Bidirectional Conduction through the A-V Junction*

Allan H. Harris, M.D.,** and Harman A. Shecket, M.D.†

Eleven patients who had a sinus rhythm with PVC's were studied with a bipolar esophageal lead for a total of 41 evaluations. Four of these patients had a varying degree of prematurity of the ventricular extrasystole. In these patients it was demonstrated that in the human heart the impulse can be conducted in an antegrade or retrograde fashion through the A-V junctional tissue. The direction of conduction is dependent upon the degree of prematurity of the preceding ventricular extrasystole. These findings support the premise that the human heart has the capacity of bidirectional conduction through the A-V junction.

Retrograde conduction in the human heart was thought to be a rare phenomenon* until the work of Kistin and Landowne5 who found that conduction to the atria from PVC occurred in 15 to 33 patients they studied. The result of this study was contrary to accepted principles at that time since the presence of a consistent retrograde block at the level of the A-V node was believed to be the "normal" circumstance in the human heart. In accord with their findings Kistin and Landowne questioned the validity of this theory believing that bidirectional conduction through the A-V node probably was "a normal" occurrence. Bussan and co-workers6 repeated the study and found that in nine of ten patients they investigated retrograde conduction was present. However, they eliminated 25 patients from their statistics because of the presence of sinus arrhythmia or sinus tachycardia; thus the true incident in this study is obscure.

One of the conditions that determines whether retrograde conduction will occur following a PVC is the degree of prematurity of the ventricular extrasystole. If bidirectional conduction through the A-V junction is present in the human heart, it should be possible to demonstrate retrograde conduction associated with PVC's that occur "early" in the electrical cycle and antegrade conduction associated with PVC that occur later.

The purpose of this investigation was to determine whether varying degrees of prematurity of a ventricular extrasystole can be associated with a reverse in the direction of the impulse traversing the atria once a primary direction of atrial depolarization has been established.

Patient Selection and Method

Eleven hospitalized and ambulatory patients having sinus rhythm with PVC's are the subject of this study. No patient was receiving medication directed at suppressing the PVC's at the time of their evaluations. Patients were selected without regard to age, sex or type of cardiac disease.

Using a standard Cambridge ECG machine a long rhythm strip of standard lead II was obtained. A bipolar esophageal lead (BEL*) was then passed into the esophagus so that the distal end was 40 cm from the external nares. The terminals leading to the distal end and proximal electrodes of the BEL were then connected to the LA and RA terminals of the patient cable. Under ECG monitoring of "lead I," the BEL lead was maneuvered to a position that produced the greatest P wave deflection. No attempt was made to standardize the orientation of the P wave so that it was positive in some patients and negative in others.

An esophageal electrogram was obtained every five minutes.

*From the Department of Cardiology, Polyclinic Hospital, Cleveland.
**Clinical Instructor in Medicine, Case Western Reserve School of Medicine; Director, Coronary Care Unit, Polyclinic Hospital.
†Senior Clinical Instructor, Case Western Reserve School of Medicine; Director, Division of Medicine, Polyclinic Hospital.

Reprint requests: Dr. Harris, 902 Rose Bldg., Cleveland 44115

CHEST, VOL. 62, NO. 4, OCTOBER, 1972

403
Table 1

<table>
<thead>
<tr>
<th>PT</th>
<th>P-X*</th>
<th>A-C**</th>
<th>R-C†</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.52</td>
<td>+</td>
<td></td>
<td>80</td>
</tr>
<tr>
<td>2</td>
<td>.48</td>
<td>+†</td>
<td></td>
<td>84</td>
</tr>
<tr>
<td>3</td>
<td>.59</td>
<td>+</td>
<td></td>
<td>84</td>
</tr>
<tr>
<td>4</td>
<td>.41</td>
<td>+</td>
<td></td>
<td>90</td>
</tr>
<tr>
<td>5</td>
<td>.56</td>
<td>+</td>
<td></td>
<td>90</td>
</tr>
</tbody>
</table>

*P-X—Interval measured from beginning of PVC to preceding sinus P wave (measured in hundredths of a second). The figure is a mean of a number of intervals measured.

**A-C—Antegrade conduction.
†R-C—Retrograde conduction.
‡+—Direction of conduction through the atria following a PVC.
§Group 1—Retrograde conduction as primary occurrence.
*Group 2—Antegrade conduction as primary occurrence.


Results

All patients tolerated well the electrode for the entire study period. Four patients were omitted from the study due to the presence of sinus arrhythmia.

Group 1

Retrograde conduction: In seven patients it was found that the primary mechanism was retrograde conduction following a PVC. However, three of these patients exhibited occasional PVCs that were associated with antegrade conduction originating from the SA node. Figures 1 through 3 are the esophageal electrograms of these three patients (case 1-3 of Table 1). Each rhythm strip shows a PVC associated with antegrade conduction and one associated with retrograde conduction of the atria. The P-X interval (I) of the PVC associated with antegrade conduction was always greater than the corresponding interval associated with retrograde conduction. This finding was constant for all three patients (Table 1). In the other four patients in this group, the degree of prematurity of the ventricular extrasystoles never varied.

Group 2

In four patients antegrade conduction following a PVC was the primary mechanism. In one of these patients retrograde conduction constantly occurred following the second extrasystole when coupled PVCs appeared (Fig 4-case 4). The P-X interval of the PVC associated with antegrade conduction is .56 seconds and the corresponding interval of the PVC associated with retrograde conduction is .41 seconds (Table 1-case 4). The P-X interval of the PVC associated with antegrade conduction is .41 seconds (Table 1-case 4). This finding was constant throughout the entire evaluation of this patient. In the three other patients in this group the degree of prematurity was constant and never demonstrated retrograde conduction. As seen in Table 1, the PVCs that were associated with retrograde conduc-

![Figure 1](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21547/)

FIGURE 1. Esophageal electrogram of case 1. The first PVC (X) of the tracing is associated with retrograde conduction to the atria (P'). The arrow denotes the retrograde P' wave which is premature and of a different configuration from the P waves of sinus origin. The P-X interval (I) is .52 seconds. The second PVC is associated with a P wave which originated from the sinus node (antegrade conduction). This P wave is of the same configuration as the other sinus P waves and is not premature. The P-X interval (I) is .58 seconds.
BIDIRECTIONAL CONDUCTION THROUGH A-V JUNCTION

FIGURE 2. Esophageal electrogram of case 2. The first PVC (X) is associated with a P wave of sinus origin. The P wave is not premature and of the same configuration as the other P waves of sinus origin. The P-X interval (1) is .59 seconds. The second PVC is associated with retrograde conduction to the atria (P'). The arrow points to the retrograde P' wave which is premature and is of different configuration from the P waves of sinus origin. The P-X interval (1) is .48 seconds.

Discussion

Retrograde conduction to the atria from a PVC occurred in seven of 11 patients, a frequency that parallels the findings of previous reports. The true incidence is obscure, however, and may well be meaningless since this study demonstrates the ability of the human heart to conduct in antegrade or retrograde fashion through the A-V junction depending upon the degree of prematurity of the preceding ventricular extrasystole. In the patients that demonstrated retrograde conduction as the primary mechanism, when antegrade conduction occurred, it was always associated with a PVC that was later in the electrical cycle than the PVC's that were associated with retrograde conduction. Conversely when antegrade conduction was the primary mechanism, retrograde conduction was always associated with PVC's that had a greater degree of prematurity. In their study, Bussan and co-workers found that retrograde conduction was usually associated with a heart rate of 80 per minute or less. Since PVC's usually occur at slower heart rates, they concluded that retrograde conduction following a PVC is probably a common phenomenon. Since the cardiac rate was constant when bidirectional conduction occurred, we believe that the relationship between the degree of prematurity and the cardiac rate, rather than the rate itself, is a major factor that determines whether retrograde or antegrade conduction will occur. However, we agreed that rapid rates will more likely be associated with antegrade conduction since under this condition it is more likely that the antegrade impulse will encounter refractory atrial tissue. Conversely, during slower rates, the degree of prematurity of the PVC would not have to be as marked to produce retrograde conduction since the excitable state of the atria would persist for a longer period.

FIGURE 3. A and B is the esophageal electrogram of case 3 (not a continuous rhythm strip). The first PVC (X in Fig 3-A) is followed by a P wave of sinus origin. The P wave is not premature and of the same configuration as the other P waves of sinus origin. The P-X interval (1) is .56 seconds. The second PVC (X in Fig 3-B) is followed by retrograde P' (arrow) which is premature. The P-X interval (1) is .54 seconds, which is only slightly shorter than the P-X interval associated with the antegrade conduction. The retrograde P wave is slightly altered in its configuration so that it might well represent a fusion "P" wave.
Retrograde conduction occurred following the second PVC each time coupled ventricular extrasystoles appeared. A P wave of sinus origin is superimposed upon the first PVC (X) of the coupled extrasystoles. Following the second ventricular extrasystole the retrograde P' wave is inscribed (arrow). The P-X interval (1) associated with the P wave of sinus origin is .56 seconds, while the same interval associated with retrograde conduction is .41 seconds.

Until the work of Kistin and Landowne, unidirectional antegrade conduction through the A-V node was considered the only "normal" sequence of activation in the human heart. By demonstrating that 15 of 33 patients conducted in a retrograde fashion to the atria following a PVC, these investigators challenged the existence of unidirectional retrograde block as a "normal occurrence." They suggested that the human heart normally has the capacity for retrograde conduction through junctional tissue, a phenomenon previously considered to be uncommon, probably due to the technique used to demonstrate retrograde P waves.

Recently Castillo and Castellanos and others demonstrated that the bundle of His was activated in a retrograde fashion following a ventricular extrasystole. Varying delays at the A-V junction were present and varied depending upon the degree of prematurity of the testing stimuli.

This study confirms the ability of the human heart to conduct in a bidirectional fashion through the A-V junction depending upon the degree of prematurity of a ventricular extrasystole.

REFERENCES


The Beginning of Claude Bernard's Scientific Career

The leading drama critic of Paris, Sorbonne Professor Saint-Marc Girardin, sighed. He shuffled the neatly written sheets; glanced again at a sentence, long and labored rhetoric. Slowly he turned, looked up at the tall, slim, handsome Burgundian youth, and said firmly: "You have done some pharmacy. Now study medicine. You have not the temperament of a dramatist." In that simple act, Professor Girardin served his country and society far better than he knew. The disappointed aspirant heeded his advice: France lost a potential playwright; she gained her greatest nineteenth-century physiologist, Claude Bernard (1813-1878).

Bender GA: Great Moments in Medicine, In Parke, Davis & Co.: A History of Medicine in Pictures, Detroit, Northwood Inst Press, 1966