In summary, we report the first patient with bilateral pneumothoraces, bilateral empyemas and bacteremia resulting from the common practice of illicit drug injection into the internal jugular veins. Needle marks in the subclavicular area in dyspneic patients suspected of intravenous drug abuse should alert physicians to the possibility of these potentially life-threatening complications.

**References**


**Concealed Ventricular Bigeminy with Exceptions due to Time-Dependent Modulation of an Ectopic Rhythm**

Giuseppe Oretto, M.D.,* Gaetano Satullo, M.D.,* Francesco Luna, M.D.,* and Leo Schamroth, M.D., F.C.C.P.†

This presentation reflects a case of atypical concealed bigeminy, where some interectopic intervals contain even numbers of sinus beats. Exceptions to the rule of concealed bigeminy only occur during slowing of the sinus node. The pattern is explained on the basis of modulated parasystole, by drawing a phase-response curve which explains all the interectopic intervals on the basis of the modulating effect exerted by the sinus impulses upon a parasystolic focus.

The term, concealed bigeminy, was introduced by Schamroth and Marriott† to describe a peculiar pattern of intermittent extrastysotolic ventricular bigeminy where the interectopic intervals always contained odd numbers of sinus beats. Additional cases have since been described where ventricular extrastostoles were separated by intervening sinus beats in numbers conforming to formulae different from those initially reported for concealed bigeminy (2n-1) and concealed trigeminy (3n-1). Cases with long-term pattern of pure concealed bigeminy indeed are relatively rare. Thus, more often, odd numbers of intervening sinus beats are prevalent and predominant, but some interectopic intervals contain sinus beats in even numbers.

It was originally suggested, and recently restated, that concealed bigeminy can be explained on the basis of a modulated parasystole: a parasystolic focus which is electrotonically influenced by the sinus impulses. This was confirmed experimentally by Jalife and Moe, and associates. Antzelevitch and associates, and Rosenthal and Ferrier. This presentation reflects a case of atypical concealed bigeminy, where some of the interectopic intervals contain even numbers of intervening sinus beats. The occurrence of both odd and even numbers of intervening beats is explained on the basis of a time-dependent influence which is exerted by the sinus impulses upon an ectopic focus.

**Case Report**

The electrocardiogram was recorded from a 65-year-old woman with diabetes mellitus and angina pectoris. Figure 1 (section of a continuous 6-minute recording of standard lead 2) reflects numerous uniform ventricular extrasystoles with almost constant coupling intervals. The distributional pattern of the extrasystoles is typical for concealed bigeminy with the intervening sinus beats in odd numbers. The intervening beats were nearly always in odd numbers, apart from a few exceptions which only occurred during slowing of the sinus node (Table 1). Figure 2 shows the effect of carotid sinus compression. The vagally induced sinus slowing is associated with a change in the extrastysolic pattern. The intervening sinus beats are now in even numbers, etc. Contrariwise, as the sinus rate increases, following the end of carotid sinus pressure, the pattern of concealed bigeminy reappears, as is revealed by the last interectopic interval of Figure 2 which contains three intervening sinus beats.

Ectopic ventricular beats will hereafter be termed X, whereas sinus beats will be termed R. The sinus beats contained in each interectopic interval are numbered progressively as Rn, Rx, Rn, etc.

**Discussion**

This electrocardiogram demonstrates that the maintenance of concealed bigeminy depends (within certain limits) on the constancy of the sinus rate. Thus, a definite slowing of the sinus node induced by carotid sinus stimulation changes the distributional pattern of the extrasystoles from the typical form of concealed bigeminy to an even variant. This suggests that the time intervals between an ectopic complex and the ensuing sinus beats play a role in determining the extrastysotic distributional pattern. Such a relationship between sinus rate and extrastysotic distribution could be the expression of a time-dependent influence exerted by the sinus impulses upon an automatic focus. Such an influence occurs in modulated parasystole. Thus, Jalife and Moe showed that a parasystolic focus may be electrotonically influenced or modulated by the sinus impulses. The ectopic impulse may be delayed or accelerated, with respect to the scheduled discharge, according to the timing of the sinus impulses within the ectopic cycle. Thus, relatively early sinus impulses delay the ensuing parasystolic discharge, whereas relatively late sinus impulses accelerate the next.
parasystolic discharge. This is expressed by a biphasic phase-response curve. As a consequence of the modulation, the parasystolic cycle may undergo distinct variations, so much so that the mathematical relationship between the interflecopic intervals is absent, and the underlying parasystolic mechanism no longer evident. Even the coupling intervals may become fixed.

Laboratory studies performed with a mathematic model of parasystole have revealed that concealed bigeminy can represent a form of modulated parasystole, where the ratio between the parasystolic cycle and the sinus cycle is slightly less than 2.3.

It has recently been reported that clinical examples of typical concealed bigeminy may be interpreted by drawing a phase-response curve which explains all the interflecopic intervals on the basis of the time-dependent modulating effect exerted by the sinus impulses upon an otherwise rhythmic ectopic focus. The present case of concealed bigeminy with exceptions can be viewed in terms of this study, on the assumption that the arrhythmia is generated by a regularly discharging parasystolic focus modulated by the sinus impulses.

The diagnosis of modulated parasystole is based upon the derivation of a phase-response curve which can be deduced as follows:

1) The true or unmodulated ectopic cycle is not evident from the tracing, since two consecutive ectopic beats, not separated by sinus complexes, do not manifest. The true ectopic cycle, however, can be approximated. The calculation is based on the sinus cycle length, since in concealed bigeminy the ratio between the ectopic cycle and the sinus cycle is 2.5 or less, and since the mean sinus cycle length is 0.82 s, the true parasystolic cycle length would have to be about 1.9 s.

2) In concealed bigeminy, the interflecopic intervals containing one single sinus beat (X-R,X) correspond to shortened parasystolic cycles. Thus, the true ectopic cycle must be longer than the longest X-R,X interval, namely longer than 1.65 s.

3) The true parasystolic cycle must be longer than any X-R,X interval. Had the true ectopic cycle been shorter than any X-R,X interval, then two consecutive parasystolic beats would have appeared, thereby revealing the true parasystolic cycle; since the longest X-R,X interval measures 1.7 s (Fig 2, middle strip), the true ectopic cycle must be longer than this value.

4) In concealed bigeminy due to modulated parasystole, beat R always occurs in the negative or acceleration phase of the phase-response curve. Thus, the reversal point of the curve must be earlier than any R, beat, namely, earlier than 0.93 s.

**Table 1—Analysis of Number of Intervening Sinus Beats from Complete ECG Recording**

<table>
<thead>
<tr>
<th>No. intervening sinus beats</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>6</td>
<td>*</td>
<td>12</td>
<td>*</td>
<td>3*</td>
<td>35</td>
<td>1*</td>
<td>1</td>
<td>1*</td>
<td>2</td>
<td>1*</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1</td>
</tr>
</tbody>
</table>

* = Exceptions to the formula of concealed bigeminy.
Based on these assumptions, a phase-response curve was constructed using a method of trial and error. The reversal point was fixed at 0.9 s, while the assumed true ectopic cycle was increased by steps of 0.02 s starting from the minimal possible value of 1.72 s. The curve best fitting the data was obtained using a true ectopic cycle of 1.80 s with a reversal point at 50 percent. This curve is reflected in Figure 3, and explains all the features of the tracing, as depicted in the diagrams of Figures 1 and 2. The diagram of Figure 1 reflects the typical concealed bigeminy. Every \( R_1 \) beat accelerates the ensuing ectopic discharge to the extent that the parasystolic impulse falls roughly at the end of the refractory period of the myocardium surrounding the focus. The ectopic impulse thus can be modulated as follows:

1) If it occurs after the end of the refractory period (impulses labelled \( a \) and \( b \)) it will be manifest, giving rise to an ectopic complex.

2) If it occurs within the refractory period (impulse labelled \( c \)) it will be concealed. Under this circumstance, beat \( R_1 \) is followed by \( R_n \), which occurs very early in the ectopic cycle and, according to the phase-response curve, causes but a slight delay of the next parasystolic impulse. Beat \( R_n \) in turn, is late within the ectopic cycle, and accelerates the ensuing parasystolic discharge. The ectopic impulse following \( R_n \) (impulse \( d \)) is delivered once again at or after the end of the refractory period. This impulse could therefore be: (a) manifest, and if so, the interectopic interval would contain three intervening sinus beats, or (b) concealed, as is actually the case. Consequently, \( R_n \) will behave like \( R_n \) and \( R_n \) like \( R_n \). The ectopic impulse following \( R_n \) (impulse \( e \)), however, is manifest, so that five intervening sinus beats occur. It is thus evident that the sinus beats with odd numbers (\( R_n \), \( R_n \), \( R_n \), etc) always accelerate the next parasystolic impulse, whereas the sinus beats with even numbers (\( R_n \), \( R_n \), \( R_n \), etc) delay it.

The maintenance of concealed bigeminy is based on this mechanism, which can persist as long as the sinus rate does not exceed a definite range. Contrariwise, a critical variation

![Figure 2. A continuous recording of standard lead 2. Symbols as in Figure 1. Carotid sinus compression has been performed in the section between the arrows (see text).](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21575/)

![Figure 3. Phase-response curve deduced from analysis of the case. The triangles correspond to the modulating effect exerted by the sinus impulses during carotid sinus pressure. The abscissa reflects the ectopic cycle length percentage. The ordinate reflects the positive or negative variations of the ectopic cycle length, expressed as a percentage of the basic value.](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21575/)
of the sinus rate alters the distributional pattern of the extrasystoles. This is demonstrated in Figure 2, where some exceptions to the formula of concealed bigeminy manifest. The diagram under the middle strip reveals that after the first X beat, R₈ occurs at 1.44 s, thereby accelerating the ensuing parasystolic impulse, which is concealed. Beat R₈, in turn, delays the next parasystolic discharge. The delay induced by R₈, however, is more marked, when compared with that provoked by beats R₆ during typical concealed bigeminy. Such an inordinate delay occurs because, as a result of the slower sinus rate, beat R₈ occurs earlier in the ectopic cycle than happens with a faster sinus rate. For example, in Figure 1, beat R₈ (the 7th beat in the top strip) occurs at 16.5 percent of the ectopic cycle, delaying the next parasystolic impulse by 0.04 s. Contrariwise, in the middle strip of Figure 2, beat R₈ (the 3rd beat) occurs at 43 percent of the ectopic cycle, near the reversal point of the phase-response curve. The ensuing parasystolic impulse will accordingly suffer greater delay (0.36 s) than in Figure 1. Moreover, in the second strip of Figure 2, beat R₈ occurs very late within the ectopic cycle (at 91.5 percent), so that its modulating effect is irrelevant. Beat R₈, in turn, is relatively late, occurring at 58 percent of the ectopic cycle, namely, after the reversal point. The next parasystolic impulse is thus accelerated, giving rise to a manifest ectopic beat which occurs after four intervening sinus complexes. This behavior is clearly different from that of typical concealed bigeminy, where each even numbered sinus beat (R₈, R₆, R₄, etc) occurs within the first section of the phase-response curve, the phase of delay. It is worth noting that the change from typical concealed bigeminy to the even variant of concealed bigeminy associated with sinus rate variations has already been described. 

The tracing reported here does not reflect any of the classic diagnostic criteria for parasystole. The coupling intervals of the ectopic beats, indeed, are almost fixed, and the interectopic intervals are not mathematically related. Nevertheless, it is possible to construct a typical phase-response curve which explains all the interectopic intervals according to a constant ectopic cycle modulated by the sinus impulses. It could possibly be questioned whether this pattern can still be defined as parasystole or not. In any event, it does express a time-dependent biphasic (delay/ acceleration) influence exerted by the sinus impulses upon an automatic focus. This interpretation conforms with experimental and clinical data. 

After the initial report by Schamroth and Marriott, several variant types of concealed extrasystoles were reported, namely, cases where the intervening sinus beats were in even numbers (even variant of concealed bigeminy) or conform to atypical formulae. It is likely that both the classic patterns of concealed extrasystoles and the variant patterns express a unique mechanism where the distribution of the ectopic beats is governed by the relationship between the ectopic cycle length and the sinus cycle length. Following critical variations of the sinus rate and/or of the ectopic pacemaker rate, a transition from the typical concealed bigeminy to a variant pattern can occur, resulting in coexistence of odd and even numbers of intervening sinus beats.

ACKNOWLEDGMENT: This study was supported by a grant from the South African Medical Research Council.

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Double Valve Replacement and Coronary Artery Bypass in a Patient with Chronic Osteomyelitis

Pedro A. Rubio, M.D., F.C.C.P.,* and Mahdi S. Al-Bassam, M.D.†

Implantation of a prosthetic heart valve is generally contraindicated in the presence of infection. A 68-year-old man with chronic osteomyelitis underwent successful double valve replacement, combined with coronary artery bypass, after his draining osteomyelitic fistula was controlled with antibiotics. During the 30 months since surgery, he has shown no sign of paravalvular leakage or infectious complications.

Combined valve replacement and myocardial revascularization has been the subject of several recent articles,1,2 which report various results. Although combined procedures continue to be a source of controversy, they are not, in themselves, regarded as extraordinary. The placement of prosthetic valves is generally contraindicated in the presence of infection, but such treatment can be undertaken before a complete bacterial cure has been achieved if significant hemodynamic compromise exists and if appropriate antibiotic therapy has been instituted for several days. The following case was unusual in that the patient underwent combined aortic valve replacement, mitral valve replacement, and aortocoronary bypass grafting in the presence of chronic osteomyelitis.

CASE REPORT

A 68-year-old man was admitted for evaluation of aortic and mitral valve disease, as well as coronary artery disease. During the month before admission, he had experienced decreasing exercise tolerance, which caused him to be limited to remaining at home, and secondary symptoms of congestive heart failure. He had two-pillow orthopnea, nocturnal paroxysmal dyspnea, and episodes of angina pectoris that manifested as precordial heaviness radiating to the left arm. The pain occurred with exertion and was relieved by rest. Thirty-five years earlier, a cardiac murmur had been noted. There was no history of diabetes, hypertension, hypercholesterolemia, gout, or rheumatic fever. The patient also had chronic osteomyelitis of the left femur, which apparently started with a fall when he was four years old. Drainage had been present for over ten years.

Upon admission, physical examination revealed blood pressure of 150/40 mm Hg, a regular pulse rate of 80/min, and respirations of 18/min. Examination of the heart disclosed the point of maximum impulse at the anterior axillary line. There was no left sternal border heave. The first heart sound was of normal intensity, but the second heart sound had a reduced aortic component. A grade 3/6 holosystolic murmur at the apex radiated to the axilla. There was also a grade 3/6 ejection systolic murmur at the apex, radiating along the sternal border into the aortic area and the neck. A grade 3/6 diastolic blow extended through the diastole; a ventricular gallop was also heard at the apex. Electrocardiography indicated left atrial enlargement and left ventricular hypertrophy, whereas a chest x-ray film showed left ventricular dilatation and findings compatible with congestive heart failure.

The results of cardiac catheterization and coronary angiography performed elsewhere revealed severe calcific aortic stenosis, severe mitral regurgitation, and 95 percent stenosis of the left anterior descending coronary artery.

Because a chronic draining sinus was present in the left hip, an infectious disease consultation was obtained. Osteomyelitis with a chronic fistula was diagnosed, and both a culture specimen of the draining sinus and a Craig needle biopsy of the femur revealed Staphylococcus aureus. Owing to the patient's allergy to penicillin, he was treated with intravenous cefuroxime (1.5 g. q8h) and oral rifampicin (600 mg, qd) for 14 days before clearance for surgery was obtained.

On the 15th day, the patient underwent mitral valve replacement (with a No. 31 St. Jude valve), aortic valve replacement (with a No. 25 St. Jude valve), and saphenous vein bypass grafting from the ascending aorta to the left anterior descending coronary artery without incident. Total cardiopulmonary bypass, moderate systemic hypothermia (25°C), and cardioplegic arrest (4°C) were used. Pathologic examination revealed fibrosis, fusion, and heavy calcification of the aortic valve, as well as thickening of the mitral valve leaflets and fusion of the chordae tendineae.

The patient was treated postoperatively with intravenous cefuroxime (1.5 g, q8h) and intravenous vancomycin (500 mg, q8h) for 14 days. His postoperative course was uneventful, and he was discharged from the hospital two weeks after surgery on a regimen of cephalixin (Keftix) (500 mg, po qid for 30 days), to suppress the infection at the site of osteomyelitis in the left femur; he was also placed on a regimen of digoxin (0.25 mg, po daily); furosemide (Lasix) (40 mg, po daily); spironolactone (Aldactone) (50 mg, po bid); disopyramide (Norpace) CR (150 mg, po bid); diprydamole (Persantine) (75 mg, po bid); and warfarin (Coumadin) (10 mg, po daily), as well as a 2-g/day sodium diet and progressive ambulation.

The patient's fistula closed one month after surgery, and his chronic osteomyelitis has remained localized. From a cardiac standpoint, he has done quite well. Approximately nine months after surgery, M-mode and two-dimensional echocardiography revealed paradoxical septal motion with a suggestion of right ventricular enlargement at 3.3 cm, prosthetic aortic and mitral valves with apparent normal openings, and good left ventricular contraction. Treadmill stress test result was normal. At his most recent checkup, 39 months after surgery, the M-mode and two-dimensional echocardiographic findings and the treadmill stress test remained the same. No paravalvular leak has been detected, and, except for standard prophylactic treatment before dental work or invasive procedures, routine antibiotics are not required.

DISCUSSION

Thirty to 50 percent of patients who require aortic or mitral valve replacement also have coexisting coronary atherosclerosis.3 If the valvular disorder alone is corrected, the remaining coronary artery disease often underlines the effect of the successful valve repair. Combined double valve replacement and coronary artery bypass is relatively rare.4,5,6,7,8 Our case was unusual in that these procedures...