Retrograde Conduction in Complete Heart Block*

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In complete heart block, absolute independence between atrial and ventricular activity does not always occur. Several mechanisms may be postulated to explain this phenomenon. One is incomplete atrio-ventricular block; another is atrio-ventricular synchronization and accrochage (Marriott, 1956; Schubart, Marriott, and Gorten, 1958; Ettinger, 1965). A third possibility rarely considered is unidirectional block in the atrio-ventricular conduction system, that is, forward block may exist in complete atrio-ventricular block but retrograde ventriculo-atrial conduction may be preserved. The purpose of this report is to present relevant data in 7 patients with complete heart block studied with bipolar catheter electrodes in both right atrium and right ventricle. An eighth patient with 2:1 atrio-ventricular block was investigated by similar techniques. Gubbay and Mora (1964) have previously reported a patient with complete heart block in whom right ventricular pacing resulted in retrograde ventriculo-atrial conduction, with suppression of the sinus node by raising the rate of the ventricular stimulus. Fusion P waves were also observed. Unlike our cases, retrograde conduction and retrograde P waves were evident in the control electrocardiogram before institution of ventricular pacing. Winternitz and Langendorf (1944) have also described retrograde ventriculo-atrial conduction in complete heart block.

SUBJECTS AND METHODS

Seven patients with complete heart block and idio-ventricular rhythm and one with 2:1 block were studied, whose ages ranged from 62-76 years. In five, the cause was arteriosclerotic heart disease, and in three, it was heart disease of undetermined aetiology.

A 3.5 bipolar catheter† was passed to the right ven-

tricular outflow tract for ventricular pacing. A second 3.5 bipolar catheter* was passed to the right atrium. A 100 cm. No. 6F Lehman catheter was passed into the pulmonary artery under fluoroscopic guidance. The femoral artery was cannulated with a Cournand needle. The right atrial unipolar electrocardiogram was recorded simultaneously with lead II during the control rhythm and during ventricular pacing. A Medtronic stimulator‡, model 5038, was used in all studies. Currents of 5-7 mA. were used, with pulses of 2 msec. duration.

RESULTS

Data in a patient with complete heart block are shown in Fig. 1, at a paper speed of 25 mm./sec., 1.0 sec. time lines to the left, and 75 mm./sec., 0.02 sec. time lines to the right. Lead II and the right atrial electrocardiogram illustrate a paced right ventricular rate of 47 a minute; the sinus P wave rate is 72 a minute. The femoral and pulmonary arterial pressure curves are also shown. When the right ventricular pacing rate is increased to 80, each stimulus-QRS complex is followed by a retrograde P wave (Fig. 2, left side). When the pacing rate is decreased to 70, the sinus rate of 72 is uncovered. The sinus P-P time interval is 0.84 sec.; the retrograde P-P interval is 0.74 sec. When the ventricular rate is increased to 85, each QRS complex is again followed by a retrograde P wave; the retrograde P-P interval is 0.69 sec. Retrograde P waves are thus present when the paced ventricular rate exceeds the sinus atrial rate.

Comparable data are shown in another patient (Fig. 3, left side). The control ventricular paced rate is 66; the sinus rate is 79. Complete heart block is present. When the pacing rate is increased to 91 a minute, each QRS complex is followed by a retrograde P wave (Fig. 3, right side).

The data in a third patient are shown in Fig. 4. The control electrocardiogram demonstrates complete heart block (Fig. 4, left side). In Fig. 4 (right

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FIG. 1.—Electrocardiogram in a patient with complete heart block during right ventricular pacing. The sinus P waves are independent of the QRS complexes. The atrial rate is 72.

FIG. 2.—When the right ventricular pacing rate is increased above the control sinus rate (72), retrograde P waves appear, with identical atrial and ventricular rates at 80. When the ventricular paced rate is 70, the atrial P wave rate remains 72/minute.

FIG. 3.—*Left*: electrocardiogram in another patient with complete heart block. The paced ventricular rate is 66; the atrial rate is 79. *Right*: when the pacing rate is increased to 91, retrograde P waves appear at the same rate of 91/minute.

side), the ventricular rate has been raised to 80 by ventricular pacing. Each QRS complex is followed by a retrograde P wave best seen in the right atrial electrocardiogram. Similar data were obtained at a paced ventricular rate of 70. In all 3

subjects mentioned above, retrograde P wave conduction was present when the paced right ventricular rate was increased to a level greater than the control sinus rate.

Similar findings are presented in a patient with

FIG. 4.—*Left*: electrocardiogram demonstrating complete heart block in a third patient. *Right*: at a ventricular rate of 80, retrograde P waves at a rate of 80 are evident.

FIG. 5.—Left: electrocardiogram during 2:1 atrio-ventricular block in a fourth patient. Right: two varieties of P waves are evident during right ventricular pacing, i.e. sinus P waves (S.P.) and retrograde P waves (R.P.).

FIG. 6.—Same patient as in Fig. 5. At a ventricular paced rate of 71, the atrial rate is also 71. Retrograde P waves are evident.

FIG. 7.—Complete heart block in a fifth patient. When the paced ventricular rate is 90, the atrial rate remains 60 without retrograde P waves.

2:1 atrio-ventricular block (Fig. 5, left side). During right ventricular pacing, a continuous recording of lead II (Fig. 5, right side) reveals two varieties of P waves. The first, labelled S.P., represent sinus P waves, the second, labelled R.P., represent retrograde P waves. At a paced ventricular rate of 71, there are retrograde P waves following each QRS complex (Fig. 6).

Not all patients with complete heart block exhibit retrograde P waves on right ventricular pacing at rates above the control sinus rate (Fig. 7). When the ventricular rate is increased to 90 the atrial rate remains at 60 (Fig. 7); the shape of the P wave remains unaltered from the control sinus P form, and the P waves do not follow each QRS complex. In all, 4 of 7 patients with complete heart block and 1 with 2:1 atrio-ventricular block, exhibited retrograde P waves during right ventricular pacing.

DISCUSSION

Retrograde P waves following ventricular premature systoles are relatively well known (Kistin and Landowne, 1951). Retrograde P waves in patients with complete heart block are less familiar but have been described (Bellet, 1963; Katz and Pick, 1956; Gubbay and Mora, 1964; Winternitz and Langen-

dorf, 1944). Such observations can best be explained by unidirectional atrio-ventricular block, i.e. block to forward conduction without corresponding block to retrograde conduction. The exact mechanism for such unidirectional block is uncertain. The phenomenon of synchronization (Segers, 1946; Jacobs, Donoso, and Friedberg, 1961) seems to us to be an unsatisfactory explanation, since retrograde P waves appeared only when the paced ventricular rate exceeded the control sinus rate in the present study. If mechanical synchronization were the explanation, this relation between atrial and ventricular rates would not be anticipated. The possibility of a mechanism for retrograde conduction other than the A-V node and His bundle system cannot be eliminated. Further studies are required to explain the unidirectional block. The existence of unidirectional block suggests that complete atrio-ventricular block may be caused not only by fixed discrete constant lesions, but also by pathology that is variable in electrocardiographic consequence. The not infrequent temporary reversion of complete heart block to normal sinus rhythm is also in keeping with this concept.

The concept of concealed retrograde conduction in the atrio-ventricular node in patients with atrio-ventricular dissociation has recently been discussed

(Schamroth and Friedberg, 1965). This phenomenon does not shed light on the problem of unidirectional block.

SUMMARY

The right atrial electrocardiogram was recorded in seven patients with complete heart block and one subject with 2:1 atrio-ventricular block during right ventricular pacing with bipolar electrode catheters. In 4 of the former patients and in the latter subject, retrograde P waves were detected. The cause of the dissociation between forward and retrograde block is unknown, and further studies are required to elucidate this phenomenon.

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