) database and the Cochrane Database for Systematic Reviews and Central Register of Controlled Trials were searched using the above terms. All citations and abstracts were reviewed and reference lists of articles found through these strategies were reviewed for further relevant articles.
Table 1. Summary of best evidence papers

<table>
<thead>
<tr>
<th>Author, date, journal and country</th>
<th>Patient group</th>
<th>Outcome(s)</th>
<th>Results</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Toto et al., (2000), J Card Surg, Italy, [2]</td>
<td>n = 124</td>
<td>Retrospective single centre case series</td>
<td>Duration: 18 months</td>
<td>Mixed aortic valve disease</td>
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<tr>
<td></td>
<td>Isolated AS n = 60 (48%)</td>
<td>2. Surgical technique only independent risk factor on multivariate analysis</td>
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<td></td>
<td>Isolated AR n = 45 (36%)</td>
<td>Major – PPM implantation for third degree AVB or first and second degree AVB with severe bradycardia &lt; 50 bpm persistent for ≥ one week</td>
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<td>Duration: 12 months</td>
<td>Continuous suture technique: n = 72 (58%), mean age 66 ± 7 years, 55.5% male</td>
<td>2. Multivariate risk factors for PPM implantation</td>
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<tr>
<td>Level of evidence: 2b</td>
<td>Interrupted suture technique: n = 52 (48%), mean age 70 ± 9 years, 63.4% male</td>
<td>Major – first degree AVB with severe bradycardia &lt; 50 bpm persistent for ≥ one week and not requiring PPM implantation</td>
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<tr>
<td>Limongelli et al., (2003), Heart, Italy, [3]</td>
<td>n = 276</td>
<td>Retrospective single centre case series</td>
<td>Duration: 12 months</td>
<td>Isolated AS n = 108 (39%)</td>
</tr>
<tr>
<td></td>
<td>Age/sex breakdown for whole cohort not provided</td>
<td>First time isolated AVR</td>
<td>Isolated AR n = 80 (29%)</td>
<td>Mixed aortic valve disease n = 88 (32%)</td>
</tr>
<tr>
<td>Elahi and Usmaan, (2006), J Interv Card Electrophysiol, Pakistan, [4]</td>
<td>n = 510</td>
<td>Retrospective single centre case series</td>
<td>Duration: three years</td>
<td>Stented AVR n = 360, mean age 70.3 ± 7.2 years, 53% male</td>
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<td></td>
<td>First time isolated AVR for AS</td>
<td>Stented AVR n = 150, mean age 61.7 ± 12.3 years, 53% male</td>
<td>2. Risk factors on multivariate analysis: preoperative MI, preoperative EF &lt; 35%, preoperative LBBB, CPB time &gt; 100 min with x-clamp time &gt; 70 min, prosthetic valve size ≤ 21 mm</td>
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<tr>
<td>Erdogan et al., (2006), J Card Surg, Turkey, [5]</td>
<td>n = 465</td>
<td>1. Incidence of postoperative PPM implantation</td>
<td>1. Nineteen patients (4.1%) required PPM implantation</td>
<td>Seventeen patients (89.5%) requiring PPM had AS as primary diagnosis</td>
</tr>
<tr>
<td>Retrospective single centre case series</td>
<td>Age/sex breakdown for whole cohort not provided</td>
<td>PPM in those with third degree AVB persisting after day 10 postAVR</td>
<td>2. Risk factors on multivariate analysis: female sex, preoperative LBBB or RBBB, hypertension, bicuspid aortic valve, annular calcification and longer CPB time</td>
<td>No comment on median time to PPM implantation postAVR</td>
</tr>
<tr>
<td>Duration: 10 years</td>
<td>Isolated AVR</td>
<td></td>
<td></td>
<td>In-hospital stay significantly longer for PPM group (25.7 ± 12.7 days vs. 11.4 ± 9.7 days, P &lt; 0.001)</td>
</tr>
<tr>
<td>Level of evidence: 2b</td>
<td>Isolated AS n = 243 (52%)</td>
<td>2. Multivariate risk factors for PPM implantation</td>
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<td></td>
<td>Isolated AR n = 196 (42%)</td>
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<td></td>
<td>Mixed aortic valve disease n = 68 (15%)</td>
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<tr>
<td>Dawkins et al., (2008), Ann Thorac Surg, UK, [6]</td>
<td>n = 354</td>
<td>1. Incidence of postoperative PPM implantation</td>
<td>1. Twenty-nine patients (8.2%) required PPM implantation</td>
<td>Pre-existing conducting system disease present in 89 patients (26%)</td>
</tr>
<tr>
<td>Retrospective single centre case series</td>
<td>Isolated AVR</td>
<td></td>
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<td>Mean time to PPM implant postAVR 13 days (range six to 57 days). Eleven patients (90%) received PPM during index admission, a mean duration postAVR of 11 days (range six to 25 days)</td>
</tr>
<tr>
<td>Duration: 30 months</td>
<td>AS n = 224 (66%)</td>
<td>PPM in those with third degree AVB persisting after day 5 postAVR</td>
<td>2. Risk factors on multivariate analysis: preoperative conducting system disease and AR</td>
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<tr>
<td>Level of evidence: 2b</td>
<td>AR n = 70 (20%)</td>
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<tr>
<td></td>
<td>Mixed aortic valve disease n = 20 (6%)</td>
<td>2. Multivariate risk factors for PPM implantation</td>
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</tr>
<tr>
<td>Huynh et al., (2009), Pacing Clin Electrophysiol, USA, [7]</td>
<td>n = 207</td>
<td>1. Prevalence and predictors of postoperative PPM implantation</td>
<td>1. Fifteen patients (7.2%) required PPM implantation</td>
<td>Mean time to PPM implant postAVR 6.1 ± 2.3 days</td>
</tr>
<tr>
<td>Retrospective single centre case series</td>
<td>Age/sex breakdown for whole cohort not provided</td>
<td>No reference to indication for PPM or time to wait postAVR</td>
<td>2. Risk factors on multivariate analysis: preoperative first degree fascicular block or intra-ventricular conduction delay, postoperative cardiac arrest and combined AVR + MVR</td>
<td>No comment on length of in-hospital stay</td>
</tr>
<tr>
<td>Duration: seven years</td>
<td>AVR ± MVR ± CABG</td>
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<td>Of those patients dependent on epicardial pacing at end of aortic valve surgery were more likely to receive a PPM than those requiring only intermittent epicardial pacing [66.7% (n = 10) vs. 25.5% (n = 49), P = 0.002]</td>
</tr>
<tr>
<td>Level of evidence: 2b</td>
<td>AS n = 161 (78%)</td>
<td>2. Multivariate risk factors for PPM implantation</td>
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</tbody>
</table>

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5. Search outcome

A total of 705 papers were found using this search strategy. No randomised controlled trials, meta-analyses or registries were identified. Seven single-centre retrospective observational case series represent the best evidence on the topic and are summarised in Table 1 [2–8].

6. Discussion

All seven studies are retrospective single-centre observational case series, inclusive of 2557 patients from Asia, Europe and North America. There is no randomised controlled data in this field. The incidence of permanent pacemaker (PPM) implantation postAVR varied from 3.0% to 11.8% (mean 7.0%, median 7.2%). In each study, multivariate logistic regression analysis was undertaken to identify preoperative, perioperative and postoperative predictors of PPM implantation.

6.1. Preoperative predictors

The most consistently identified preoperative predictor for PPM insertion was evidence of preoperative conducting system disease including left bundle branch block. Aortic valve replacement; CABG, coronary artery bypass grafting; CPB, cardiopulmonary bypass; PHT, pulmonary hypertension; MI, myocardial infarction; EF, ejection fraction; LBBB, left bundle branch block; RBBB, right bundle branch block; LV, left ventricle; NS, not significant.

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<tr>
<td>Nardi et al., (2010), J Cardiovasc Med, Italy, [8]</td>
<td>n=261, mean age 69±12 years, 52.1% male</td>
<td>1. Incidence and predictors of postoperative PPM implantation</td>
<td>1. Eight patients (3%) required PPM implantation</td>
<td>Median time to PPM implant postAVR 11.6 days (range four to 26 days)</td>
</tr>
<tr>
<td>Retrospective single centre case series</td>
<td>Isolated AVR</td>
<td>PPM in those with symptomatic second degree or third degree AVB persisting after day 4 postAVR</td>
<td>2. Risk factors on multivariate analysis: greater preoperative end systolic diameter and left ventricular septal hypertrophy</td>
<td>No comment on length of in-hospital stay</td>
</tr>
<tr>
<td>Duration: 49 months</td>
<td>AS n=156 (60%)</td>
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<td>Eighteen cases (6.8%) were re-do procedures</td>
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<td></td>
<td>AR n=42 (16%)</td>
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<td>Preoperative conducting system disease in two patients (25%) requiring PPM vs. 64 patients (25.7%) not requiring PPM (P=NS)</td>
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<tr>
<td></td>
<td>Mixed aortic valve disease n=63 (24%)</td>
<td>2. Multivariate risk factors for PPM implantation</td>
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AVR, aortic valve replacement; PPM, permanent pacemaker; AS, aortic stenosis; AR, aortic regurgitation; AV, atriocentric; AVB, atriocentric block; MVR, mitral valve replacement; CABG, coronary artery bypass grafting; CPB, cardiopulmonary bypass; PHT, pulmonary hypertension; MI, myocardial infarction; EF, ejection fraction; LBBB, left bundle branch block; RBBB, right bundle branch block; LV, left ventricle; NS, not significant.

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6.1. Preoperative predictors

The most consistently identified preoperative predictor for PPM insertion was evidence of preoperative conducting system disease including left bundle branch block (LBBB) and right bundle branch block (RBBB), first degree atrioventricular block (AVB) and left anterior hemiblock.

Additional, preoperative predictors identified in more than one series were preoperative myocardial infarction (MI) [3, 4] and aortic regurgitation (AR) as the primary valvular pathology [3, 6]. It is postulated that annular ectasia associated with AR imposes mechanical stretch on the nearby AV node and his bundle that is further damaged during surgery [3]. Fibrous endocardial thickening of the ventricular septum and subsequent impingement of the underlying conducting tissue has also been implicated [6]. Nardi et al. [8] found that those with greater septal hypertrophy and greater end-systolic diameter, indirect evidence of more severe valvular disease, were more likely to require PPM implantation. Similarly, several other indirect indices of more severe valvular disease were identified as predictors: ejection fraction (EF) < 35% [4], pulmonary hypertension (PHT) [3], hypertension and aortic annular calcification [5]. Lastly, female sex and a bicuspid aortic valve were identified as preoperative predictors [5].

6.2. Perioperative predictors

Only two series examined a specific surgical technique/strategy. Totaro et al. [2] found that a continuous suture technique to secure the new prosthesis versus an interrupted suture technique resulted in a greater need for PPM implantation (17.5% vs. 2.2%, P<0.01). The continuous suture technique was associated with longer cardiopulmonary bypass (CPB) time (73±24 min vs. 60±24 min, P<0.01). Elahi and Usman [4] identified that a stentless aortic prosthesis for AS was associated with a higher rate of PPM implantation in comparison with a stented prosthesis (18.0% vs. 9.1%, P<0.05). The CPB time was longer in the stentless valve group (107.5±20.7 min vs. 81.3±13.4 min, P<0.05). Whether, it is the surgical techniques in isolation or their association with longer CPB times that is the important factor is uncertain. However, a longer CPB time, independent of surgical technique was identified as a predictor of PPM implantation [5].

Other perioperative factors identified as predictors include smaller valvular prosthesis (< 21 mm) [4] and concurrent mitral and AVR [7]. Multi-valve surgery is recognised as increasing the risk of PPM implantation in much larger observational series incorporating all types of cardiac surgery [9, 10].

6.3. Postoperative predictors

Postoperative predictive factors are the least defined in the series. Only a postoperative cardiac arrest [7] and electrolyte disturbance [3] were identified as predictors of PPM implantation.
The period of time postAVR to allow AVB to persist prior to implanting a PPM varied in the studies, ranging from four to 10 days. Current European Society of Cardiology (ESC) guidelines [11] recommend a PPM in those with persistent postoperative heart block lasting for seven days post-surgery whilst the American Heart Association/American College of Cardiology/Heart Rhythm Society guidelines [12] leave the decision at the discretion of the physician. Four studies report the mean or median time to implant postAVR, which ranged from 6.1 to 13 days [3, 6–8]. In larger observational series incorporating all types of cardiac surgery, the mean time to PPM implant ranged from 8.4 to 13 days [10, 13–15]. The period of seven days advocated by ESC guidance is within the range of all the previously mentioned studies.

7. Clinical bottom line

The most consistent preoperative predictor of PPM requirement postAVR is evidence of pre-existing conducting system disease. AR as the dominant valvular pathology and prior MI also confer a greater risk of PPM implantation. A longer CPB time was a consistent perioperative predictor whilst no consistent postoperative predictors have been identified. The time to PPM implant postAVR ranged from 6.1 to 13 days in the four studies that reported it. Current ESC guidelines recommend a period of seven days of persistent AVB postsurgery prior to PPM implantation.

References