BILATERAL determinations of blood pressure are of importance in the physical diagnosis of certain pathologic conditions involving the aortic arch or its tributaries to the upper extremities. Inequalities may be found in the blood pressure in the 2 arms of some patients who have syphilitic aortitis with aneurysm,1-3 or who have coarctation of the aorta proximal to the left subclavian artery4,5 or inflammatory or degenerative disease of the aorta such as "Takayasu's disease" with which the patient may be pulseless at times.6 The pathology of acquired diseases of the aorta which may be manifested clinically has been reviewed by Edwards.7 It also is generally accepted that differences in blood pressure in the arms may be noted in association with marked unilateral narrowing of an artery to the upper extremity,8,9 whether due to a congenital anomaly of the artery or an anomaly due to atheroma, embolus, thrombus, or external compression by structures in the shoulder girdle, a cervical rib, or a mediastinal tumor.

A stumbling block to attributing diagnostic significance to differences in the blood pressure in the 2 arms has been the repeated comment in the literature that disparities in bilaterally determined blood pressure have been found in a large percentage of apparently healthy individuals2,10,11 and in patients8,12-14 without apparently unilateral pathologic changes in the arteries and that the frequency and the magnitude of these differences apparently were increased in hypertensive persons.1,13 Although several investigators have pointed out the importance of such inequalities of blood pressure in the diagnosis and evaluation of treatment of hypertension,8,12,15,16 other workers17,18 have denied emphatically that these inequalities are found in persons without asymmetric arterial abnormalities if the measurements are taken simultaneously and under basal conditions. Thus, blood pressure that is high in one arm and low or normal in the other presents the serious problem of its significance.

Roth and Kvale19 pointed out that inequality in brachial blood pressures can result in an incorrect interpretation of results in pharmacologic tests for pheochromocytoma. In patients with permanent inequalities in basal brachial blood pressures due to structural vascular differences, a dramatic alteration in blood pressure is recorded when the basal blood pressures have been measured on one arm and then, after the administration of histamine or phenolamine (Regitine), were compared with pressures in the opposite arm. Also, if the blood pressure is not always taken in the same arm, the routine blood pressure records of such patients may indicate a pattern of paroxysmal hypertension such as is found in some patients with pheochromocytomas.

The results of studies of bilateral blood pressures in 100 or more subjects recorded in the medical literature are shown in table 1. All the investigators employed the indirect method of determining blood pressure. The inherent inaccuracies of the indirect method have been indicated by some workers as one of the reasons for the differences.17,18

Since progress in medical instrumentation has made available more accurate devices such as the strain-gage manometer*28 and Polyviso recorder† by means of which direct continu-

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*Statham Laboratories.
†Sanborn Company.
## Table 1

### Studies of Bilateral Indirect Blood Pressure on 100 or More Subjects

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Subjects</th>
<th>Differences in blood pressure</th>
<th>Determined simultaneously</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Systolic, mm. Hg</td>
<td>Diastolic, mm. Hg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10 or more</td>
<td>20 or more</td>
</tr>
<tr>
<td>Cyrax</td>
<td>1921</td>
<td>128</td>
<td>35%</td>
<td>7%</td>
</tr>
<tr>
<td>Bodenstab</td>
<td>1925</td>
<td>100</td>
<td>Average: 11.7 mm.</td>
<td>Average: 9.6 mm.</td>
</tr>
<tr>
<td>van Balen</td>
<td>1929</td>
<td>150</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Kay and Gardner</td>
<td>1930</td>
<td>125</td>
<td>20%</td>
<td>13.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Usually higher on rt.</td>
<td></td>
</tr>
<tr>
<td>Stiegltiz and Propst</td>
<td>1932</td>
<td>600</td>
<td>10 mm. or more systolic or 5 mm. or more diastolic</td>
<td>15.7%</td>
</tr>
<tr>
<td>Korns and Guinand</td>
<td>1933</td>
<td>1000</td>
<td>22.2%</td>
<td></td>
</tr>
<tr>
<td>Southby</td>
<td>1935</td>
<td>516</td>
<td>20 mm. or more systolic or 10 mm. or more diastolic</td>
<td>60%</td>
</tr>
<tr>
<td>Shock and Ogden</td>
<td>1940</td>
<td>102</td>
<td>Compared mean values (rt.-lt.): systolic = 1.6 ± 0.36 mm. diastolic = 0.36 ± 0.18 mm.</td>
<td></td>
</tr>
<tr>
<td>Amsterdam and Amsterdam</td>
<td>1943</td>
<td>1000</td>
<td>Rt. &gt; lt. in 70% and of these 44.6% differed by 10 mm. or more, and 12.1% by 20 mm. or more</td>
<td>Part of study</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>272 hypertensive</td>
<td></td>
</tr>
<tr>
<td>Israel</td>
<td>1944</td>
<td>125 hypertensive</td>
<td>18.4%</td>
<td></td>
</tr>
<tr>
<td>Heddaeus</td>
<td>1948</td>
<td>100</td>
<td>17%</td>
<td></td>
</tr>
<tr>
<td>Rieger</td>
<td>1951</td>
<td>755</td>
<td>50%</td>
<td>13.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rt. &gt; lt. 71.5%</td>
<td></td>
</tr>
<tr>
<td>Randig, Bading and Eismann</td>
<td>1952</td>
<td>100</td>
<td>17% &gt; 15 mm.</td>
<td></td>
</tr>
<tr>
<td>Beckmann</td>
<td>1953</td>
<td>126</td>
<td>31%</td>
<td></td>
</tr>
<tr>
<td>Bauereisen</td>
<td>1953</td>
<td>458</td>
<td>2.6%</td>
<td></td>
</tr>
<tr>
<td>Hoyer</td>
<td>1956</td>
<td>1600</td>
<td>Systolic differences of 5 mm. or more in 70%, Diastolic differences of 5 mm. or more in 47%</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rt. usually &gt; lt.</td>
<td></td>
</tr>
<tr>
<td>Hagen</td>
<td>1956</td>
<td>152</td>
<td>Compared mean values (rt.-lt.): systolic = 6.7 mm. diastolic = 0.1 mm.</td>
<td>Yes</td>
</tr>
<tr>
<td>Stein</td>
<td>1956</td>
<td>250</td>
<td>16%</td>
<td></td>
</tr>
</tbody>
</table>

*Continuous indirect methods.
ous graphic measurements can be obtained, an assessment of the bilateral disparities of blood pressure was undertaken. In this study bilateral measurements of blood pressure by the 2 methods were evaluated: (1) by comparing the bilateral determinations obtained by using the simultaneous indirect and simultaneous direct (intra-arterial) methods in a group of normal subjects; (2) by comparing the results of bilateral, nonsimultaneous and simultaneous determinations obtained by the indirect method in a large group of patients; (3) by obtaining bilateral intra-arterial blood pressures on a selected group of patients who were found to have bilateral inequalities of blood pressure by the simultaneous indirect method, and (4) by determining the effect of change in body position, age, difference in arm sizes, right or left-handedness, and antihypertensive drugs on the bilateral differences.

Materials and Methods

Control Group (14 Normal Subjects)

The control group consisted of 14 healthy men whose ages averaged 23 years and ranged from 18 to 32 years. Bilateral blood pressures were determined simultaneously in both brachial arteries by the indirect method and by the intra-arterial or direct method on each subject. Direct measurements were obtained from the radial arteries in 9 subjects and from the brachial arteries in 5.

Patients Studied

The brachial blood pressures were determined bilaterally by the indirect method on 450 patients examined at the Mayo Clinic. The results in 3 of these patients will be presented separately. Of the remaining 447 patients 264 were males and 183 were females. The average age was 48 years, with a range from 15 to 83 years. The 447 patients were divided into hypertensive and nonhypertensive groups on the basis of whether the resting blood pressure was 140 mm. Hg systolic and 90 mm. Hg diastolic or more. The hypertensive group was further divided into those with systolic blood pressures of 140 to 170 mm. Hg and those with systolic blood pressures of more than 170 mm. Fifty-three patients from the entire group, predominantly those who had shown inequalities of blood pressure by the simultaneous, indirect method, were selected for bilateral, intra-arterial studies. The sex and mean ages of the patients in these groups are shown in table 2.

Indirect Method

Each subject was allowed to rest quietly in the supine position for 20 to 30 minutes. The circumference of each arm was measured in centimeters at a point 10 cm. above the radial epicondyle by means of a steel tape.

Following this, nonsimultaneous measurements of the blood pressure in the arms were taken in order to assess the inequalities that may be found by this method in routine physical examinations. Then, auscultatory blood pressure readings were taken simultaneously on the arms by 2 observers, using a bilateral cuff apparatus (fig. 1). Three determinations were made with an interval of 1 minute between observations. Since the apparatus was constructed by joining 2 Tyco aneroid sphygmomanometers with 13-cm. cuffs to a single rubber hand-bulb through a Y-connection, simultaneous inflation or deflation of the cuffs was obtained. In order to insure accuracy of registration, the aneroid sphygmomanometers were checked periodically against each other as well as against standard mercury manometers. Systolic pressures were recorded at the first sounds heard over the brachial arteries and diastolic pressures at the disappearance of the sounds. The recommendations of Borderly and associates for determinations of blood pressure on human beings were followed.

Three bilateral simultaneous indirect determinations of blood pressures were made on 50 of the
patients while they were in the supine position and later in the sitting position and on 19 hypertensive patients before and during antihypertensive drug therapy.

After the indirect readings of blood pressure the subject rested for 20 to 30 minutes before bilateral intra-arterial studies were undertaken.

Bilateral Direct Method

The apparatus employed (fig. 1) was a modification of the equipment used by Godden, Roth, and Hines in a study of the changes in intra-arterial pressure during immersion of the hand in ice-cold water. Its composition was outlined by them and was based on the work of Wood, Lambert, and Burchell. Through the use of the bilateral hypodermic strain-gage manometric systems, simultaneous arterial pressure pulses were inscribed by the Sanborn multichannel recorder. When brachial intra-arterial studies were made, the arms were supported on folded towels and 20-gage needles were inserted into the arteries just medial to the biceps tendons at the cubital regions after local anesthesia was obtained with 1.5 per cent procaine hydrochloride.

The calibration system consisted of an aneroid gage which was connected by rubber tubing to a rubber hand-bulb and to a bottle containing 100 ml. of sterile, heparinized saline solution. The bottle was inverted and connected to both strain gages by means of a Y-connection and rubber tubing. Through this system, simultaneous calibrations at increments of 10 mm. Hg were obtained at the beginning and end of each record. The menisci of the saline solution and the sites of arterial punctures were leveled to the midline of the side of the chest at the third intercostal space.

The paper speed was set at 1 mm. per second and the paper was allowed to run at least 20 minutes at the beginning of a recording. Then, the speed was changed to 5 or 10 mm. per second for 3 brief intervals spaced 1 minute apart. The systolic and diastolic levels of simultaneously recorded bilateral pulse pressures were measured once for each of these intervals. More detailed pressure pulse contours were obtained at paper speeds of 1

![Figure 1](http://circ.ahajournals.org/)  

**Figure 1**  
*Apparatus arranged for bilateral direct radial and indirect brachial blood pressure determinations on a subject. The strain-gage manometers are located adjacent to the subject's wrists and are connected to the radial intra-arterial needles and to the calibration system and recorder (left). The bilateral brachial cuff apparatus seen here was removed during the direct recordings.*

*Circulation, Volume XXII, September 1960*
BILATERAL ARTERIAL PRESSURES

Table 3
Control Group: Mean Bilateral Blood Pressures Determined by Simultaneous Indirect and Direct Methods

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Right</th>
<th>Left</th>
<th>Differences (Bl.-Lt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S. D.</td>
<td>Mean</td>
</tr>
<tr>
<td>Indirect</td>
<td>Bilateral systolic blood pressures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brachial</td>
<td>14</td>
<td>120 ± 1.6*</td>
<td>10.2</td>
</tr>
<tr>
<td>Direct</td>
<td>Radial</td>
<td>9</td>
<td>123 ± 2.6</td>
</tr>
<tr>
<td></td>
<td>Brachial</td>
<td>5</td>
<td>117 ± 2.6</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>121 ± 1.9</td>
<td>12.4</td>
</tr>
</tbody>
</table>

| Indirect | Bilateral diastolic blood pressures |
| Brachial  | 14    | 70 ± 1.1 | 7.0 | 70 ± 0.9 | 6.3 | −.3 ± .5 | 3.3 |
| Direct   | Radial | 9     | 69 ± 1.7 | 8.7 | 68 ± 1.7 | 9.0 | +.5 ± .3 | 1.7 |
|          | Brachial | 5     | 63 ± 2.4 | 9.5 | 63 ± 2.4 | 9.3 | +.1 ± .2 | .9 |
| Total    | 14    | 67 ± 1.4 | 9.3 | 66 ± 1.4 | 9.4 | +.4 ± 1.4 | .2 |

*The figure after the ± sign is the standard error of the mean.

25 mm. per second after the measurements were recorded at the lower speeds.

Bilateral Differences in Blood Pressure in the Control Group (14 Subjects)

Systolic Blood Pressures

The statistical mean bilateral systolic blood pressures and the (right-left) differences in the statistical means are tabulated for the control group in table 3. Bilateral simultaneous cuff pressures were taken 3 times on each of the 14 control subjects, thus giving a total of 42 bilateral measurements for the group. There was only a slight difference in the means for the indirect readings on both arms. However, bilateral differences of 5 mm. Hg or greater occurred in 9 simultaneous measurements and of 10 mm. or more in 3 measurements.

Mean systolic blood pressures by the direct method were the same for the 2 arms, and there was no significant difference in the mean values in either the 9 bilateral radial or the 5 bilateral brachial arteries studied. However, 6 of the 42 individual bilateral measurements differed by 5 mm. Hg or more, but none differed by 10 mm.

Variability of Differences

The differences recorded by each method were frequently inconstant in that they could decrease or increase in magnitude or become greater on the opposite side in the same individual during the 3 paired readings. A typical recording of bilateral intra-arterial blood pressures which shows this variability is presented in figure 2.

In order to evaluate this variation, the number of subjects who manifested inequality in bilateral systolic blood pressures of 5 mm. or greater for one bilateral measurement, which in another measurement increased or decreased by 5 mm. Hg on the same side or became equal on the two sides, or changed to the opposite side, was tabulated. From this tabulation we found that by the indirect method 5 of the 14 subjects had inequalities in the systolic blood pressures of 5 mm. Hg or greater and 4 of these varied in the 3 1-minute measurements. By the direct method, 5 subjects had differences of 5 mm. Hg or greater and the blood pressure differences in 2 of these 5 varied in 3 minutes; however, all varied at some time during their entire recording and none of the subjects who had a difference by the indirect method showed a similar difference by the direct method.

Diastolic Blood Pressures

A similar appraisal of the mean bilateral diastolic blood pressures in the control group (table 3) revealed essentially equal values
for the right and left sides by both the indirect and direct methods. When the incidence of bilateral differences in the indirect diastolic blood pressures were considered as they occurred in all measurements, only 5 measurements (on 3 subjects) had differences of 5 mm. or greater, and all of these were variable. None of the paired measurements differed 10 mm. or more. The direct method disclosed no differences of 5 mm. Hg or more.

Results of Studies on Patients

Bilaterally Nonsimultaneous and Bilaterally Simultaneous Indirect Determinations of Blood Pressures

Each of the 447 patients had 1 set of bilaterally nonsimultaneous measurements of the blood pressures in the 2 arms and 3 sets of bilaterally simultaneous measurements (1,341 simultaneous measurements). For the entire group by the nonsimultaneous indirect method the mean right systolic pressure was 163 ± 1.9 mm. and the mean left systolic pressure was 165 ± 1.9 mm. The mean (right-left) difference was −2.3 ± 0.6. By the simultaneous indirect method, however, the mean right systolic pressure was 168 ± 1.0 mm., the mean left pressure was 167 ± 0.9 mm., and the mean right-left difference was +0.5 ± 0.1 mm.

The same tendency also was noted in the 131 nonhypertensive and 310 hypertensive patients in that the mean bilateral values were slightly higher on the left when obtained by the nonsimultaneous method and essentially equal when obtained simultaneously. This tendency was reversed in the 6 patients who had pheochromocytomas in that the mean systolic values obtained nonsimultaneously were nearly equal and they were slightly higher on the right by the simultaneous method.

Comparison of the mean bilateral diastolic blood pressures obtained by the nonsimultaneous and the simultaneous indirect method shows near equality in each of the groups considered. The mean differences were −0.8 ± 0.4 mm. by the nonsimultaneous indirect and −1.3 ± 0.2 mm. by the simultaneous indirect method for all patients (table 4).

Bilateral Simultaneous Indirect and Direct Blood Pressures of 53 Selected Patients

The mean values of bilateral systolic blood pressure by the indirect and the direct measurements on 53 selected patients are presented in table 5. There were no marked bilateral differences by either method. No attempt was made to compare absolute values for systolic or diastolic blood pressures by the indirect and direct methods because of the lapse of time between the applications of the 2 methods.

Figure 2
Direct bilateral recordings of radial pressure on a 27-year-old man of the control group showing the production of transient inequality in the systolic blood pressure. Paper speeds shown are 1, 5, and 25 mm. per second.
Table 4

Patient Group: Mean Bilateral Blood Pressures by Nonsimultaneous and Simultaneous Indirect Methods

<table>
<thead>
<tr>
<th>Patients</th>
<th>Nonsimultaneous, mm Hg</th>
<th>Simultaneous, mm Hg</th>
<th>Difference (Rt-Lt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
<td>Left</td>
<td>Mean</td>
</tr>
<tr>
<td>Nonhypertensive</td>
<td>131 ± 1.5 ± 1.4</td>
<td>131 ± 1.5 ± 1.5</td>
<td>−1.4 ± 0.7</td>
</tr>
<tr>
<td>Hypertensive</td>
<td>140-170 mm Hg</td>
<td>156 ± 1.7 ± 1.9</td>
<td>159 ± 1.5 ± 1.7</td>
</tr>
<tr>
<td>170+ mm Hg</td>
<td>183 ± 1.9 ± 3.1</td>
<td>194 ± 3.0 ± 4.6</td>
<td>−2.3 ± 0.1</td>
</tr>
<tr>
<td>All</td>
<td>310 ± 1.3 ± 3.1</td>
<td>180 ± 1.2 ± 2.7</td>
<td>−2.3 ± 0.4</td>
</tr>
<tr>
<td>Pheochromocytoma</td>
<td>6 ± 8.7 ± 20.7</td>
<td>168 ± 9.7 ± 23.2</td>
<td>0 ± 3.0 ± 7.3</td>
</tr>
<tr>
<td>All patients</td>
<td>447 ± 1.9 ± 9.1</td>
<td>165 ± 1.9 ± 39.4</td>
<td>−2.3 ± 0.6</td>
</tr>
</tbody>
</table>

Bilateral diastolic blood pressures

<table>
<thead>
<tr>
<th>Patients</th>
<th>Nonsimultaneous, mm Hg</th>
<th>Simultaneous, mm Hg</th>
<th>Difference (Rt-Lt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonhypertensive</td>
<td>131 ± 0.6 ± 0.6</td>
<td>81 ± 0.9 ± 10.6</td>
<td>0 ± 0.2</td>
</tr>
<tr>
<td>Hypertensive</td>
<td>140-170 mm Hg</td>
<td>95 ± 1.0 ± 11.3</td>
<td>97 ± 1.2 ± 14.1</td>
</tr>
<tr>
<td>170+ mm Hg</td>
<td>183 ± 1.9 ± 26.9</td>
<td>117 ± 2.0 ± 27.5</td>
<td>−0.8 ± 0.6</td>
</tr>
<tr>
<td>All</td>
<td>310 ± 0.8 ± 24.2</td>
<td>108 ± 0.9 ± 25.0</td>
<td>−1.0 ± 0.3</td>
</tr>
<tr>
<td>Pheochromocytoma</td>
<td>6 ± 6.5 ± 15.5</td>
<td>103 ± 6.2 ± 14.8</td>
<td>−2.3 ± 3.2</td>
</tr>
<tr>
<td>All patients</td>
<td>447 ± 1.3 ± 26.8</td>
<td>100 ± 1.2 ± 25.1</td>
<td>−0.8 ± 0.4</td>
</tr>
</tbody>
</table>

*The figure after the ± sign is the standard error of the mean.

Table 5

Selected Group of Patients: Mean Bilateral Blood Pressures Determined by Simultaneous Indirect and Direct Methods

<table>
<thead>
<tr>
<th>Patients</th>
<th>Indirect, mm Hg</th>
<th>Direct, mm Hg</th>
<th>Difference (Rt-Lt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
<td>Left</td>
<td>Mean</td>
</tr>
<tr>
<td>Nonhypertensive</td>
<td>11 130 ± 3.3</td>
<td>127 ± 1.2</td>
<td>6.7</td>
</tr>
<tr>
<td>Hypertensive</td>
<td>159 ± 1.7</td>
<td>159 ± 1.6</td>
<td>9.7</td>
</tr>
<tr>
<td>170+ mm Hg</td>
<td>30 198 ± 2.6</td>
<td>197 ± 2.5</td>
<td>23.8</td>
</tr>
<tr>
<td>All</td>
<td>42 187 ± 2.5</td>
<td>186 ± 2.4</td>
<td>27.0</td>
</tr>
<tr>
<td>All patients</td>
<td>53 175 ± 2.8</td>
<td>174 ± 2.8</td>
<td>35.0</td>
</tr>
</tbody>
</table>

Bilateral diastolic blood pressures

<table>
<thead>
<tr>
<th>Patients</th>
<th>Indirect, mm Hg</th>
<th>Direct, mm Hg</th>
<th>Difference (Rt-Lt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonhypertensive</td>
<td>11 75 ± 1.2</td>
<td>74 ± 1.3</td>
<td>7.2</td>
</tr>
<tr>
<td>Hypertensive</td>
<td>94 ± 1.1</td>
<td>94 ± 1.2</td>
<td>7.1</td>
</tr>
<tr>
<td>170+ mm Hg</td>
<td>30 114 ± 1.8</td>
<td>114 ± 1.7</td>
<td>16.1</td>
</tr>
<tr>
<td>All</td>
<td>42 108 ± 1.5</td>
<td>109 ± 1.5</td>
<td>16.8</td>
</tr>
<tr>
<td>All patients</td>
<td>53 101 ± 1.6</td>
<td>102 ± 1.6</td>
<td>20.7</td>
</tr>
</tbody>
</table>

*The figure after the ± sign is the standard error of the mean.
A summary of bilateral differences in blood pressure of 10 mm. Hg or greater obtained by nonsimultaneous and simultaneous indirect methods on 447 patients and by simultaneous indirect and simultaneous direct methods on 53 selected patients.

Incidence and Variability of Bilateral Differences in Blood Pressures

Comparison of the bilateral systolic blood pressures obtained by the nonsimultaneous and simultaneous indirect methods (fig. 3) disclosed that 26.6 per cent of the nonsimultaneous measurements in the 2 arms differed by 10 mm. Hg or greater and 7.2 per cent differed by 20 mm. or greater, whereas 5.3 per cent of the total bilateral measurements by the simultaneous indirect method differed by 10 mm. and only 0.1 per cent differed by 20 mm.

Also, small systolic differences in the bilaterally simultaneous indirect measurements, that is, differences of 4 to 9 mm., occurred with approximately equal frequency (38 to 40 per cent of measurements) in nonhypertensive as well as in the 2 hypertensive groups. Differences of 10 mm. or more occurred with approximately equal frequency in the nonhypertensive patients and in the subjects with systolic blood pressures of 140 to 170 mm. (2.8 and 2.6 per cent respectively). Of the measurements on hypertensive subjects with basal systolic blood pressures of more than 170 mm. Hg, 8.8 per cent differed by 10 mm. or greater; this indicated a slight trend toward larger differences at high levels of systolic blood pressure.

The incidence of differences in bilaterally simultaneous systolic blood pressures measured by the indirect and direct methods in 53 patients is shown in figure 4. Fifty (31 per cent) of the 159 measurements by the indirect method (3 paired measurements on each of 53 subjects) and 46 (29 per cent) of the measurements by the direct method differed by at least 5 mm. in the 2 arms. Sixteen (10 per cent) of measurements by the indirect method and 9 (6 per cent) by the direct method differed by 10 mm. or more. Both the indirect and the direct measurements tended to differ by 10 mm. Hg or more slightly often in hypertensive patients who had basal systolic pressures of more than 170 mm. Hg.

Thus, of the 447 patients studied by the simultaneous indirect method, 224 (50 per cent) had bilateral differences in systolic blood pressure of 5 mm. or greater and 160 (71 per cent) of these differences varied during the 3 readings. Fifty-five of the 447 patients (12 per cent) had differences of 10 mm. or more, and 30 (55 per cent) of these 55 patients had differences which varied in 3 measurements. A similar appraisal for the nonhypertensive, hypertensive, and pheochromocytoma subgroups is shown in table 6. In the selected patients the indirect method yielded bilateral differences in the systolic blood pressure in more nonhypertensive and hypertensive patients than the direct method did, and it gave differences that were more variable. Only 1 of 53 patients in the selected group had a consistent difference by both methods and this was less than 10 mm. Hg.

Of 447 bilaterally nonsimultaneous measurements of diastolic pressure by the indirect method (fig. 3), 15 per cent differed by 10 mm. or more, whereas of the 134 bilaterally simultaneous measurements by the indirect method 4 per cent differed by 10 mm. or more. The incidence of bilateral differences in diastolic blood pressures determined nonsimultaneously was greater in both the nonhypertensive and hypertensive groups. The frequency of differences of 10 mm. or more was slightly greater.
in hypertensive than in nonhypertensive patients.

The incidences of differences in diastolic blood pressures obtained simultaneously in the 2 arms of 53 patients by the indirect and direct methods are compared in figure 4. Of 159 bilateral measurements by the indirect method, 44 (28 per cent) differed by at least 5 mm., and 13 (8 per cent) by at least 10 mm. By the direct method, 6 measurements (4 per cent) differed by at least 5 mm. and only 2 differed by 10 mm. or more. Thus, the frequency and magnitude of bilateral differences in diastolic blood pressure determined by the direct method were slightly less than those obtained by the indirect. Bilateral differences in diastolic blood pressure of 10 mm. or more were slightly more frequent among hypertensive than among nonhypertensive patients.

The bilateral differences in the diastolic blood pressure of 447 patients studied by the simultaneous indirect method varied as follows: 197 (44 per cent) had differences of at least 5 mm., and 127 (6 per cent of the 197) had variable differences in the 3 1-minute readings; 42 patients (9 per cent of 447) had differences of 10 mm. or more, and 24 patients (57 per cent of the 42) had variable differences in the 3 measurements (table 6). In the nonhypertensive and hypertensive patients in the selected group, the bilateral diastolic differences were more frequent by the simultaneous indirect method than by the simultaneous direct method, and many of these varied in the 3 measurements. None of these 53 patients had a consistent difference in the diastolic blood pressure which was revealed by both methods.

### Possible Factors in the Production of Differences

#### Body Position

The mean values of bilateral, systolic and diastolic, indirect blood pressures of 50 patients in the supine and then in the sitting position are given in table 7. Significant bilateral differences were not seen in the mean values obtained in either position. However, 9.3 per cent of all bilateral measurements of systolic blood pressure showed inequalities of 10 mm. Hg or more when the subjects were in the sitting position compared to 3.3 per

---

**Table 6**

<table>
<thead>
<tr>
<th></th>
<th>Simultaneous indirect</th>
<th>Selected group</th>
<th>Simultaneous direct</th>
<th>Selected group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Differences,*</td>
<td></td>
<td>Differences,*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mm. Hg 5+</td>
<td></td>
<td>mm. Hg 5+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mm. Hg 10+</td>
<td></td>
<td>mm. Hg 10+</td>
<td></td>
</tr>
<tr>
<td>Patients</td>
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<tr>
<td>Nonhypertensive</td>
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<td>310</td>
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<tr>
<td>Number</td>
<td>67</td>
<td>16</td>
<td>44</td>
<td>13</td>
</tr>
<tr>
<td>Systolic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>10</td>
<td>8</td>
<td>5</td>
<td>1</td>
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<tr>
<td>Hypertensive</td>
<td>310</td>
<td></td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Number</td>
<td>155</td>
<td>44</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>108</td>
<td>21</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Pheochromocytoma</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Number</td>
<td>224</td>
<td>55</td>
<td>53</td>
<td>33</td>
</tr>
<tr>
<td>Variable</td>
<td>160</td>
<td>20</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>All</td>
<td>447</td>
<td>55</td>
<td>53</td>
<td>33</td>
</tr>
</tbody>
</table>

*5+ = 5 mm. Hg or greater; 10+ = 10 mm. Hg or greater.

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*Circulation, Volume XXII, September 1960*
Bilateral differences in blood pressure found in simultaneous indirect and simultaneous direct measurements on 53 selected subjects. These are included under the side, right or left, that had the higher reading and are also totaled irrespective of side.

Antihypertensive Therapy and Level of Blood Pressure

The mean bilateral simultaneous indirect blood pressures of 19 hospitalized patients recorded before and during treatment with antihypertensive drugs are given in table 7. Drugs used included hydralazine (Apresoline), reserpine (Serpasil), pentolinium tartrate (Ansolysen), protoveratrine, hexamethonium chloride (Bistrium), crytenamine (Unitensin) and potassium thiocyanate. Inequalities of blood pressure due to individual drugs could not be analyzed because this was a relatively small group of patients and also because some were treated with combinations of these drugs. With the lowering of the mean values of blood pressure by antihypertensive drugs there was a shift from a slight right-sided preponderance of differences toward more equal distribution of differences on the 2 sides. Also, bilateral systolic differences of 10 mm. or more were present in 8.8 per cent of all measurements on this group before treatment and in only 3.5 per cent during treatment. Diastolic differences of this degree were present in only 1.8 per cent of measurements before treatment and 3.5 per cent of measurements during treatment. In this part of the study only 1 patient was encountered who had a static, reproducible difference, and her case, therefore, is presented separately.

Case 1

A 63-year-old housewife registered at the clinic on October 26, 1954, and was hospitalized immediately. She complained of paroxysmal nocturnal dyspnea, orthopnea, exertional dyspnea and slight swelling of the ankles of 1 month's duration. She had known that she had diabetes mellitus and hypertension for 10 years. She was aware that for a number of years her physician obtained her pulse and blood pressure more easily on the left than on the right arm.

A roentgenogram of the thorax showed marked cardiac enlargement and calcification of aorta.

Bilateral inequalities of blood pressure were reproducible in the 3 1-minute simultaneous indirect readings. The typical values obtained were right brachial artery, 170 mm. systolic and 128 mm. diastolic; left brachial artery, 254 mm. systolic and 100 mm. diastolic. A Regitine test for pheochromocytoma gave negative results when the brachial blood pressure was followed bilaterally. Bilateral direct recordings of the radial pressure were made, and they confirmed the inequality of blood pressure (fig. 5). For example, blood pressure in the right radial artery was 166 mm. systolic and 80 mm. diastolic; that in the left radial artery was 260 mm. systolic and 78 mm. diastolic. During treatment with antihypertensive drugs (including Serpasil, Apresoline, Protoveratrine and Ansolysen), 11 days after the initial study, typical bilateral indirect brachial pressures were right, 132 mm. systolic and 90 mm. diastolic; left, 180 mm. systolic and 80 mm. diastolic. The inequality was considered due to atheromatosis of the right subclavian artery, yet congenital narrowing of the right subclavian or brachial artery could not be excluded.

Inequality of Size of the Arm

Ragan and Bordley pointed out that in subjects with small arms blood pressure determined by the auscultatory method with a standard 13-cm. cuff tended to be too low when compared to that determined by the
BILATERAL ARTERIAL PRESSURES

Table 7
Mean Bilateral Blood Pressures Determined by the Simultaneous Indirect Method in Supine and Sitting Positions or before and during Treatment with Antihypertensive Drugs

<table>
<thead>
<tr>
<th>Blood pressure</th>
<th>Condition</th>
<th>Subjects</th>
<th>Measurements</th>
<th>Right, mm Hg</th>
<th>Left, mm Hg</th>
<th>Differences (Rt.-Lt.), mm Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean*</td>
<td>S.D.</td>
<td>Mean*</td>
</tr>
<tr>
<td>Systolic</td>
<td>Supine</td>
<td>50</td>
<td>150</td>
<td>163 ± 2.5</td>
<td>34.7</td>
<td>162 ± 2.8</td>
</tr>
<tr>
<td></td>
<td>Sitting</td>
<td>50</td>
<td>150</td>
<td>169 ± 0.9</td>
<td>11.7</td>
<td>168 ± 0.9</td>
</tr>
<tr>
<td>Diastolic</td>
<td>Supine</td>
<td>50</td>
<td>150</td>
<td>94 ± 1.6</td>
<td>19.9</td>
<td>95 ± 1.6</td>
</tr>
<tr>
<td></td>
<td>Sitting</td>
<td>50</td>
<td>150</td>
<td>103 ± 1.7</td>
<td>21.0</td>
<td>103 ± 1.6</td>
</tr>
</tbody>
</table>

Effect of position

<table>
<thead>
<tr>
<th>Blood pressure</th>
<th>Condition</th>
<th>Subjects</th>
<th>Measurements</th>
<th>Right, mm Hg</th>
<th>Left, mm Hg</th>
<th>Differences (Rt.-Lt.), mm Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean*</td>
<td>S.D.</td>
<td>Mean*</td>
</tr>
<tr>
<td>Systolic</td>
<td>Before</td>
<td>19</td>
<td>57</td>
<td>213 ± 4.8</td>
<td>35.8</td>
<td>210 ± 4.7</td>
</tr>
<tr>
<td></td>
<td>During</td>
<td>19</td>
<td>57</td>
<td>165 ± 3.5</td>
<td>26.1</td>
<td>165 ± 3.6</td>
</tr>
<tr>
<td>Diastolic</td>
<td>Before</td>
<td>19</td>
<td>57</td>
<td>121 ± 2.8</td>
<td>21.0</td>
<td>121 ± 2.8</td>
</tr>
<tr>
<td></td>
<td>During</td>
<td>19</td>
<td>57</td>
<td>92 ± 1.8</td>
<td>13.6</td>
<td>93 ± 1.9</td>
</tr>
</tbody>
</table>

*The figure after the ± sign is the standard error of the mean.

Table 8
Mean Circumferences of Arms

<table>
<thead>
<tr>
<th>Group and method</th>
<th>Subjects measured</th>
<th>Right, cm.</th>
<th></th>
<th></th>
<th>Left, cm.</th>
<th></th>
<th></th>
<th>Difference (Rt.-Lt.), cm.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean*</td>
<td>S.D.</td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
</tr>
<tr>
<td>Control</td>
<td>13</td>
<td>28.2 ± 0.5</td>
<td>1.8</td>
<td>28.2 ± 0.4</td>
<td>1.6</td>
<td>0            ± 0.5</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect</td>
<td>43</td>
<td>28.0 ± 0.2</td>
<td>3.2</td>
<td>27.8 ± 0.2</td>
<td>3.3</td>
<td>+0.3 ± 0.1</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Direct</td>
<td>52</td>
<td>28.7 ± 0.5</td>
<td>3.3</td>
<td>28.5 ± 0.5</td>
<td>3.4</td>
<td>+0.2 ± 0.1</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

*The figure after the ± sign is the standard error of the mean.

direct method, whereas in patients with large arms it tended to be too high. This difference was dependent on the fullness of the pulse wave. It is conceivable, therefore, that arms of unequal size could cause bilateral inequality of simultaneously determined indirect blood pressures when standard 13-cm. cuffs are used. The mean circumferences of the arms recorded are shown in table 8. The mean values on the 2 sides were essentially equal, and were about 28 cm. for both the control and patient groups.

Some subjects with a difference in circumference of the arm of as little as 4 cm. could have higher blood pressure in the larger arm or in the opposite arm or could have equal blood pressures in the 2 arms. Also, the subjects with arms of nearly equal or equal size showed inequalities of blood pressure with the higher pressure being found on either side. An interesting problem was encountered which was related to this aspect of the study. It demonstrated, as did the report of Trout and associates, that blood pressure readings in extremely obese arms may be erroneous.

Case 2

The patient, a 53-year-old, obese, white woman, had mild diabetes mellitus and had been under observation at the clinic since June 1950, at which time an adenocarcinoma of the rectum had been treated surgically. Blood pressure at that time was reported to be 210/116. She was hospitalized in January 1955 because of blood pressure of 230/140. At this time her height was 60 inches and her weight 245 pounds. Her right arm measured 48 cm. and her left 50 cm. Her left arm was too large to be encircled by a Tyco blood pressure cuff, which just encompassed the right arm. Recordings of the left brachial and right radial intraarterial pressures were made simultaneously. The
cuff was allowed to remain on the right arm so that synchronous direct and indirect determinations could be compared. A portion of the tracing obtained is shown in figure 6. The right radial pressure served a double purpose in that a marked disparity in the 2 sides would be apparent at once in a bilateral tracing and it could be used to indicate that the auscultatory systolic readings were corresponding with the first pulse wave recorded on the tracing. Representative basilar blood pressures were 170 mm. Hg systolic and 95 mm. diastolic in the left brachial artery by the indirect method, and 130 mm. systolic and 66 mm. diastolic in the right brachial artery by the direct method. The systolic cuff readings taken on the forearm by the palpatory method corresponded closely to the direct readings.

Right or Left-Handedness

In this study 437 patients were questioned as to whether they were right or left-handed. The 6 who were left-handed did not have blood pressures higher on the left side and the 431 who were right-handed did not have consistently higher blood pressures in the right than in the left arm or vice versa.

Age

The importance of age in relation to bilateral inequalities of the blood pressure was investigated, since loss of vascular elasticity and concomitant increase in arterial resistance to compression through arteriosclerosis might produce bilateral inequalities in the blood pressures. This study did not disclose any trend for a greater incidence of differences in blood pressure at any age level.

Arteriosclerosis

If arteriosclerosis were an important factor, one would not expect such frequently variable inequalities of blood pressures as were found. That arteriosclerosis may be a factor in certain isolated cases was brought out by the following case:

Case 3

An 83-year-old retired farmer was brought to the emergency room of a hospital in Rochester in December 1954 because of sudden transitory, sharp precordial pain, and palpitation. Marked peripheral arteriosclerosis was noted by palpation of arteries. The retinal vessels did not show hypertensive changes. The electrocardiographic findings were normal. Blood pressure recorded by the cuff method was 300 mm. systolic and 140 mm. diastolic on the right arm and 300 mm. systolic on the left arm; the diastolic pressure could not be recorded on the left arm. Korotkoff's sounds were indistinct and muffled, and several physicians had difficulty in obtaining satisfactory indirect brachial pressures. Bilateral direct determinations of radial blood pressure were done (fig. 7). Simultaneous direct readings were 130 mm. systolic and 52 mm. diastolic on the right and 92 mm. systolic and 52 mm. diastolic on the left. Bilateral application of the brachial cuff could obliterate the right radial pulse at 220 mm., yet the left radial pulse was still being recorded when the brachial cuff pressure was raised to 300 mm. Hg. The brachial arteries were palpated and found to be of "pipe-stem" firmness. A roentgenogram of the thorax was interpreted as showing calcification of the aortic arch and fibrosis of the left midlung field.

Discussion

The literature implies that the degree of discrepancies in the bilaterally determined blood pressures parallels the consistency and accuracy of the methods used to record the blood pressure. The same careful technique for determining blood pressure must be followed for each arm when bilateral blood pressures are obtained, and this technique must be applied symmetrically and simultaneously for accurate comparisons. Since indirect readings of blood pressure can be varied by the use of
BILATERAL ARTERIAL PRESSURES

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a wider or a narrower cuff, it is obvious that a standard cuff of the same width should be used on each arm. Similarly, the instruments used must be accurate and should be checked against one another. The patient’s arms must be in the same horizontal plane, for, according to Kahn, blood pressure in arms placed at different levels will differ because of the hydrostatic pressure of the column of blood between the 2 points of measurement.

The data presented herein support the contention of some investigators that, if bilateral measurements of blood pressure are to be compared, strictly simultaneous bilateral measurements must be obtained. Otherwise, transient bilateral fluctuations due to vascular hyper-reactivity, effects of respiration, cardiac arrhythmias, or moment-to-moment differences in pressure pulse waves may be misinterpreted as bilateral inequalities.

The subjective error of 2 observers admits a factor for possible error in the results of paired readings. Shock and associates, in a careful, statistical study of 102 subjects with 48 bilateral measurements, determined that a difference in blood pressure of more than 3 mm. Hg should be measurable by 2 observers. It must be granted, however, that differences in blood pressure of less than 10 mm. are of uncertain clinical significance.

The incidence of bilateral differences in blood pressure in our series was considerably less than in many previous reports. The most prominent characteristic was their inconstancy, which also has been noted by others. Allen and Hines summarized the variable nature of some differences of blood pressure in 1939: ‘These differences are not constant but transient and it is reasonably certain that all people have inequalities of blood pressure in the two arms at some time. Naturally, one should suspect organic disease when the differences are marked and persistent.’

The height of the blood pressure is apparently related in some way to bilateral differences in blood pressure. There was a slight increase in the number and magnitude of inequalities in blood pressure of hypertensive patients whose basal systolic blood pressures were 170 mm. Hg or more over those of hypertensive patients with blood pressures below this level or of persons without hypertension. When antihypertensive therapy had lowered the blood pressure in some patients with hypertension, the incidence of bilateral differences in systolic blood pressure also decreased slightly.

Several theories have been advanced concerning the causation of bilateral inequalities in blood pressure. Authorities generally agree concerning the existence of differences due to unilateral pathologic involvement of the subclavian or brachial arteries. Some investigators have insisted that the differences in normal vascular anatomy are the major causative factors in all bilateral inequalities in blood pressure. Proponents of a structural explanation have defended their findings of a high incidence of right-sided inequalities by considerations of the anatomic arrangement of the aortic arch. Southby proposed that since the innominate artery is closer to the source of pressure and since it is more in the direction of flow of blood from the ascending aorta, the blood pressure should be higher in the right brachial artery than in the left brachial. This, however, does not explain the existence of equality of blood pressure.
Bilateral, direct, radial pressures in an 83-year-old man with marked arteriosclerosis. Inflation of bilateral brachial cuffs failed to obliterate the left radial pulse waves even when the cuffs were inflated to a pressure of 300 mm. Hg. The right radial pulse was obliterated at cuff pressure of 220 mm. Hg. Note also the constant inequality of radial pressures apparently due to arterial structural differences.

Pressure on the 2 sides or of left-sided elevation in some persons, nor does it explain variable differences. Also, it is difficult to project this concept beyond the sites of the orifices of the innominate and left subclavian arteries. Perhaps a comparison of catheterization pressures from these vessels will eventually disclose the importance of the normal anatomy of the aortic arch in the production of blood pressure inequalities.

Southby also classified his patients according to age groups and did not find a relationship between increasing age and the magnitude of the differences in blood pressure found. Stein found a tendency for greater differences with increasing age. In our study 2 older patients were encountered on whom reproducible inequalities of blood pressure were found, and it appears to us that arteriosclerosis may be a major cause of differences in some patients. Randig and co-workers proposed that increased rigidity of the arteries of older patients may give differences in blood pressure in 2 ways: (1) by increase in the unilateral resistance to compression, and (2) by the presence of small patent channels through which the blood can pass when the artery is compressed by the inflated cuff. In young patients they contended that differences in tonus of the arterial wall might be a major factor in differences in blood pressure.

Tissue factors were considered by Phipps, in 1915, who placed a layer of fat meat about the arm beneath the cuff. This did not change the blood pressure, and he inferred that determinations of the brachial blood pressure are not affected by the thickness of the tissue surrounding the artery as much as by the position of the artery in relation to bone and muscle. Yoshino noted a higher systolic blood pressure in the larger arms of athletes or laborers who used mainly 1 arm in their endeavors. Ragan and Bordley, who studied blood pressure on 1 arm only, reported that dependent on the width of the cuff used, the indirect values could be too high in patients with large arms or too low in those with small arms. In our study inequality in the size of the 2 arms was not a factor in producing differences in the blood pressure. We also found, as previously pointed out in the literature, that the dominant hand is not a factor in inequality of blood pressure, since left-handed persons may have a higher pressure on the right and vice versa.

Wiggers has reviewed the complex dynamic reactions induced by compression of an artery, including production of Korotkoff's sounds and augmentation of the impinging pressure pulse, as well as its loss of energy in opening up a collapsed vessel, and pointed out that the answers to such basic problems are incompletely understood and need further investigation. Similarly, the cause of transitory inequalities of blood pressure in bilateral simultaneous determinations has not been clarified as yet.

In 1953 Beckmann postulated that differences in systolic blood pressure are due to changes in vascular elasticity which have both central and peripheral causes and that diastolic differences are due to differences in peripheral resistance. Baueisen, reporting
in the same year, stated that these differences
do not appear in a healthy subject under sta-
tionary circulatory conditions. The differ-
ences that he found in 12 of 458 healthy stu-
dents could not be reproduced by a bilateral
optical sphygmographic method. He stated
that when differences appear, they are expres-
sions of regulatory processes acting through
a central resistance to flow or change of vas-
cular elasticity.

In the present study, however, clinically
significant differences in blood pressure (10
mm. or greater) did occur in some subjects,
and smaller differences occurred much more
frequently under basal conditions. Transi-
tory differences in pressure found by both
the simultaneous indirect and direct measure-
ments may be due to a unilateral change in
arterial elasticity or vascular resistance, as
postulated by previous investigators, and me-
diated through dynamic neurovascular con-
trols, operating even at rest. A factor of
amplification of the systolic peaks through
reflected waves from unequal peripheral re-
sistance would be of greater importance in
the direct determination, since in the indirect
method the peripheral circulation is occluded
until the systolic level is reached. Perhaps
additional factors incident to compression of
the arteries by the cuffs may have accounted
for the greater frequency of differences found
by the simultaneous indirect method than by
the direct method.

In some patients studied herein by the bi-
lateral direct method and on whose arms we
inflated and then deflated a brachial blood
pressure cuff, the pulse waves subsequently
recorded varied markedly from those on the
opposite side. Ragan and Bordley52 in a com-
parison of indirectly and directly determined
blood pressures found that slow occlusion with
the cuff proximal to the site of direct measure-
ment was followed by a rise of the diastolic
pressure above that in the unoccluded artery,
and in addition there was a marked auscul-
tatory gap. With fast inflation of the cuff this
did not occur. They stated that prolonged
partial occlusion of the veins of the arm dur-
ing inflation of the blood pressure cuff affects
the arterial as well as the venous pressure
distal to the cuff. This suggests that study
of the partial unilateral venous occlusion to-
gether with bilateral determinations of the
blood pressures by the direct method might
elucidate the importance of venous factors in
the production of bilateral inequalities. This
is but one of the facets of the problem re-
quiring additional investigation.

In the course of our study, we found only
1 patient who had a marked and reproducible
bilateral difference in blood pressure by both
the simultaneous indirect and direct methods.
This difference was considered to be due to
asymmetrical occlusive arterial disease. The
blood pressure record of such a patient may
suggest paroxysmal hypertension, and phar-
macologic tests for pheochromocytoma may be
misinterpreted as giving positive results, if
the bilateral determinations of blood pressure
are made nonsimultaneously on the arms. In
addition, 2 patients were encountered who had
pseudohypertension, in that indirect readings
of blood pressure were found to be falsely
high when compared to those obtained by the
direct method. One of these patients had ad-
vanced arteriosclerosis and the other was ex-
tremely obese. This suggests that bilateral
simultaneous determinations of blood pressure
as employed in this study are not only of
value in detecting asymmetrical pathophysiol-
y of the aortic arch or its tributaries, but
also may be useful in the evaluation of certain
hypertensive patients, especially those being
tested for pheochromocytoma or considered
for antihypertensive therapy.

**Summary**

Bilateral determinations of the blood press-
ures were made nonsimultaneously and simul-
taneously by the indirect method under basal
conditions on 447 patients. In this group 26.6
per cent of the paired measurements by the
nonsimultaneous indirect method exhibited
systolic differences of 10 mm. Hg or greater
and 15 per cent exhibited diastolic differences
of this magnitude, whereas only 5.3 per cent
of the measurements by the simultaneous in-
direct method had systolic differences and

*Circulation, Volume XXII, September 1960*
only 4 per cent had diastolic differences of this degree. This indicates that bilateral determinations of blood pressure must be performed simultaneous'y on patients being examined for possible inequalities of blood pressure.

Bilateral differences in blood pressure obtained by the simultaneous indirect and simultaneous direct methods in 14 normal subjects and 53 selected patients were compared. In the normal subjects, 3 of the 42 paired indirect measurements and none of the paired direct measurements in either the radial or brachial arteries had systolic differences of 10 mm. Hg or greater, and none of the diastolic differences were of this level. In the 53 selected patients, 10 per cent of the indirect and 6 per cent of the direct measurements of systolic blood pressure differed by 10 mm. Hg or more and 8 per cent of the paired indirect measurements of diastolic blood pressure and less than 1 per cent of the paired direct measurements differed by this amount. These differences in bilateral blood pressures were characterized by their inconstancy and lack of agreement with subsequent measurements when studied by both the indirect and direct methods, which apparently separates them from those due to altered hemodynamics from pathologic conditions of the aortic arch or its tributaries.

Bilateral differences of blood pressure are of clinical importance when they are great and are reproducible by the direct as well as by the indirect methods, as illustrated by a patient encountered in this study.

In addition, 1 case of extreme obesity and 1 of advanced arteriosclerosis were reported. Both patients were found to have pseudohypertension, which was detected in this study.

A slight increase in the incidence of bilateral differences in indirect blood pressures was found in a group of patients whose blood pressures were measured while they were in the supine and then in the sitting position.

A slight increase in the incidence of bilateral differences was found at higher levels of blood pressure by comparing the blood pressures of nonhypertensive and hypertensive patients and of hypertensive patients before and during treatment with antihypertensive drugs.

Bilateral inequalities of blood pressure did not appear to be related to the age or sex of the subjects. Likewise, differences in circumstances of the arm or right or left-handedness did not appear to influence these inequalities, and there was no marked side dominance for differences found.

Bilaterally simultaneous, indirect measurements of blood pressure should be carried out on patients with hypertension who will be treated with antihypertensive drugs. Bilateral direct measurements may be used to verify the existence of inequality of blood pressures detected by the indirect method and to determine the correct pressure to be followed. This is particularly important in patients being screened for pheochromocytomas, since such differences may produce false-positive results.

**Sumario in Interlingua**

Determinationes bilateral del tension de sanguine esseva effectuate nonsimultaneamente e simultaneamente per le metodo indirecte sub conditiones basal in 447 patientes. In iste gruppo, 26,6 pro cento del pares de mesurationes non simultaneamente per le metodo indirecte exhibiva differentias systolic de 10 mm de Hg o plus, e 15 pro cento exhibivo differentias diastolic de iste magnitude, durante que in le pares de mesurationes simultaneamente per le mesme metodo indirecte, le incidentia de tal differentias systolic esseva solmente 5, 3 pro cento, illo de tal differentias diastolic solmente 4 pro cento. Isto significa que determinationes bilateral del tension de sanguine debe esser effectuate simultaneamente in patientes sub examine pro le presentia possibile de inequalitates del tension de sanguine.

Le tensiones al duo lateres, obtenite per simultanea mesurationes indirecte e per simultanea mesurationes directe, esseva compare pro 14 subjectos normal e 53 seligite patientes. In le subjectos normal, 3 del 42 pares de mesurationes indirecte e nulle del pares de mesurationes directe in le arterias radial o in le arterias brachial mostrava un differentia systolic de 10 mm de Hg o plus, e nulle del differentias diastolic esseva de iste ordine de magnitude. In le 53 seligite patientes, 10 pro cento del indirecte e 6 pro cento del directe mesurationes mostrava differentias systolic de 10 mm de Hg o plus, e 8 pro cento del indirecte e minus que 1 pro cento del directe mesurationes mostrava differentias diastolic de ille magnitude. Iste differentias inter le tensiones del sanguine al duo lateres esseva caracterisate per inconstanlia e non-
congruentia con subsequente mesurationes, tanto in le uso del directe como etiam in le uso del indirecete methodo. Iste caracteristica differentia los ab illos causate per un alteration del hemodynamica in consequentia de conditiones pathologic in le arco aortic o in le tributarios de illo.

Differentias bilateral del tension de sanguine es de significacion clinie quando illos es mareate e quando illos es reproducibile tanto per le directe como etiam per le indirecete methodo. Isto es illustrate per le caso de un del patientes includite in le presente studio.

Es reportate in plus un caso de extreme obesitate e un altore de arteriosclerosis avantitate. In ame iste casos, le presente studio detega le facto che le patiente habeva pseudohypertension.

Un level augmento in le incidentia de differenties bilateral del indirecete tension de sanguine eseva constatate in un gruppo de patientes in qule le mesurationes eseva effectuate primo quando illes se trovava in deecubito doral e postea quando illes se trovava in position sedente.

Un leve augmento del incidentia de differenties bilateral eseva constatate a plus alte nivellus del tension de sanguine in un comparation del mesurationes in patientes con e sin hypertaension e etiam in un comparation del mesurationes in patientes hypertensive ante e post le tractamento con drogas anti-hypertensive.

Le inequalitates del tension de sanguine al duo lateres non pareva esser relationate con le etate o con le sexo del subjectos. Similemente, differenties in le circumferentias del bracios e dexterismo o sinisterismo non pareva influentar iste inequalitates, e le differenties constatate non exhibiva un marcate dominancia de un later super le altrare.

Simultane indirecte mesurationes bilateral del tension de sanguine debevia esser effectuate in patientes con hypertension qui es candidatos pro un therapia a drogas antihypertensive. Directe mesurationes bilateral pote esser usate pro verificare le existentia de inequalitates lateral del tension de sanguine detegite per le indirecete methodo e pro determinar le correcte tension comme base del observationes suausequente. Isto es particularmente importante in patientes investigate pro pheochromocytomas, proque tal differenties es capace a producer resultatos falsamente positive.

References


It may naturally be supposed that the erroneous view which Laennec took of the heart's action, led to corresponding errors in his doctrines of auscultation. Yet these are, fortunately, not of such magnitude as might be expected. With one exception—that of considering loudness of the second sound to be an indication of dilatation of the auricles, the errors are those of omission, and of incorrect explanation. The omissions are considerable and important. He was not aware of a fact noticed by the writer several years ago, that bellow-murmurs are produced by regurgitation through the valves.—J. Hope, M.D. Diseases of the Heart and Great Vessels. London, William Kidd, 1832, p. 14.
Bilateral Indirect and Direct Arterial Pressures
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