Postural Variation in Second Sound Splitting*

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Phonocardiograms were obtained of 30 normal men in the supine and sitting positions. They demonstrated significantly greater S2 splitting and respiratory variation in S2 in the sitting position. However, several individuals showed wider splitting or greater variation while supine. Fixed splitting occurred in three subjects while supine and five others while sitting, but in no normal subject was splitting fixed in both positions.

In 1866, Potain1 first described the normal increase in splitting of the second heart sound with inspiration. Unlike the first heart sound, which is composed of several components which do not correspond well temporally, to valve closure, the second sound has been well documented to be produced by both aortic and pulmonic closures. Boyer and Chisholm,2 Aygen and Braunwald,3 and Castle and Jones4 found that both aortic and pulmonic closures vary with respiration. From 12 percent to 50 percent of the variation in splitting is accounted for by change of the Q-A2 interval.

Splitting of the second heart sound has been found to vary in certain states. Shah and Slodki5 found that advancing age brought a gradual decrease in second sound splitting, and that hypertension correlated with a prolonged Q-A2 interval and reduced splitting. Right bundle branch block causes wide splitting,6 but respiratory variation is usually preserved. DePasquale and associates7 found that right ventricular failure was associated with fixed wide splitting and left-sided failure with reduced or paradoxical splitting. A patient with biventricular failure may demonstrate normal splitting with slight or paradoxical respiratory variation.

Tests of cardiac function have been devised that utilize observation of the splitting of the second heart sound. Cobbs and co-workers8 found that pulmonary embolism produced a wide fixed split, the degree of splitting increasing with the severity of embolism. Differences in the respiratory variation of the Q-A2 and Q-P2 intervals may help differentiate chronic constrictive pericarditis from African cardiomyopathy.9 In constrictive pericarditis there is inspiratory shortening of Q-A2 interval which causes inspiratory splitting, with a fixed Q-P2. In biventricular failure due to cardiomyopathy, Q-A2 is fixed while Q-P2 is either fixed or moves very little. Auscultation of the second heart sound is especially helpful in the diagnosis of congenital heart disease. It remains an important clinical means of differentiating the Eisenmenger form of atrial septal defect (ASD), from other causes of Eisenmenger's syndrome.10 In the former the splitting is more likely to be fixed. Both ASD and VSD cause wide splitting in proportion to the shunted blood flow but relatively fixed splitting occurs in ASD. Relatively fixed widely split S2 is a helpful sign when a significant shunt exists in children over five years of age. In ASD fixed splitting is associated with simultaneous delay in aortic and pulmonic closure. Breen and Rekate11 pointed out that a child suspected of ASD must be auscultated in the sitting position as some normal children have fixed wide splitting in the supine position. Castle and associates12 also found that some children have fixed narrow splitting in the sitting position. Final cardiac evaluation must therefore be done supine, immediately after sitting and after sitting several minutes.

A few studies have been done concerning the effect of posture on second sound splitting. ASD shows wide splitting in the supine and sitting positions. Standing has been found to decrease the wide splitting associated with pulmonary embolus.8 Castle studied 116 children with respect to the effects of posture, heart rate, sex, age, height and weight on second sound splitting and found wider

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splitting and greater respiratory variation in the sitting versus supine position. After sitting five minutes, girls showed 7 msec wider splitting. No other variable significantly affected splitting.

There have been no adequate studies showing the effect of posture on splitting of the second heart sound in adults. One study showed greater respiratory variation in splitting in the supine position than sitting, but most subjects in this study showed relatively fixed splitting, ie respiratory variation of less than 10 msec. This study investigated the effects of posture on second sound splitting in a population of normal men.

**METHODS**

Phonocardiograms were obtained from 33 men, between 22 and 25 years of age. Each had a normal cardiorespiratory system by history and clinical examination. No attempt was made to correlate age, height, weight, pulse, blood pressure or respiratory rate with splitting because of the fairly narrow distribution of these variables in these subjects, and because of previous studies showing slight or no differences produced by these factors.12,14

A Sanborn 4-channel photographic recorder was used to record responses from a Bowles high frequency chest microphone. Recordings were made at 75 or 100 mm per second. Respiratory motion was recorded from a pressure sensitive tambour attached to a blood pressure cuff around the subject's chest. Lead 2 of the ECG was simultaneously recorded.

Each subject rested several minutes in the supine position. A phonocardiogram, as described above, was then recorded from the second left intercostal space. The subject then sat up and a second recording was taken after sitting 30 seconds. A final recording was made after sitting five minutes. Three to five normal respiratory cycles were included in each recording and the average maximum and minimum splitting was obtained. Three of the original 33 recordings were discarded because of interference.

**RESULTS**

Table 1 summarizes the average splitting intervals found in inspiration and expiration in each of these body positions. In the supine position, inspiratory splitting was 41.8 msec, standard deviation ±11.5, after sitting 30 seconds 47.4 msec ±13.0, and after sitting five minutes 48.2 msec ±13.6. Average expiratory splitting in the three positions was 24.8 msec ±7.5; 21.5 msec ±7.8; and 24.2 msec ±9.4 respectively. Splitting of S2 in the sitting position in inspiration is statistically significantly greater than that in the supine position (P<.01). Also, the respiratory variation in splitting is significantly greater in the sitting position than in the supine (P<.01).

Subjects demonstrated variations in patterns of splitting. Seventeen of 30 had wide splitting in upright postures after both 30 seconds and five minutes, but three of 30 had widest splitting while supine. Twenty-one of 30 had greater respiratory variation in the sitting positions, although five had most variation while supine. Three of 30 showed fixed splitting (defined as respiratory variation less than 10 msec) while supine, and five others showed this after sitting five minutes. All of the subjects demonstrating "fixed" splitting in some position showed respiratory variation greater than 12 msec in one of the other positions.

**DISCUSSION**

The results of this study agree with the analysis of respiratory variation of S2 splitting by Castle and co-workers.12 One other publication concerning postural variation in adults showed contradictory results.13 Castle's study gave results similar to those reported here, for postural variation in children: 21 to 38 msec supine, 21 to 45 msec sitting 30 seconds, and 24 to 48 msec sitting five minutes. This suggests that the same factors causing respiratory variation in children occur in young adults. It is also apparent that a significant fraction of normal adults, as well as children, have fixed splitting in either supine or sitting positions.

A well-known mechanism of respiratory variation in second sound splitting has been proposed from animal and human experiments. Inspiration causes decreased intrathoracic pressure, increased right ventricle filling and prolonged Q-P2. Pulmonary vascular capacity increases and left ventricular filling decreases, causing a shorter Q-A2. During expiration, the above sequence is reversed, causing longer Q-A2, shorter Q-P2 and decreased splitting. Other factors such as the differential pressures between the abdominal and thoracic cavities are less easy to quantitate but are probably quite significant.

Besides different respiratory muscle action in

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**Table 1—Average Splitting Intervals in Supine and Sitting Positions (30 Subjects).**

<table>
<thead>
<tr>
<th>Position</th>
<th>Respiratory Phase*</th>
<th>Average Difference AC-PC** (msec)</th>
<th>Standard Deviation (msec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supine</td>
<td>Inspiratory</td>
<td>41.8</td>
<td>11.5</td>
</tr>
<tr>
<td></td>
<td>Expiratory</td>
<td>24.8</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>Average variation</td>
<td>17.0</td>
<td>8.1</td>
</tr>
<tr>
<td>Sitting</td>
<td>Inspiratory</td>
<td>47.4</td>
<td>13.0</td>
</tr>
<tr>
<td>30 seconds</td>
<td>Expiratory</td>
<td>21.5</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td>Average variation</td>
<td>25.9</td>
<td>10.8</td>
</tr>
<tr>
<td>Sitting</td>
<td>Inspiratory</td>
<td>48.2</td>
<td>13.6</td>
</tr>
<tr>
<td>5 minutes</td>
<td>Expiratory</td>
<td>24.2</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td>Average variation</td>
<td>24.0</td>
<td>10.5</td>
</tr>
</tbody>
</table>

*Average of values for 3 to 5 respiratory cycles.

**AC = Aortic closure.

PC = Pulmonic closure.
different body positions, another mechanism may cause more variation in splitting found in the sitting position. The mean central venous pressure (CVP) is less in the sitting position than supine and the cardiac output lower. Right heart output (RO) affects the Q-P₂ interval. The plot of RO vs CVP on the Starling curve is steeper at lower filling pressures. Inspiratory and expiratory movements causing the same variation in CVP in the sitting position should cause slightly greater respiratory variation in right-sided output in this position. This should cause greater variation in the Q-P₂ interval and second sound splitting in the sitting position.

The clinical implications of this study are that if one encounters difficulty in appreciating splitting of S₂ when the patient is supine, then auscultation should also be performed when the patient is sitting. Exploring different areas along the LSB with the stethoscope diaphragm is, of course, also helpful. If fixed or relatively fixed splitting is heard either sitting or lying, auscultation in the other position may clarify whether or not the splitting is really fixed.

REFERENCES


Apropos of Productivity

The Latin name of the mason-bees, Chalicodoma, means pebble-house. All these bees build their nests of calcareous clay mixed with sand and saliva; this sets the form of a hard mortar. The nests are rounded objects. Their outer surfaces are left rough like rustic architecture. Several bees may build close together so that their combined nests form a sort of comb and there may be cooperation between a number of bees putting a final coat of mortar around the finished structure. The inner walls of the nests are always smooth. They are filled with honey, sainfoin and broom flowers being favorite sources. Fabre calculated that collecting mud to build a cell and journeying to a sainfoin for honey involved journeying for 9% miles to complete and store one cell. To provision all the cells and put on the final cover would mean flying for 275 miles.


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