VENTRICULAR ARRHYTHMIAS LATE AFTER AORTIC AND/OR MITRAL VALVE REPLACEMENT

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Since it is not yet known whether ventricular arrhythmias in patients with valve replacement are associated with an increased risk of sudden death, as in patients with coronary artery disease, a total of 46 patients who were long-term survivors of aortic and/or mitral valve replacement were examined with 24-hour ambulatory electrocardiographic monitoring, and the factors influencing the occurrence of ventricular arrhythmias were analyzed. The significance of ventricular arrhythmias in the prognosis of valve replacement is discussed.

The occurrence of ventricular arrhythmias was significantly higher: 1) in patients with aortic stenosis than in those with aortic regurgitation, 2) in patients with multiple valve surgery than in those with single valve replacement and 3) in patients with larger heart size. Pre- and postoperative hemodynamics, including left ventricular function, were not significantly related to the incidence of ventricular arrhythmias.

A review of the patients who died suddenly, late after valve replacement suggests that frequent ventricular arrhythmias and thromboembolism are the most important factors in the late mortality of these patients.

The prognostic significance of postoperative ventricular arrhythmias in patients with valve replacement requires additional study.

SUDDEN, unexplained late death after valve replacement remains an important and unsolved problems. Its incidence is approximately 15–30% of late death in reported series1–3 and 25% in our experience. Ventricular arrhythmia in patients with coronary artery disease is believed to be a major risk factor for sudden death, but there is little information on the prognostic significance of ventricular arrhythmias after valve replacement.

In this study, 24-hour ambulatory electrocardiographic monitoring was performed on patients with aortic and/or mitral valve replacement to determine the presence and grade of ventricular arrhythmias. Results indicate the incidence of ventricular arrhythmias was correlated with various hemodynamic parameters. The role of ventricular arrhythmias in patients with valve replacement was discussed.

Key Words:
Ventricular arrhythmia
Valve replacement
Sudden death
Holter monitoring

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Ventricular Arrhythmias and Valve Replacement

![Bar chart showing distribution of VPC according to Lown's classification.]

Fig. 1. Distribution of VPC according to Lown’s classification.

![Bar chart showing incidence of VPC in the course of years after surgery.]

Fig. 3. Incidence of VPC in the course of years after surgery.

modified V₁ and V₅ leads were used in all patients. Their ages at the time of surgery ranged from 9–63 years (mean 41 ± 12 years). The ambulatory electrocardiographic monitoring was performed 4 months to 18 years (mean 4.9 ± 4.5 years) after surgery. Hemodynamic conditions were assessed by cardiac catheterization preoperatively and within one year after surgery, followed periodically by radioangiography or radiouclide angiocardiography. Lown’s grading system was used to classify ventricular arrhythmias: grade 0, no ventricular premature contractions (VPC); grade 1, occasional VPC but less than 30 in any hour of monitoring; grade 2, more than 30 VPC in any hour of monitoring; grade 3, multiform VPC; grade 4A, two consecutive VPC; grade 4B, ventricular tachycardia (no cases in this series). VPC greater than grade 2 were called “significant” in this study. The VPC grades were compared with various parameters in an analysis of the factors influencing the occurrence of VPC in patients with valve replacement.

The records of four other patients who died suddenly were reviewed for the causes of death.

RESULT

Incidence of VPC: Ventricular premature
TABLE I  TYPE OF VALVE LESION AND VPC. VALVE LESIONS WERE CLASSIFIED ACCORDING TO THE DOMINANT LESION, BUT PATIENTS WITH TWO SIGNIFICANT LESIONS WERE PLACED IN TWO GROUPS

<table>
<thead>
<tr>
<th>Type of valve lesion</th>
<th>No. of case</th>
<th>Grade of VPC</th>
<th>Incidence of VPC (%)</th>
<th>Incidence of significant VPC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS</td>
<td>8</td>
<td>0 0 2 4 2</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>AR</td>
<td>15</td>
<td>9 3 3 1 0</td>
<td>40 - p &lt; 0.005</td>
<td>20 - p &lt; 0.001</td>
</tr>
<tr>
<td>MS</td>
<td>18</td>
<td>5 1 5 2 5</td>
<td>72</td>
<td>67</td>
</tr>
<tr>
<td>MR</td>
<td>14</td>
<td>5 2 2 5 0</td>
<td>64</td>
<td>50</td>
</tr>
</tbody>
</table>

AS (R) = Aortic stenosis (regurgitation); MS (R) = Mitral stenosis (regurgitation).

TABLE II SURGICAL METHOD AND VPC

<table>
<thead>
<tr>
<th>Type of surgery</th>
<th>No. of case</th>
<th>Grade of VPC</th>
<th>Incidence of VPC (%)</th>
<th>Incidence of significant VPC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolated valve replacement</td>
<td>20</td>
<td>0 1 2 4 1</td>
<td></td>
<td>40*</td>
</tr>
<tr>
<td>AVR</td>
<td>10</td>
<td>6 1 2 1 0</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>MVR</td>
<td>10</td>
<td>6 0 1 1 1</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Mixed valve surgery</td>
<td>26</td>
<td>2 7 7 6 4</td>
<td>73</td>
<td>65</td>
</tr>
<tr>
<td>AVR + MVR</td>
<td>9</td>
<td>4 0 2 2 1</td>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>AVR + OMC</td>
<td>5</td>
<td>1 1 2 0 1</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>AVR + MVR + TAP</td>
<td>1</td>
<td>0 0 0 1 0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>MVR + TAP</td>
<td>10</td>
<td>2 1 3 3 1</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>MVR + TVR</td>
<td>1</td>
<td>0 0 0 0 1</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

AVR (M) VR = Aortic (mitral) valve replacement; TAP = Tricuspid annuloplasty; TVR = Tricuspid valve replacement; OMC = Open mitral commissurotomy; * = p < 0.05; ** = p < 0.001; isolated valve replacement versus mixed valve surgery.

TABLE III PROCEDURE DURING CARDIOTOMY AND VPC

<table>
<thead>
<tr>
<th>Procedure during cardiotomy</th>
<th>No. of case</th>
<th>Grade of VPC</th>
<th>Incidence of VPC (%)</th>
<th>Incidence of significant VPC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardioplegia</td>
<td>30</td>
<td>0 1 2 4 3</td>
<td>53</td>
<td>43</td>
</tr>
<tr>
<td>Coronary perfusion</td>
<td>10</td>
<td>3 2 3 1 1</td>
<td>70</td>
<td>50</td>
</tr>
<tr>
<td>Anoxic clamp</td>
<td>3</td>
<td>1 0 1 1 0</td>
<td>67</td>
<td>67</td>
</tr>
<tr>
<td>Ventricular fibrillation &amp; aortic clamp</td>
<td>3</td>
<td>1 1 0 1 1</td>
<td>67</td>
<td>33</td>
</tr>
</tbody>
</table>

contractions after valve replacement were present in 27 of the 46 patients (60%). The distribution of VPC according to Lown's classification is shown in Fig. 1. Standard electrocardiography, on the other hand, showed VPC in only seven patients (15%) at some time during postoperative follow-up. These seven patients had VPC of grade 2 or 3 on Holter monitoring. Six of the 46
patients were on antiarrhythmic drugs at the time of Holter monitoring: one with grade 0, one with grade 2, three with grade 3 and one with grade 4 VPC. The drugs had begun to be given postoperatively when VPC were found by standard electrocardiography and had continued for 2 to 15 months up to the time of the examination. VPC tended to increase slightly with the patients' age (Fig. 2), as well as with time after surgery (Fig. 3), but they were not statistically significant.

**Type of valve lesion and VPC:** The relationship between preoperative diagnosis and the occurrence of postoperative VPC was investigated (Table I). The incidence of VPC, especially frequent or complex VPC, was significantly higher in patients with predominant aortic stenosis than in those with predominant aortic regurgitation (p < 0.005). However, no significant differences were found in patients with predominant mitral stenosis versus those with predominant mitral regurgitation.

**Surgical factors and VPC:** The surgical factors, especially the procedures, myocardial protection and types of prostheses implanted were investigated. After isolated valve replacement the incidence of VPC was significantly lower than after multivalvular surgery, including valve plasty (p < 0.05), but the incidence after isolated aortic valve replacement and isolated mitral valve replacement was the same; and that among several types of multivalvular surgery was not significantly different (Table II). The use of cardioplegia tended to reduce postoperative VPC, but not significantly (Table III). Patients with Starr-Edwards and Lillehei-Kaster prostheses had a higher incidence of VPC than did those with other types, but the difference was not significant (p > 0.05) (Table IV).

**Pre- and postoperative conditions and VPC:** The patients were divided into two groups, group I with no or occasional unifocal VPC

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Fig. 4. Pre- and postoperative hemodynamic data.

Fig. 5. Follow-up radiocardiographic data.
TABLE VI SUMMARY OF PATIENTS WHO DIED SUDDENLY, LATE AFTER VALVE REPLACEMENT

<table>
<thead>
<tr>
<th>Case</th>
<th>Diagnosis</th>
<th>Age* sex</th>
<th>Surgery</th>
<th>Postop. period</th>
<th>Last CTR</th>
<th>Routine ECG</th>
<th>Postop. course</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AS</td>
<td>29 ♂</td>
<td>AVR</td>
<td>10.5</td>
<td>0.62</td>
<td>2.8</td>
<td>Bigeminy multifocal LBBB</td>
</tr>
<tr>
<td>2</td>
<td>ASR + MSR</td>
<td>47 ♂</td>
<td>AVR + MVR</td>
<td>9.5</td>
<td>0.65</td>
<td>4.5</td>
<td>†</td>
</tr>
<tr>
<td>3</td>
<td>MR</td>
<td>22 ♂</td>
<td>MVR</td>
<td>9.5</td>
<td>0.70</td>
<td>4.1</td>
<td>Bigeminy</td>
</tr>
<tr>
<td>4</td>
<td>AR</td>
<td>21 ♂</td>
<td>AVR</td>
<td>7.0</td>
<td>0.48</td>
<td>2.8</td>
<td>Bigeminy</td>
</tr>
</tbody>
</table>

AS (R) = Aortic stenosis (regurgitation); MS (R) = Mitral stenosis (regurgitation); A (M) VR = Aortic (mitral) valve replacement; CTR = Cardiothoracic ratio; † = At the time of surgery

(Lown classes 0–1) and group II with significant VPC (Lown classes 2–4). Table V summarizes pre- and postoperative (around the time of Holter monitoring) conditions. Postoperative functional recovery and pre- and postoperative cardiothoracic ratios in group I were better than group II (p < 0.05). Embolic episodes occurred in four patients in group II in spite of anticoagulant therapy, but, in none in group I. Cardiac catheterization performed pre- and postoperatively showed some improvement in most parameters after surgery; and pulmonary artery wedge pressure in both groups, and left ventricular ejection fraction in group II were significantly improved. Nevertheless, there were no significant differences in any parameters between the two groups (Fig. 4). Postoperative radiocardiographic examinations also revealed no significant differences between the two groups, except for left heart volume in group II, which remained high for years after surgery (Fig. 5).

Sudden death: Before this study, 16 of our patients had died long after valve replacement. Unexplained sudden death occurred in four cases (25%) which were non-hospitalized and fully rehabilitated patients. These patients’ data are summarized in Table VI. All four patients had Starr-Edwards prostheses and two of them had a history of thromboembolism. Frequent VPC had been detected by standard electrocardiograms in all four patients, but only one patient had been given antiarrhythmic drug. The heart was large in cases 1, 2 and 3, but of normal size in case 4, in which myocardial infarction had occurred 2.5 years after valve replacement with complete recovery. The homodynamic data of these patients were extremely scarce because their relatively good health kept them away from clinic visits or detailed examinations.

DISCUSSION

According to Lown et al., classification of VPC based on frequency, multiformity and repetitiveness is useful in determining the risk of sudden death in patients with coronary artery disease. However, the role of VPC in patients with valve replacement has not been clarified.

Role of left ventricular function: Several reports on aortic valve disease or aortic valve replacement have demonstrated a significant relationship between the occurrence of VPC and left ventricular dysfunction. Left ventricular dysfunction seen late after valve replacement may be due to long-standing valve disease, intraoperative injury or coexistent coronary artery disease. Chronic pressure or volume overload of the myocardium in patients with valve disease increases ventricular wall stress, which is a possible cause of VPC, although pathophysiologic mechanisms underlying ectopic ventricular activity are unclear. In the present study of patients with mitral as well as aortic valve replacement, the occurrence of VPC was significantly related to the cardiothoracic ratio on chest roentgenograms. Radiocardiography (Fig. 4) showed that increased heart size in patients with significant VPC appeared to be due to an increase of both right and left heart volumes preoperatively, and to failure to decrease left heart volume postoperatively. The fact that mixed valve surgery caused more VPC than isolated valve surgery may be related, not only to greater pressure or volume overload of the myo-
cardium preoperatively, but also to intraoperative myocardial damage due to prolonged cardiopulmonary bypass. However, left ventricular function, as reflected in ejection fraction and left ventricular end-diastolic pressure, was not a significant factor in the occurrence of VPC. On the other hand, the higher incidence of VPC in patients with aortic stenosis than in those with aortic regurgitation suggests that pressure overload is more arrhythmogenic than volume overload. Most of our patients did not undergo coronary angiography pre- and postoperatively because there was no evidence of coronary artery disease. Recent studies have failed to demonstrate a relationship between the occurrence of VPC and the presence or absence of coronary artery disease.

Arrhythmia and sudden death: Bigger et al. showed that the risk of sudden death in patients with coronary artery disease increased with the frequency of VPC. All of our patients who died suddenly had frequent or multifocal VPC on standard electrocardiography at some time before death. However, in their study of Holter monitoring at the time of sudden death, Roelandt et al. noted no specific pattern in frequency or type of VPC during the hour before the terminal event, and no predictable electrical trigger for the lethal arrhythmia. Thus, it is difficult to be certain whether ventricular arrhythmias or abnormal hemodynamics underlying VPC are associated with an increased risk of sudden death in patients with valve replacement.

Role of thromboembolism: Of interest was the finding that a thromboembolic episode occurred in only four patients in group II with significant VPC and in two patients in the sudden death group. It is generally considered that late myocardial infarction or sudden death is not related to thromboembolism. It is possible, however, that small valve-related emboli, without apparent signs of neurological disturbance, can cause transient myocardial ischemia or myocardial infarction, which increases the propensity for sudden fatal arrhythmias. This speculation is further supported by the fact that all patients who died suddenly had Starr-Edwards prostheses, which were found in our previous study to be associated with a high incidence of thromboembolism, and in this study, a relatively high incidence of VPC; moreover, a young patient who died suddenly (case 4 in Table VI) had a history of myocardial infarction 2.5 years after valve replacement.

Implications: There were not enough data from this small group to predict sudden death in patients with valve replacement. However, careful attention should be paid to frequent VPC, as detected by routine electrocardiograms, and to thromboembolism as precipitating factors in cases of sudden death.

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