Blood Pressure during Supine Exercise in Idiopathic Orthostatic Hypotension

By ROBERT J. MARSHALL, M.D., ALEXANDER SCHIRGER, M.D., AND JOHN T. SHEPHERD, M.D.

IDIOPATHIC orthostatic hypotension is characterized by an excessive fall in arterial blood pressure on standing and by other manifestations of an extensive loss of autonomic nervous function.

In the present study the arterial blood pressure was measured in seven patients with orthostatic hypotension during the performance of mild leg exercise in the supine position. The finding of a pronounced fall in blood pressure during and immediately after the exercise indicates that there is a major disturbance in the control of blood pressure even in circumstances in which gravitational factors are excluded.

Method

The group of patients with idiopathic orthostatic hypotension comprised four men and two women aged 50 to 61 years (table 1, cases 1 to 6). Studies were performed also in a man aged 44 years who had recently undergone thoracolumbar sympathectomy for essential hypertension (table 1, case 7).

The patients exercised by pedaling a cycle ergometer while in the supine position with the supporting table horizontal. On four occasions the exercise was repeated with the table tilted downward 15 degrees at the head end. Because most of the patients suffered from muscular weakness even when in the supine position, the exercise performed was mild, and it was carried out in periods of about 2 minutes. Oxygen consumption was measured in the two fittest patients during more prolonged periods of exercise; in the first patient (case 3), it increased from a resting value of 250 to 740 ml per minute and in the second (case 5), from 260 to 530 ml per minute.

Oxygen consumption was not measured in the remaining patients owing to the mildness, brevity, and occasional irregularity of the exercise, but it was not likely to have increased by more than 100 per cent. The blood pressure was recorded from the radial artery by a Statham strain-gage transducer. The mid-chest level was taken as the zero reference point.

Results

The blood pressure in the supine position was within normal limits for the age in six patients, ranging from 135 to 160 mm of mercury systolic and 60 to 85 mm of mercury diastolic; in the other patient it was 185/100 (table 1). The pressures measured with the head end of the table tilted downward by 15 degrees were similar to those recorded in the horizontal position.

During exercise in the horizontal position the arterial blood pressure was unchanged in one patient (case 5). The other patients showed striking falls in both systolic and diastolic pressures (figs. 1-3). The pressure began to increase again in three patients (cases 3, 4, and 7) about 30 seconds after exercise was stopped, and it returned to the original level within 5 minutes. In the other three patients (cases 1, 2, and 6), however, it continued to fall for 20 seconds or more after the exercise was stopped. In the four patients tested, a fall of comparable magnitude occurred while the same exercise was performed with the table tilted 15 degrees downward at the head end (table 1 and figs. 2b and 3b).

Discussion

The abnormality of the arterial blood pressure in patients with orthostatic hypotension becomes evident on changing from the supine to the standing position (table 1). Further evidence that the patients in the present study had severe loss of autonomic nervous function

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SUPINE EXERCISE IN ORTHOSTATIC HYPOTENSION

Systolic and diastolic blood pressures at radial artery during exercise in supine position (horizontal). Continuous line: during exercise. Interrupted line: before and after exercise.

was obtained from the response to the Val-salva maneuver (fig. 4). Following release of the raised intrathoracic pressure no "overshoot" of the arterial blood pressure occurred; instead, it returned slowly to its original level. A similar response was described previously in orthostatic hypotension\(^1,2\) and in other conditions involving interruption of autonomic nervous pathways, such as tabes dorsalis\(^3\) and diabetic neuropathy,\(^4\) as well as after thoracolumbar sympathectomy or the administration of ganglion-blocking agents.\(^2\)

Table 1

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Supine, horizontal (mm Hg)</th>
<th>Supine, 15 degrees head down (mm Hg)</th>
<th>Standing (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rest</td>
<td>Exercise</td>
<td>Rest</td>
</tr>
<tr>
<td>1</td>
<td>55</td>
<td>M</td>
<td>135/60</td>
<td>90/30</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>F</td>
<td>185/100</td>
<td>140/70</td>
<td>--</td>
</tr>
<tr>
<td>3</td>
<td>52</td>
<td>M</td>
<td>160/85</td>
<td>110/55</td>
<td>160/85</td>
</tr>
<tr>
<td>4</td>
<td>61</td>
<td>M</td>
<td>140/85</td>
<td>100/50</td>
<td>145/70</td>
</tr>
<tr>
<td>5</td>
<td>58</td>
<td>F</td>
<td>150/70</td>
<td>155/70</td>
<td>--</td>
</tr>
<tr>
<td>6</td>
<td>61</td>
<td>M</td>
<td>150/85</td>
<td>90/40</td>
<td>145/80</td>
</tr>
<tr>
<td>7(†)</td>
<td>44</td>
<td>M</td>
<td>160/85</td>
<td>100/50</td>
<td>165/80</td>
</tr>
</tbody>
</table>

*Values are lowest values obtained during, or shortly after termination of, exercise.

†This patient had orthostatic hypotension after thoracolumbar sympathectomy for hypertension.

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The finding in five of six patients with idiopathic orthostatic hypotension of a pronounced fall in blood pressure during mild leg exercise in the supine position, in which the effect of gravitational forces on the circulation is minimized, was unexpected. Indeed, a similar fall in blood pressure occurred during exercise performed with the head end of the table tilted downward; in this position the return of blood from the legs to the heart is aided by gravity. In normal persons compensatory constriction occurs in resting vascular beds during muscular exercise. It may be that in patients with orthostatic hypotension this regulatory system is abolished, so that the net peripheral resistance is lower than in
normal persons performing comparable exercise. Similar falls in systemic arterial blood pressure have been noted during supine leg exercise after administration of the adrenergic-blocking agents guanethidine and bretylium tosylate.

An additional factor that had to be considered was the possibility that partial or complete denervation of the heart prevented an adequate increase of cardiac output during exercise. Therefore, in two patients the cardiac output was measured during the second minute of exercise by the indicator-dilution method. In one of these patients.

Figure 3
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INTRA-

those obtained had the whom heart similarmild by exercise during these other vascular arterial stenosis.

orthostatic (upper) with the normal thoracic pressure (mm. Hg) (lower) with idio

ARTERY

PRESSURE 40

PRESSURE 40 (mm. Hg)

RADIAL ARTERY

(mm. Hg)

HEART RATE

(beats/min.)

Figure 4
Effects of Valsalva maneuver in a normal subject (upper) and in two patients (cases 4, center, and 6, lower) with idiopathic orthostatic hypotension.

(case 3), cardiac output increased from 4.7 to 6.4 liters per minute and in the other (case 5), from 6.8 to 8.8 liters per minute. These increases were of the same order as those obtained in normal subjects performing similar mild exercise. In the patient who had had thoracolumbar sympathectomy and in whom the reflex nervous pathways to the heart were intact, the similar fall in pressure during exercise must have been caused solely by the failure of compensatory constriction of other vascular beds.

The effect of exercise in the supine position on arterial blood pressure in patients with orthostatic hypotension can be contrasted with that observed in patients with severe mitral stenosis. In the latter condition the cardiac output may be incapable of increasing; however, despite dilatation of vessels in the active skeletal muscles, the blood pressure is well maintained owing to compensatory constriction in other vascular beds.

Thus, although arterial blood pressure depends on both cardiac output and peripheral resistance, the results of this study suggest that the reflex coordination of the various vascular beds plays the major role in maintaining arterial pressure.

Summary
The arterial blood pressure was measured during exercise in six patients with idiopathic orthostatic hypotension. In five there was a pronounced fall of arterial pressure while the subjects exercised in the supine position on a horizontal table. The systolic and diastolic pressures fell by an average of 50 and 32 mm. of mercury, respectively. During comparable exercise with the table tilted 15 degrees head downward, the pressures fell to a similar degree. Thus, an abnormal response of blood pressure occurred under conditions in which venous pooling was unlikely to be present.

It is suggested that the fall in blood pressure during exercise in the supine position was the result of failure of compensatory constriction of other vascular beds and not of failure of the cardiac output to increase. Thus, the net peripheral resistance in such patients is less than that in normal persons performing comparable exercise.

Acknowledgment
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References
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On Percussion of the Chest
First Observation

Of the Natural Sound of the Chest, and Its Character in Different Parts

I. The thorax of a healthy person sounds, when struck. I deem it unnecessary to give in this place any description of the thorax. I think it sufficient to say that, by this term, I mean that cavity bounded above by the neck and clavicles, and below by the diaphragm: in the sound state, the visera it contains are fitted for their respective uses.

II. The sound thus elicited (1) from the healthy chest resembles the stifled sound of a drum covered with a thick woollen cloth or other envelope.

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