Cardioversion Following Prosthetic Mitral Valve Replacement

By HOWARD SEMER, M.D., HERBERT HULTGREN, M.D., ROBERT KLEIGER, M.D., AND BLAINE BRANIFF, M.D.

SUMMARY
Direct current conversion of atrial fibrillation has been attempted in 60 consecutive patients following prosthetic mitral valve replacement (Starr-Edwards prosthesis). Sinus rhythm was attained and persisted for at least 24 hours after the procedure in 68% (41 patients) and 40% of the entire group (24 patients) were still in normal sinus rhythm an average of 10 months later. Successful initial conversion and persistence of sinus rhythm occurred most frequently in patients whose duration of atrial fibrillation was less than 5 years and who had a small left atrium.

Results differed little whether conversion was attempted 7 to 21 days or 1 to 15 months after open valve replacement. Atrial disease associated with a long period of antecedent atrial fibrillation and marked left atrial enlargement appeared to be the most important factors responsible for persistence of atrial fibrillation or early relapse.

Attempts at cardioversion are recommended for all patients with persistent atrial fibrillation following mitral valve replacement in view of the high success rate and the safety of the procedure.

ADDITIONAL INDEXING WORDS:
Atrial fibrillation Closed mitral valvulotomy Sinus rhythm

THE SAFETY and high initial success of electrical conversion of atrial fibrillation to sinus rhythm originally demonstrated by Lown and his workers in 1962 have been amply confirmed by many investigators. This study presents the results of electrical conversion of atrial fibrillation in a consecutive group of patients who have had prosthetic mitral valve replacement.

Following effective mitral valve replacement, resting left atrial pressure is frequently normal and lower than that following closed nonreplacement techniques. For this reason it might be expected that conversion of atrial fibrillation following valve-replacement surgery would be easier to achieve and maintain than it is following nonreplacement surgery. In addition, investigation of this problem would provide information regarding factors tending to perpetuate atrial fibrillation in patients with normal resting left atrial pressure.

Methods
Postoperative cardioversion using a standard DC discharge was attempted in patients who had atrial fibrillation preceding insertion of a Starr-Edwards caged-ball mitral prosthesis. Consecutive patients were chosen for this study without consideration being given to age or duration of fibrillation. Left atrial enlargement was graded slight, moderate, or marked by examination of standard four view cardiac roentgenograms with barium in the esophagus. Additional information regarding left atrial size was obtained by inspection at the time of surgery. Pertinent clinical data are summarized in table 1.

The Lown DC cardioverter was used according to the technique previously described. When possible, anteroposterior placement of the paddles was used. Our experience paralleled those

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*American Optical Co., Chelsea, Massachusetts.
Table 1
Clinical Characteristics of Patients Presented in This Study

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>60</td>
</tr>
<tr>
<td>Mean age (yr)</td>
<td>51 (30-65)</td>
</tr>
<tr>
<td>Males</td>
<td>26</td>
</tr>
<tr>
<td>Females</td>
<td>34</td>
</tr>
<tr>
<td>Duration of atrial fibrillation prior to cardioversion</td>
<td>74.5 mo</td>
</tr>
<tr>
<td>Observation time after cardioversion</td>
<td>10 mo</td>
</tr>
<tr>
<td>Male valveular lesion</td>
<td>16</td>
</tr>
<tr>
<td>Mitral stenosis</td>
<td>27</td>
</tr>
<tr>
<td>Mitral stenosis and insufficiency</td>
<td>27</td>
</tr>
<tr>
<td>Multiple valve replacement (number)</td>
<td>16</td>
</tr>
<tr>
<td>Aortic and mitral</td>
<td>12</td>
</tr>
<tr>
<td>Tricuspid and mitral</td>
<td>2</td>
</tr>
<tr>
<td>Tricuspid, aortic and mitral</td>
<td>2</td>
</tr>
</tbody>
</table>

of others who maintained that reversion to sinus rhythm could be attained with lower energies when this method of electrode placement was employed.8–10

All patients received a pre-anesthesia evaluation prior to cardioversion and were brought to the laboratory in the postabsorptive state. No premedication was used. Each patient was preoxygenated with 5 to 6 L/min of oxygen for 5 minutes, and induction of anesthesia was accomplished with 25 to 50 mg increments of thiopental sodium (Pentothal) or methohexital (Brevital) until the lid reflex was abolished. The desired level of anesthesia was maintained with small aliquots of the thiobarbiturate. The total dose ranged from 75 mg to 600 mg (mean 200 mg). No muscle relaxants or inhalation anesthetics were administered. Oxygen was continued until the patient was awake, and the vital signs were stable. No digitalis was administered for 48 to 72 hours prior to the procedure. A 0.2-g test dose of quinidine was given on the evening before and from 0.3 to 0.4 g at 8:00 a.m. the following morning before conversion was attempted. Following conversion all but two patients received quinidine, 0.2 g four times a day as a prophylactic measure.

Usually an initial discharge of 50 watt seconds was employed. This was followed by increasing the discharge energy until either sinus rhythm was restored or an energy level of 400 watt seconds was reached. Patients were seen in the cardiac outpatient clinic 4 to 6 weeks following cardioversion and at 6-month intervals thereafter.

Results
Cardioversion was attempted in a total of 60 patients from 6 days to several months following valve replacement surgery. Forty-one patients (68%) were successfully reverted to normal sinus rhythm. A successful cardioversion was considered to be maintenance of sinus rhythm for at least 24 hours following the procedure. Four patients maintained sinus rhythm for less than 24 hours. Data regarding these patients are summarized in Table 2. Follow-up information is available on 40 patients from 2 to 26 months following cardioversion. After a mean follow-up time of 10 months, 24 patients or 60% of the follow-up group (40% of the total group) remain in sinus rhythm. Twenty-one patients underwent cardioversion within 7 to 21 days (mean of 11 days) following surgery and 39 patients had attempts at reversion 1 to 15 months (mean 6 months) following valve replacement. Initial success was greater when cardioversion was done late but no essential difference could be found regarding final success when these groups were compared (Table 3).

Table 2
Arrhythmias in Four Patients with Sinus Rhythm for Less than Twenty-four Hours after Cardioversion

<table>
<thead>
<tr>
<th>Patient</th>
<th>Energy used (ws)</th>
<th>Arrhythmia</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.C.</td>
<td>200</td>
<td>First degree A-V block (P-R 0.24 sec)</td>
<td>Several beats only</td>
</tr>
<tr>
<td>M.O.</td>
<td>200</td>
<td>A-V dissociation, nodal rhythm, ventricular bigeminy</td>
<td>Several minutes</td>
</tr>
<tr>
<td>H.M.</td>
<td>200</td>
<td>Wenckebach’s rhythm</td>
<td>1 hr</td>
</tr>
<tr>
<td>J.F.</td>
<td>200</td>
<td>Sinus rhythm (P-R 0.20 sec)</td>
<td>18 hr</td>
</tr>
</tbody>
</table>
Two patients were not given quinidine because of hypersensitivity to this drug. One of these patients remains in sinus rhythm 9 months after the conversion. The second patient relapsed to atrial fibrillation after 1 week of sinus rhythm.

Possible factors that could influence the attainment and successful maintenance of sinus rhythm were analyzed. When the patients who initially reverted to sinus rhythm were compared to the group who did not revert, it was found that initial success was most commonly associated with: (1) duration of atrial fibrillation of less than 5 years; (2) presence of only slight or moderate left atrial enlargement.

Patients who remained in sinus rhythm during the follow-up period were compared to those who relapsed. The presence of only slight-to-moderate left atrial enlargement as well as a short duration of preceding atrial fibrillation correlated well with the maintenance of sinus rhythm. These results are summarized in table 4. No definite correlation could be found between cardioversion success and age, preoperative presence of associated mitral insufficiency, fine or coarse F-wave activity in lead V1, or decrease in cardiac size postoperatively.

An analysis was made of pulmonary artery wedge pressure at rest and during exercise after operation in 16 patients. In eight patients who either failed to convert (six patients), or relapsed (two patients), the mean wedge pressure at rest was 12 mm and during exercise, 20 mm. In eight patients with successful cardioversion and no relapse, the mean wedge pressure was 10 mm at rest and 22 mm during exercise, indicating no essential difference in pressure between these two groups.

Relapse to atrial fibrillation was less frequently seen when lower electrical energies were required for conversion. The mean energy required for conversion in those maintained in sinus rhythm was 150 ws (25-400 ws) as compared to 215 ws (100-400 ws) in those who relapsed.

Sixteen patients with multiple valve replacements had a slightly greater initial success rate (75%) than those with only mitral valve replacement. Relapse in this group, however, was more frequent (only 31% of the group with multiple valve replacements remain in sinus rhythm as compared to 43% of the group with single valve replacement). Relapse most commonly occurred 1 to 4 weeks following cardioversion (fig. 1). The mean time of relapse was 2½ months following conversion.

**Discussion**

There are several advantages to restoring sinus rhythm following mitral valve replacement. Cardiac output is enhanced, the risk of embolization is less, the heart rate is lower at rest and during exercise, palpitation is re-

<table>
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<tr>
<th>Table 3</th>
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<tbody>
<tr>
<td><strong>Comparison of the Initial and the Follow-up Success of Cardioversion Attempted Several Days Following Surgery (Early) and Several Months Following Surgery (Late)</strong></td>
</tr>
<tr>
<td>Cardioversion Time</td>
</tr>
<tr>
<td>Early</td>
</tr>
<tr>
<td>Late</td>
</tr>
</tbody>
</table>

*Data on the 40 patients on whom follow-up information was available 2 to 26 mo (mean 10 mo), after cardioversion.

**Table 4**

<table>
<thead>
<tr>
<th>Factors Related to Success and Maintenance of Sinus Rhythm</th>
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</thead>
<tbody>
<tr>
<td>No.</td>
</tr>
<tr>
<td>Atrial fibrillation less than 5 yr</td>
</tr>
<tr>
<td>Atrial fibrillation more than 5 yr</td>
</tr>
<tr>
<td>Small-to-moderate left atrial enlargement at time of cardioversion</td>
</tr>
<tr>
<td>Large left atrium at time of cardioversion</td>
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</tbody>
</table>

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lieved, and subjective improvement is experienced by most patients. Therefore, an attempt to attain sinus rhythm in all patients with postoperative atrial fibrillation seems warranted, and an evaluation of the problem of cardioversion following mitral valve surgery is indicated.

In contrast to the normal left atrial pressures usually seen after mitral valve replacement surgery, elevated left atrial pressures have been shown to exist more frequently following closed valotomy. It is important, therefore, to compare results obtained in the present study with those obtained following various types of mitral valve operations. A summary of this comparison is shown in figure 2. With valve replacement or open cardiac surgery, final success rates of 37%, 50%, and 40% have been observed by Selzer and Yang with their associates, and in the present series, respectively. With closed mitral valve surgery, final success rates of 29%, 27%, and 48% have been reported by Korsgren, Selzer and Oram and their associates, respectively. The patients in the series reported by Oram and Davies apparently had less severe mitral valve disease than the patients in the present study for the following reasons: The mean duration of atrial fibrillation was only 32 months compared to 74.5 months in our study. In addition the mean follow-up observation time was only 5 months compared to our 10 months.

In view of these points, the results of cardioversion appear to be superior in patients
who have had mitral valve replacement surgery or open valvotomy. This view is strengthened by the fact that this group of patients usually has more advance mitral valve disease than those treated with closed valvotomy alone. For example, the duration of antecedent atrial fibrillation is longer and incidence of multiple valve disease is higher.

Is cardioversion more successful when performed several months after surgery or when performed at the end of the immediate postoperative period? In the present study initial success was slightly greater in patients having cardioversion late but no difference was noted between the two groups in the final incidence of persisting sinus rhythm. Since the overall results in both groups were essentially similar, there appears to be no reason to defer cardioversion unless persisting failure or other factors are present that would make initial success unlikely.

Despite the favorable results presented in this report, failure to achieve sinus rhythm or relapse to atrial fibrillation occurred in approximately 60% of patients. Clearly, factors other than the level of left atrial pressure are responsible for the persistence of atrial fibrillation in these patients. Long duration of atrial fibrillation prior to corrective surgery may have resulted in organic changes in the atrial myocardium that do not permit the return of a normal sinus rhythm. Lack of coordinate atrial contraction could result in muscle atrophy. The presence of marked enlargement of the left atrium may be a sign of diffuse scarring and fibrosis of the left atrium secondary to rheumatic myocarditis, atrial thrombosis, or chronic elevation of left atrial pressure.

Complications were infrequent in the present series. All patients were receiving anticoagulants prior to conversion. No embolic episodes occurred at the time of, or following, the procedure. Only transient arrhythmias in the form of ventricular premature beats, atrial premature beats, nodal beats, and ventricular bigeminy occurred for several minutes following cardioversion in 42% of patients. An arrhythmia consisting of sinus rhythm with intermittent A-V dissociation and nodal rhythm appeared in one patient. This is shown in figure 3. This arrhythmia followed a DC discharge of 400 ws. Such rhythms have been seen in patients who have atrial fibrillation with a ventricular rate of less than 60,19 in those with either digitalis toxicity or those who have not had digitalis stopped for at least 24 hours prior to cardioversion,8, 20–22 and in those who have atrial fibrillation with a nodal rhythm.19 Lown8 and Paulk and Hurst19 have shown that when higher energies are required for reversion,

Figure 3

Unstable sinus and nodal rhythm occurring after a 400 ws discharge in a patient who relapsed to atrial fibrillation 30 days after cardioversion.
Arrhythmias are more likely. Killip\textsuperscript{29} has suggested that a nodal rhythm may develop following cardioversion if a diseased sinus node cannot resume pacemaking function.

Two patients died during the time of follow-up study. In one, death was related to severe serum hepatitis that occurred 11 weeks after mitral valve replacement. Sinus rhythm persisted until 4 days prior to death when atrial flutter appeared. In the other patient cardioversion had been performed for a second time with restoration of sinus rhythm, and 10 days later, sudden death occurred. The patient was known to be in sinus rhythm on the day prior to death. His postconversion rhythm was sinus with occasional ventricular premature beats, and he was taking quinidine, 0.8 g a day, and tolerating this well. Postmortem examination failed to reveal evidence of emboli or a specific cause of death. The incidence, then, of sudden death in the present series is 2\%, similar to the 2.5\% to 4\% incidence quoted in the literature of sudden death in patients with chronic atrial fibrillation.\textsuperscript{15}

Thus, the incidence of sudden death in this series corresponds to what one would expect during long-term observation of patients with chronic and severe cardiac disease.

Are repeated attempts at cardioversion warranted? In two patients who initially failed to revert, a second attempt at cardioversion was also unsuccessful. In three other patients who maintained sinus rhythm for only several days following the first attempt, a repeat cardioversion was done several months later and was successful in two. In one of these patients, chest roentgenograms made at the time of the second cardioversion showed further decrease in left atrial size; relapse had not occurred 6 weeks later. The second patient died suddenly 10 days after the repeat successful cardioversion as described above. In the third patient a second attempt was unsuccessful. This patient had a moderate to marked enlargement of the left atrium and could not maintain sinus rhythm for more than a week.

Korsgren and co-workers\textsuperscript{10} did not feel that attempting repeat cardioversion in those who relapsed within 2 months was justifiable. Although maintenance of sinus rhythm following late cardioversions (41\%) does not significantly differ from that following early cardioversions (38\%), in selected patients who failed initially, repeating the cardioversion after several months may result in success. This appears to be demonstrated by the patient just mentioned. These data support the view of Paulk and Hurst\textsuperscript{19} that attempting repeat cardioversion should be determined on an individual basis. Later repeated attempts at DC conversion may indeed be indicated in patients with valve replacement, who initially relapse but who appear to have a good surgical result and have been fibrillating for only a short time.

\textbf{Addendum}

Since this manuscript was completed, an additional 20 patients with chronic atrial fibrillation and mitral valve replacement have undergone cardioversion. Normal sinus rhythm was attained in 11 (55\%). After a mean follow-up period of 3 months (1 to 6 mo) 8 patients (40\%) remained in normal sinus rhythm. These data do not significantly change the data presented in this paper. Thus, the overall experience in 80 patients reveals an initial success rate of 65\% and a final success rate of 40\%.

\textbf{Acknowledgment}

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