Localization of the Aortic Valve by Intracavitary Electrocardiography

By William L. Underhill, M.D., Herman K. Hellerstein, M.D., John B. Tredway, M.D., and George J. D'Angelo, M.D.

In recent years, significant progress has been made in the development of more refined technics for diagnosing cardiac lesions. The aortic outflow tract presents a particularly challenging area for study, since a variety of lesions is known to cause obstruction in this area. These lesions have recently been classified as valvular, supravalvular, and subvalvular, the last being further subdivided into membranous, organic fibromuscular, and functional muscular types. In these reports, some clinical features of the different sites of obstruction are described and methods of study are suggested. Methods already described at length include refined physical examination, fluoroscopy, and hemodynamic technics including cardiac catheterization and cineangiography. One which has been little explored in

![Tracing obtained in patient S.C. with coronary insufficiency. An abrupt quantitative change in QRS amplitude is noted simultaneous with the change in pressure contour.](image)

**Figure 1**
LOCALIZATION OF AORTIC VALVE

LEAD II

ICE

PRESSURE

LEFT VENTRICLE

AORTA

Figure 2

Tracing obtained in patient M.H. with aortic valvular stenosis. Note the gradual decrease in QRS amplitude as the catheter is withdrawn through the outflow tract. Abrupt cessation as well as a qualitative change in QRS type is apparent as the catheter is drawn across the aortic valve.

the aortic outflow tract is the intracavitary electrocardiogram.

The advantage of this technic in cardiac catheterization has been emphasized by Dickens and Goldberg,14 who, in studying 50 patients, established that the basic pattern of depolarization remains essentially constant in the normal heart as well as in most anomalies. They advocated its use for accurate localization of the catheter tip, and showed how this technic might reduce radiation exposure. Emslie-Smith,15 in studying tracings taken in the region of the pulmonary valve, noted an abrupt change in the amplitude or type of complex in crossing the valve. This change has been confirmed in our laboratory and by Datey and Gandhi,16 who, however, recommended caution in interpretation, since the changes may not be constant.

If a similar change occurs in crossing the aortic valve, the advantage of this method of studying aortic outflow obstruction is obvious.

Materials and Methods

With use of electrode tip catheters or by recording through a column of 5-per cent saline as described by Luisada and Lui,17 intracavitary tracings were obtained in withdrawals across the aortic valve during retrograde left heart catheterization. Intracavitary pressures and electrocardiograms were recorded simultaneously with the peripheral electrocardiogram on a Sanborn 300 photographic recorder or a Cambridge direct-writing recorder. Measurements of QRS complexes were made in the left ventricular cavity, infundibulum, and root of the aorta, and QRS amplitude and type of complex were examined for changes in the valve area as indicated by pressure tracings. Other changes in the electrocardiogram including P waves were also noted.

The initial series of cases includes a variety of congenital and valvular heart lesions as well as a
few with no apparent cardiac disease. The bulk of the patients present no outflow abnormality; however, tracings have been obtained in three patients with valvular stenosis, in three with subvalvular obstruction, and in one with aortic insufficiency.

**Results**

Abrupt electrocardiographic changes at the aortic valve were observed in 28 of the 31 patients studied (table 1). Of the changes noted,
### Table 1

**Electrocardiographic Changes**

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Diagnosis</th>
<th>LV</th>
<th>Complex Type Infundibular</th>
<th>Aortic</th>
<th>LV</th>
<th>QRS Amplitude (mv.)</th>
<th>(mv.) Aortic Valve Change</th>
<th>Per cent change</th>
<th>Qualitative change</th>
<th>P-wave change</th>
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<tbody>
<tr>
<td>D.G</td>
<td>30</td>
<td>Mitral stenosis</td>
<td>QS</td>
<td>QS</td>
<td>qR</td>
<td>9</td>
<td>6</td>
<td>0.6</td>
<td>89</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>C.C.</td>
<td>6</td>
<td>Interatrial septal defect</td>
<td>QS</td>
<td>QS</td>
<td>QS</td>
<td>10</td>
<td>9</td>
<td>7</td>
<td>22</td>
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<td>J. M.</td>
<td>5</td>
<td>Normal</td>
<td>QS</td>
<td>QS</td>
<td>qr</td>
<td>9</td>
<td>6</td>
<td>0.6</td>
<td>89</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>S.C.</td>
<td>47</td>
<td>Coronary insufficiency</td>
<td>QS</td>
<td>QS</td>
<td>qS</td>
<td>9</td>
<td>6</td>
<td>0.6</td>
<td>89</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>D.A.</td>
<td>5</td>
<td>Truncus arteriosus</td>
<td>–</td>
<td>rS</td>
<td>QS</td>
<td>–</td>
<td>7</td>
<td>3</td>
<td>60</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>T.C.</td>
<td>47</td>
<td>Aortic valvular stenosis</td>
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<td>QS</td>
<td>QS</td>
<td>–</td>
<td>7</td>
<td>4</td>
<td>43</td>
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<tr>
<td>T.S.</td>
<td>11</td>
<td>Mitral insufficiency</td>
<td>–</td>
<td>QS</td>
<td>QS</td>
<td>–</td>
<td>10</td>
<td>4</td>
<td>60</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>S.G.</td>
<td>6</td>
<td>Aortic infundibular stenosis</td>
<td>QS</td>
<td>QS</td>
<td>QS</td>
<td>8</td>
<td>4</td>
<td>3</td>
<td>25</td>
<td>No</td>
<td>No</td>
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<td>N.L.</td>
<td>46</td>
<td>Aortic infundibular stenosis</td>
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<td>QS</td>
<td>QS</td>
<td>10</td>
<td>8</td>
<td>2</td>
<td>75</td>
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<td>E.C.</td>
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<td>QS</td>
<td>QS</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>25</td>
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<td>R.A.</td>
<td>47</td>
<td>Normal</td>
<td>OS</td>
<td>QS</td>
<td>QS</td>
<td>8</td>
<td>4.5</td>
<td>1.5</td>
<td>67</td>
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<td>P.T.</td>
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<td>QS</td>
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<td>QS</td>
<td>QS</td>
<td>8</td>
<td>4.5</td>
<td>2</td>
<td>56</td>
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<td>Yes</td>
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<tr>
<td>J.C.</td>
<td>18</td>
<td>Aortic insufficiency</td>
<td>QS</td>
<td>QS</td>
<td>Qrs</td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>67</td>
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<td>Yes</td>
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<tr>
<td>G.S.</td>
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<td>Normal</td>
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<td>QS</td>
<td>QS</td>
<td>9</td>
<td>8</td>
<td>1</td>
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<td>No</td>
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<td>Coronary insufficiency</td>
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<td>QS</td>
<td>QS</td>
<td>8</td>
<td>4.5</td>
<td>1</td>
<td>78</td>
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<td>31</td>
<td>Mitral insufficiency</td>
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<td>QS</td>
<td>qR</td>
<td>10</td>
<td>7</td>
<td>1.7</td>
<td>76</td>
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<tr>
<td>G.M.</td>
<td>51</td>
<td>Coronary insufficiency</td>
<td>QS</td>
<td>QS</td>
<td>rS</td>
<td>8</td>
<td>7</td>
<td>2</td>
<td>72</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>G.H.</td>
<td>14</td>
<td>Aortic valvular stenosis</td>
<td>QS</td>
<td>QS</td>
<td>rSr'</td>
<td>8</td>
<td>4.5</td>
<td>2.5</td>
<td>45</td>
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<td>S.H.</td>
<td>9</td>
<td>Interventricular septal defect</td>
<td>–</td>
<td>rS</td>
<td>rS</td>
<td>–</td>
<td>11</td>
<td>3</td>
<td>73</td>
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<td>Yes</td>
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<tr>
<td>H.F.</td>
<td>38</td>
<td>Mitral stenosis</td>
<td>QS</td>
<td>QS</td>
<td>rS</td>
<td>12</td>
<td>12</td>
<td>2</td>
<td>83</td>
<td>Yes</td>
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</tr>
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</table>
the most consistent was a decrease in QRS voltage of more than 40 per cent as the catheter tip crossed the valve (fig. 1). In many cases, this change represented the sudden termination of a gradual decrease in voltage in passing through the outflow tract (fig. 2). Occasionally, changes in QRS voltage could be produced by movement of the catheter tip within one heart cavity.

Thirteen cases showed a qualitative change in QRS type, the most common being from a QS pattern in the infundibulum to an rS or qRs pattern in the aorta (fig. 3). It should be noted that the only exception to the QS pattern in the outflow tract was in four cases with interventricular septal defect. There was no exception to this pattern in the ventricular body.

Finally, changes in the P waves at the aortic valve were observed in 11 patients. Generally this wave was quantitatively accentuated at the valve; however, qualitative change was observed in some patients (fig. 4).

With the exception noted above, there appeared to be no relation between cardiac abnormality and QRS changes, either quantitative or qualitative.

**Discussion**

The abrupt change in the electrocardiogram at the aortic valve in 90 per cent of the cases indicates the usefulness of this technic; the same caution, however, must be observed in this area as was noted by Datey and Gandhi in the study of the pulmonic valve. Its value.
as an adjunct to pressure measurement and cineangiography is established, and its routine use during left heart catheterization may further clarify the position of the aortic valve in relation to outflow-tract disease.

The reason for the abrupt change in the intracavitary electrocardiogram is not entirely clear, although it would appear to be related to anatomic changes in muscle mass at the valve ring. In crossing the valve, the catheter is drawn away from actively depolarizing muscle and electrical forces reaching the catheter tip are thus diluted. At the same time the overwhelming forces of the ventricular wall are withdrawn and the forces from elsewhere in the heart are able to reach the electrode, occasionally changing the type of complex. This concept is further supported by the change in amplitude observed in moving the catheter tip within the heart cavity, presumably changing its distance from the endocardium.

In order to understand fully the findings of this study, the advantages and limitations of the unipolar lead must be kept in mind. By selective placing of a lead within the heart cavity, local phenomena can thus be recorded; however, to interpret them as strictly local would be hazardous. Such leads must still record the total depolarization process in all parts of the heart and this recording is merely from a different vantage point.

Summary

The intracavitary electrocardiogram was studied in the aortic outflow tract during left heart catheterization to determine its usefulness in accurately locating the aortic valve.

Twenty-eight of 31 cases studied showed a significant electrocardiographic change at the valve which was not observed elsewhere. Changes noted included decrease in QRS voltage, qualitative QRS change, and P-wave change.

The routine use of the intracardiac electrocardiogram in conjunction with other technics is advocated.

References

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