Persistence of Abnormally High Vascular Tone in Vessels of the Finger after Digital Nerve Block in Patients with Chronic High Blood Pressure

By P. Gaskell, M.D., Ph.D., and A. Diosy, M.D.

The critical opening pressure of vessels supplying the nailfold capillaries of the finger was estimated as an index of the force being exerted by vascular smooth muscle in normal subjects and patients with various kinds of hypertension after the digital nerves were blocked. It was greater in the hypertensive patients, suggesting the existence of an abnormally high force being exerted by the smooth muscle in hypertensive patients which is not under the immediate control of the nervous system.

It is generally agreed that the immediate cause of the high blood pressure in patients with chronic essential hypertension is an increased peripheral vascular resistance. The vessels in the extremities seem to be among those involved, so the extremities provide a convenient site for studying some of the factors which may be responsible for the increased resistance. Previous work suggests that the abnormally high resistance in vessels of the finger in hypertensive patients is caused, at least in part, by an increase in the constricting force exerted by the smooth muscle in the walls of the small vessels. This was indicated by the greater critical closing pressure (CCP) of vessels of the finger in hypertensive patients than in normal subjects whether the individuals were constricted or dilated. Similar results have been found in the vessels of the nailfold with respect to the critical opening pressure (COP), which has the same significance as the CCP.

Mendlowitz, Torsdag and Sharney came to the conclusion that there is an increase in neurogenic vascular smooth muscle contraction in hypertension, but they did not find an abnormally high critical closing pressure of finger vessels in hypertensive subjects after inhibition of vasoconstrictor nerves. They therefore think that the "intrinsic narrowing of the digital vascular bed in hypertension is not produced by increased smooth muscle tone."

Observations will be presented which indicate that there is an additional or abnormal force being exerted by the vascular smooth muscle in patients with chronic hypertension which persists after removal of the immediate influence of the nervous system.

Methods

The COP of vessels supplying the capillary loops of the nailfold was estimated as previously described, after anesthetization of the digital nerves in patients with high blood pressure and subjects with normal blood pressure.

The digital nerves were blocked by injecting 1 ml. of 1 per cent xylocaine without epinephrine into each side of the base of the finger in the region of the nerves. The effectiveness of the nerve block was shown by loss of sensation to pinprick at the tip of the finger and by a rise in skin temperature at the tip to 33-35 C. It might be thought that injection of 1 ml of fluid into each side of the base of the finger and in the region where the digital artery blood pressure was measured would influence the measurement of the systolic blood pressure. Experiments performed with saline showed that this was not the case.

Besides removing the nervous control over the blood vessels, the nerve block served another useful function. It has been shown that the local tissue temperature has a great influence on the
The vasodilatation which occurs as a result of the nerve block increases the local temperature in all individuals to approximately the same point and so standardizes this factor.

In the definitive experiments, the COP was estimated 6 times after the nerve block was effective and the mean of the 6 estimations is given as the COP for that individual.

The COP was measured in the hypertensive patients as we were notified of their availability on the wards or in the out-patient department. The patients whose hypertension is not specified as to kind in table 1 were believed to have essential hypertension except B.F.L. who, on the basis of pyelographic studies, was thought to have an unidentified anomaly of the kidneys. The subjects with normal blood pressure were obtained from among our colleagues, nurses and the hospital housekeeping staff, except for one (M.M.) with a gastric ulcer and one (T.B.) with an oesophageal carcinoma.

**RESULTS**

The COP after the digital nerves were blocked was estimated in 22 subjects with normal blood pressure and 26 hypertensive patients (table 1). The blood pressures reported are supine brachial artery pressures found at the time the COP was measured. In the patients they do not differ greatly from their usual blood pressure. It will be seen that the COP in subjects with normal blood pressure were all less than 16 mm. Hg and in most it was not more than 10 mm. Hg, while the COP in hypertensive patients was greater than in the normotensive individuals. The age range of the normotensive individuals was not quite as large as that of the patients, but there was no obvious relationship between the COP and age in this small series. When the COP was estimated a second time on another day the values obtained were in most cases very similar.

When the estimation of the COP was carried out a few of the patients, indicated in the table, were receiving one or more of chlorothiazide (Diuril), serpasil or ganglion blocking agents. Four of these patients, E.L., M.D., A.P. and A.P., as well as W.L., were receiving sedative doses of a barbiturate. Patientes K.B. and H.F. were taking a digitalis preparation and K.B. and T.V. were on a low salt diet. Patient T.V. was receiving insulin. The brachial blood pressures of these patients were still high, however, except in the case of E.L.; and their COP after nerve block was higher than any seen in the normotensive individuals.

The COP estimations made in 1 female, age 40 years, who volunteered as a normal subject are not included in table 1. Her blood pressure was 125/95 and the COP was 20 mm. Hg. A few days later her blood pressure was found to be about 130/95 and the COP 17 mm. Hg. She had no complaints and she was not examined further. There was uncertainty about where to place her in the table.

Results in certain of the patients are of special interest. Patient J.R.R. had a pheochromocytoma and his COP after nerve block was 31 mm. Hg. During preoperative treatment with phenoxybenzamine (Dibenzyline) when his supine brachial blood pressure was 124/70 mm. Hg, his COP was 16 mm. Hg and fell to 9 mm. Hg when the digital nerves were blocked.

Patient L.H. had coarctation of the aorta. The first time the COP after digital nerve block was estimated it was 17 mm. Hg and was between the values observed in normotensive individuals and those found in hypertensive patients. The estimation was repeated about 10 days later and a value of 20 mm. Hg obtained. This probably means that the COP was higher than normal and higher than might be expected if the hypertension in the upper extremities was on a purely mechanical basis. Patient A.D. who also had coarctation of the aorta, had a COP of 15 mm. Hg on the first and 17 on the second occasion.

Patient H.C. was found to have a high blood pressure during a period of acute renal failure following the use of a Lysol and soap solution to induce abortion. Her blood urea nitrogen had been 90 mg. per cent, but was 23 mg. per cent and her blood pressure 168/98 mm. Hg at the time her COP, after nerve block, was estimated at 25 mm. Hg. About 9 weeks later her blood pressure was
### Table 1: COP in Normotensive and Hypertensive Individuals after Digital Nerve Block

<table>
<thead>
<tr>
<th>Age</th>
<th>Normotensive</th>
<th>COP</th>
<th>Hypertensive</th>
<th>COP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Syst.</td>
<td>Diast.</td>
<td></td>
<td>Syst.</td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.S.</td>
<td>16</td>
<td>98</td>
<td>70</td>
<td>12</td>
</tr>
<tr>
<td>S.G.</td>
<td>19</td>
<td>106</td>
<td>68</td>
<td>9</td>
</tr>
<tr>
<td>L.M.</td>
<td>20</td>
<td>110</td>
<td>55</td>
<td>15</td>
</tr>
<tr>
<td>Y.R.</td>
<td>20</td>
<td>96</td>
<td>64</td>
<td>13</td>
</tr>
<tr>
<td>R.A.</td>
<td>21</td>
<td>108</td>
<td>60</td>
<td>4</td>
</tr>
<tr>
<td>G.M.</td>
<td>21</td>
<td>98</td>
<td>70</td>
<td>7</td>
</tr>
<tr>
<td>R.O.</td>
<td>21</td>
<td>100</td>
<td>60</td>
<td>7</td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J.T.G.</td>
<td>30</td>
<td>112</td>
<td>74</td>
<td>8</td>
</tr>
<tr>
<td>P.D.</td>
<td>34</td>
<td>116</td>
<td>74</td>
<td>9</td>
</tr>
<tr>
<td>P.G.</td>
<td>41</td>
<td>130</td>
<td>72</td>
<td>13</td>
</tr>
<tr>
<td>J.A.H.</td>
<td>41</td>
<td>120</td>
<td>76</td>
<td>9</td>
</tr>
<tr>
<td>G.A.T.</td>
<td>47</td>
<td>118</td>
<td>80</td>
<td>9</td>
</tr>
<tr>
<td>F.H.W.</td>
<td>51</td>
<td>108</td>
<td>72</td>
<td>9</td>
</tr>
<tr>
<td>M.M.</td>
<td>56</td>
<td>112</td>
<td>76</td>
<td>15</td>
</tr>
<tr>
<td>T.B.</td>
<td>66</td>
<td>116</td>
<td>76</td>
<td>13</td>
</tr>
</tbody>
</table>


130/84 and her COP after nerve block was 16 mm. Hg.

**Discussion**

The COP of the vessels supplying the nailfold capillaries was found to be greater in hypertensive patients than in subjects with normal blood pressure after the nervous control over the vessels had been removed by digital nerve block. This seemed to be true in all the kinds of hypertension represented in this small series. Apparently there is an increased constrictor force being exerted by the smooth muscle in the small vessels of hypertensives and this extra force is not
dependent on the immediate control of the central nervous system. However, one circumstance which would invalidate this interpretation of the results should be pointed out. The COP is an index of the force exerted by the smooth muscle only if the elastic forces in the wall of the vessel played no part in the final closure of it. If in hypertension, for example, there was so much edema of the intima that the lumen was obliterated while there was still elastic tension being exerted by the stretched tissues of the wall, the COP as measured would be an index of the force exerted by the smooth muscle plus that produced by elastic tension and one would not know the proportion of each. While this circumstance is not considered probable, it cannot be entirely excluded at the present time.

The results presented here are compatible with the abnormally high CCP and COP observed in hypertensive patients during body heating by Yamada and Burton and by Gaskell and Krisnan. They do not agree with the results obtained by Mendlowitz et al. in hypertensive patients after inhibition of the sympathetic nerves by body heating plus administration of a ganglion blocking drug. This discrepancy may have occurred because of the different methods which were used.

It would be of great interest to know whether there is an increased force exerted by the vascular smooth muscle independently of neurogenic influence in all types and stages of hypertension. The results obtained in H.C. who had a hypertension of short duration, indicate that in some patients with acute hypertension the peripheral resistance is increased in this way.

It is evident that the increased force exerted by the vascular smooth muscle independently of the nervous system in the presence of the pheochromocytoma was the result of greater activity per unit mass of muscle. Probably the same was true during the hypertension experienced by patient H.C. It is possible that in other kinds of hypertension, such as essential hypertension, the increased force may be manifested only after hypertrophy of the media has occurred and it will not then represent any greater activity per unit mass of muscle than in normotensives.

Although the COP after nerve block was higher in the hypertensives than in normal subjects, it did not always reflect very accurately the magnitude of the brachial diastolic blood pressure. This might be expected when other influences, e.g., vasomotor nerves that are not being measured are contributing to the maintenance of the blood pressure. It may also be that the vascular smooth muscle in some tissues of the body are more affected than others and to various degrees in different individuals by any abnormal factor. The tissues most affected will contribute more to the elevation of the blood pressure than will the vessels of the tissues less affected and, in some patients, the vessels of the digits may be among the latter.

It is hoped that with more experience the estimation of the COP after digital nerve block may prove to be a better guide to the diagnosis and study of hypertension than the blood pressure, especially when the blood pressure is borderline. It may be that normal blood pressure regulating mechanisms keep the blood pressure relatively low in some individuals, obscuring the presence of an abnormal vasoconstrictor influence.

**Summary**

The critical opening pressure (COP) of vessels supplying the nailfold capillaries of the finger was estimated after anesthetizing the digital nerves in 22 subjects with normal blood pressure and 26 patients with various kinds of hypertension. The COP ranged from 3 to 15 mm. Hg in the normotensive subjects and from 17 to 44 mm. Hg in the hypertensive patients.

Under the circumstances of the tests, the COP was considered to be an index of the force being exerted by the vascular smooth muscle independently of immediate vasomotor nerve influence. With one reservation.
which is discussed, the results indicate that in the hypertensive subjects an abnormal force, not under the immediate control of the nervous system, was being exerted by the vascular smooth muscle.

Acknowledgment

We are grateful to our colleagues who allowed access to their patients and to those individuals who acted as normal subjects.

Summary in Interlingua

Le tension critic de apertura (TCA) de vasos alimentante le capillares del plicas subungual in le digitos esseva estimate post anesthetisation del nervos digital in 22 subjectos con normal tension de sanguine e in 26 subjectos con varie generes de hypertension. Le TCA variava inter 3 e 15 mm de Hg in le subjectos normotensive e inter 17 e 44 mm de Hg in le subjectos hypertensive.

Sub le conditiones del tests, le TCA esseva considerate como un indice del fortia exerceite per le musculo lisie vascular a parte le influentia de nervos vasomotori. Con un qualificazione (discutite in detalio in le texto), le resultatos indica que in subjectos hypertensive un fortia anormal, non sub le controlo immediate del sistema nervose, esseva exerceite per le lisie musculo vascular.

References

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