Study of the Right Atrial Pressure Pulse in Functional Tricuspid Regurgitation and Normal Sinus Rhythm

By George A. Rubeiz, M.D., Munir E. Nassar, M.D., and Ibrahim K. Dagher, M.D.

In spite of the long interest in tricuspid valve disease, review of the literature shows a relatively small number of reports about the incidence of functional tricuspid insufficiency. Coelho found tricuspid regurgitation in 20 per cent of 620 patients with mitral valve disease. Earlier, Mackenzie and later, Müller and Shillingford claimed that functional incompetence of the tricuspid valve appears quite often, but organic incompetence is rare.

Studies of the right atrial pressure-pulse in proved functional tricuspid regurgitation and sinus rhythm are exceedingly scarce. Wood stated "good jugular or right atrial pressure pulse tracings in functional tricuspid regurgitation and normal sinus rhythm are rare."

This paper presents a study of the right atrial pressure pulse in six patients having functional tricuspid regurgitation and normal sinus rhythm.

Materials and Methods

This study was performed on six patients with rheumatic heart disease. Four were women and two were men. Their ages ranged between 16 and 32 years. All were found to be in functional class III. Twelve-lead electrocardiograms and complete roentgenoscopy and roentgenography were obtained. Phonocardiograms were recorded from the apex of the heart and the fourth left intercostal space with a Sanborn twin-beam phonocardiograph (model 62). All the logarithmic phonocardiograms were recorded during the inspiratory and the expiratory phases of respiration. Five of the six patients had right heart catheterization by the usual technic. The Haldane and the Van Slyke and Neill methods were used for the gaseous analysis and for determination of oxygen content in the blood, respectively. Cardiac outputs were estimated according to Fick's principle. The zero reference point was taken at the middle of the anteroposterior diameter of the chest. Pressures were measured by a Statham gage P23Gb manometer and were recorded on an Electronics for Medicine apparatus.

All six patients had a right thoracotomy and the right atrial pressure-pulse tracings were obtained with a 20-gage needle, connected to the same Statham gage and recording apparatus mentioned above. This was followed by a digital exploration of the tricuspid valve. Mitral commissurotomy was subsequently performed.

Results

Examination of the six patients revealed a regular cardiac rhythm and the usual signs of mitral stenosis. In all of the six patients a holosystolic murmur, heard at the left lower sternal border and increasing in intensity during inspiration, was confirmed by phonocardiogram (fig. 1).

All electrocardiograms revealed a normal

![Figure 1](https://example.com/figure1.png)

Logarithmic phonocardiogram obtained at the left lower sternal border showing the increase in the systolic murmur with inspiration (Insp.). 1, first heart sound; 2, second heart sound; S.M., systolic murmur; Exp., expiration.
Results of Right Cardiac Catheterization

<table>
<thead>
<tr>
<th></th>
<th>S.B.</th>
<th>E.A.</th>
<th>Patient H.H.</th>
<th>M.Z.</th>
<th>S.K.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA</td>
<td>m = 3</td>
<td>m = 3</td>
<td>m = 3</td>
<td>m = 7</td>
<td>m = 9</td>
</tr>
<tr>
<td>RV</td>
<td>86/0-3</td>
<td>81/0-3</td>
<td>113/3</td>
<td>100/2-7</td>
<td>45/9</td>
</tr>
<tr>
<td>PA</td>
<td>86/45 m = 70</td>
<td>81/34 m = 42</td>
<td>113/46 m = 78</td>
<td>100/35 m = 57</td>
<td>45/28 m = 34</td>
</tr>
<tr>
<td>PC</td>
<td>m = 30</td>
<td>m = 26</td>
<td>—</td>
<td>m = 35</td>
<td>—</td>
</tr>
<tr>
<td>CI</td>
<td>1.7</td>
<td>2.36</td>
<td>2.2</td>
<td>2.8</td>
<td>2.6</td>
</tr>
<tr>
<td>(L./min./M.²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PVR</td>
<td>1360</td>
<td>352</td>
<td>—</td>
<td>429</td>
<td>—</td>
</tr>
<tr>
<td>(cm.²/sec.)</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

RA, right atrium; RV, right ventricle; PA, pulmonary artery; PC, pulmonary capillary; CI, cardiac index; PVR, pulmonary vascular resistance. Pressures are expressed in mm. Hg.

Table 2

Right Atrial Pressure Pulse Components Expressed in mm. Hg

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>12</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>C</td>
<td>—</td>
<td>4</td>
<td>—</td>
<td>—</td>
<td>12</td>
<td>—</td>
</tr>
<tr>
<td>V</td>
<td>0</td>
<td>4</td>
<td>3.3</td>
<td>8.4</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

The X descent was deeper than the Y in all cases, except that in S.K. the X descent was equal to the Y descent. In four cases the C wave was not identified. Patient M.N. had only the right atrial pressure-pulse obtained at thoracotomy.

Measurements of the different right atrial pressure-pulse components are found in table 2.

The right atrial pressure-pulse tracings recorded at surgery were found comparable to those obtained at right heart catheterization. The A wave was demonstrated but the C wave could be identified in only two cases. The X descent was well preserved. The V wave was of normal configuration and the Y descent was not abrupt. The X descent was equal to the Y in one case but was deeper than the Y in the remaining five cases.

Examples of the right atrial pressure-pulse tracings obtained during right heart catheterizations and at thoracotomy are shown in figures 2 and 3. At surgery, the right atrium was sinus rhythm, atrial enlargement, and right ventricular hypertrophy.

Figure 2

1, right atrial pressure-pulse obtained in patient H.H. at right cardiac catheterization. The X descent is well preserved. 2, the same obtained at thoracotomy.

Figure 3

1, right atrial pressure-pulse obtained in patient E.A. at right cardiac catheterization. The X descent is well preserved. 2, the same obtained at thoracotomy.
found enlarged and digital exploration of the tricuspid valve performed on the six patients revealed moderate to severe tricuspid regurgitation. The regurgitant jet into the right atrium as assessed by the gloved finger remained all through the duration of ventricular systole. During ventricular systole, the tricuspid valve leaflets were found separated from each other by a space measuring about 1 to 2 cm². In all these patients the leaflets of the tricuspid valve felt normal and retained their pliability. The commissures were not fused, and the chordae tendineae were not shortened.

**Discussion**

Gerhardt,⁷ in 1902, gave detailed descriptions of the various forms of the positive systolic wave seen in tricuspid incompetence. Later investigators including Mackenzie,⁸ Wiggers,⁹ Bloomfield et al.,* Little,¹⁰ Messer et al.,¹¹ Müller and Shillingford,¹² Korner and Shillingford,¹³ and Coelho¹⁴ have all made similar observations clinically and experimentally.

Messer et al.¹¹ noted the late occurrence of the S wave in systole in organic tricuspid regurgitation. Little¹⁰ studied tricuspid insufficiency with atrial fibrillation. He concluded that the regurgitant jet of blood into the right atrium is due to delayed closure of the atrioventricular cusps. Wood⁵ pointed out the lack of accurate criteria for the diagnosis of functional tricuspid regurgitation, which as yet have to be firmly established, and also the scarcity of good jugular or right atrial pressure-pulse tracings in patients with proved functional tricuspid regurgitation and normal sinus rhythm.

In the six patients presented the diagnosis of functional tricuspid regurgitation was firmly established by surgical exploration. The right atrial pressure-pulse tracings at right heart catheterization and at surgery were comparable. Furthermore, the tracings had a normal configuration. There was no exaggeration of the V waves in any of the curves. The X descent was well preserved. It became clear that although there is unquestionable tricuspid incompetence in all six cases, the right atrial pressure-pulse tracings were within normal limits.

During ventricular systole, tricuspid regurgitation may alter the contour of the right atrial pressure-pulse in either of two ways: impairment of the X descent and hence descent of the Y becomes more accentuated; obliteration of the X descent by a positive systolic wave—the S wave.

McMichael and Shillingford¹³ found that functional tricuspid incompetence often occurs in congestive heart failure when the venous pressure is raised above 8 mm. Hg. Only one of the six patients studied had a venous pressure of more than 8 mm. Hg.

Little's¹⁴ in vivo and in vitro experiments comparing the elastic properties of the right and left atrium showed that for equal volume increments the walls of the right atrial system is more distensible than the left. Recently Braunwald and Awe¹⁵ reported the "syndrome of severe mitral regurgitation with normal left atrial pressure," and they attributed the discrepancy between left atrial size and pressure to a disturbance in the compliance of the left atrial wall. In seven of 10 patients studied the V-wave peaks were within normal limits but minimally elevated in only three patients.

Thus the preservation of the right atrial pressure-pulses in the cases studied here, in spite of the presence of functional tricuspid regurgitation, is probably due to an increase in the compliance of the walls of the right atrium and the systemic veins.

In conclusion, the demonstration of a normally preserved right atrial pressure-pulse in patients with normal sinus rhythm does not exclude the presence of functional tricuspid regurgitation.

**Summary**

Six patients having mitral stenosis, functional tricuspid regurgitation, and normal sinus rhythm were studied.

All patients had a systolic murmur at the lower left sternal border that increased with inspiration. Five patients had right heart catheterization while all six had right atrial pressure-pulses obtained by direct puncture of the

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right atrium with a 20-gage needle during right thoracotomy. Functional tricuspid regurgitation was proved by subsequent digital exploration of the tricuspid valve. The right atrial pressure pulses obtained were analyzed. The curves taken with the needle-puncture of the right atrium were comparable to those obtained at right heart catheterization. The X descent was well preserved in all six cases. In five patients the X descent was deeper than the Y descent, while in only one patient was the X descent equal to the Y descent. There was no exaggeration of the V wave in any of the curves. The role played by the compliance of the right atrium in preserving the normal contour of the right atrial curve, in spite of tricuspid regurgitation, is discussed.

It is concluded that in functional tricuspid regurgitation with normal rhythm the normally preserved X descent followed by a normal V wave may persist in the right atrial curve. The application of this finding to the clinical study of the jugular venous pulse in functional tricuspid regurgitation and normal rhythm is evident.

References
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GEORGE A. RUBEIZ, MUNIR E. NASSAR and IBRAHIM K. DAGHER

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