Neurogenic Constriction of the Superior Mesenteric and Femoral Veins during Systemic Blood Pressure Oscillation in Rabbits

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Abstract Behavior of the mesenteric and femoral veins was studied in rabbits during an arterial pressure oscillation elicited by a method that we call the "side pressure exertion experiment." A segment of the mesenteric or femoral vein with intact innervation was vascularly isolated and was perfused under an isovolumetric condition. The force of the isovolumetric constriction of the segments was recorded in terms of the intrasegmental pressure during arterial pressure oscillation. The intrasegmental pressure of the superior mesenteric vein indicated an alternation of marked rise and fall during the oscillation. On the other hand, the response of the femoral segment during oscillation was less phasic but was better maintained at the higher range of initial pressures than that of the superior mesenteric segment. Simultaneously with the maximum rise of systemic arterial pressure, maximum elevation by 6.1, 6.1 and 6.4 mmHg was obtained in the mesenteric vein segment at initial intrasegmental pressures of 6, 10 and 14 mmHg, respectively. In the same circumstances, the femoral vein segment indicated a maximum rise of 8.1 to 9.3 mmHg at initial pressures of 10, 18, 26 and 34 mmHg. It can be concluded that there are marked differences between the mesenteric and femoral segments in behavior during systemic arterial oscillation and in the range of bearable intrasegmental pressure. The characteristics of the two veins might be related to the difference of specific circumstances in which the respective veins send blood back to the heart.

In recent years the response of the various veins to nervous stimulation have been extensively investigated in dogs and rabbits (VANHOUTTE and LEUSEN, 1969; BEVAN et al., 1974; BEVAN and LJUNG, 1974; LJUNG et al., 1975). Several investigators (WEBB-PEPLOE, 1969; IIZUKA et al., 1970) have similarly studied the reflex constrictor responses of the ileal, colic and lateral saphenous veins to hypotension in the carotid sinus region. Their results have provided us with only

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limited aspect of the behavior of the veins and it is not comprehensive enough for us to understand the significance of the innervation of the veins in overall integration of the cardiovascular system.

Miyakawa (1966a, b) devised a method of obtaining systemic arterial pressure oscillation around elevated levels by exposing rabbit brains to ischemia. This method consists of occluding all the arteries to the brain except one of the common carotid arteries and compressing the carotid artery by side pressure, which is elevated in steps. The arterial blood pressure oscillation has already been proven to be neurogenic in nature (Miyazawa and Miyakawa, 1967). In this circumstance not only the arterial system but the venous system also is expected to be controlled by the vasomotor center.

In this study, a vascularly isolated and normally innervated segment of the superior mesenteric or the femoral vein was perfused under isovolumetric condition in rabbits. The behavior of the two veins during blood pressure oscillation at varied levels was investigated in terms of intrasegmental pressure changes.

METHODS

Vascularly isolated but naturally innervated segments of the superior mesenteric and femoral veins were taken from 18 and 21 rabbits of both sexes weighing approximately 3 kg, respectively. The segments were perfused with blood of the respective donor rabbits. The host rabbit of the segment and the donor animal were anesthetized with urethane (0.9 g/kg i.m.) after a 24-hr fast. Rectal temperature of the host and donor animals was kept at 38°C with a heating pad.

The production of systemic blood pressure elevation. All routes of blood supply to the head except one of the common carotid arteries were occluded by a surgical operation (Miyakawa, 1966a, b). One of the common carotid arteries was cannulated for recording systemic arterial pressure (Fig. 1). The other common carotid artery, that was the only remaining route of blood supply to the brain, was compressed by side pressure using the device shown in Fig. 1. As the side pressure was elevated in steps, a corresponding stepwise increase in systemic arterial pressure superimposed by oscillation was invariably obtained.

Preparation of innervated venous segments. A portion of the superior mesenteric vein, which runs parallel to the axis of the intestinal loop and was 38.6±5.0 (S.D.) mm in length, or a venous segment which extended from the distal side of the iliac to the middle part of the femoral vein and was 46.0±45 mm in length, was vascularly isolated from the surrounding tissues, taking precautions against any injury to the nerve fibers of the segment. With the same carefulness, both ends of the segments were cannulated for perfusion and recording intrasegmental pressure.

Intrasegmental pressure measurements. For the mesenteric vein, two different cannulation methods were adopted (Fig. 2A and B) but no difference between...
Fig. 1. Schematic drawing of experimental methods. P1, P2: Holter's roller pumps. SBP: Systemic arterial blood pressure. IP: Inflow pressure. PM: Intrasegmental pressure of the superior mesenteric or the femoral vein.

Fig. 2. Schematic illustration of the methods of isolation and cannulation of the segments of the superior mesenteric and femoral veins. The schema of innervation of the superior mesenteric vein was modified from Furness and Marshall (1974).

the results obtained by the two methods was indicated. The cannulation method for the femoral vein is shown in Fig. 2C. The proximal side of the segment has two branches, namely the deep iliac circumflex vein and the inferior epigastric vein. First, a cannula was inserted into the proximal part of the femoral vein through the latter. Then the former and the distal end of the iliac vein were ligated. Secondly, the distal end of the segment was cannulated as shown in Fig. 2C. The
proximal cannula of the mesenteric or femoral vein segments was connected to the femoral vein of its donor animal through roller pump P1 (Holter, RL 175), as shown in Fig. 1. Each distal end was similarly connected to the external jugular vein of its donor through roller pump P2 of the same kind as shown in Fig. 1.

The pressures at the distal and proximal ends of each segment were recorded with pressure transducers of small compliance (Statham, P-37 and P-23Db), as a measure of the force of isovolumetric constriction of the segment. The compliance of the whole perfusion system, which included the transducers but excluded the segment, was less than 0.5 mm³/10 mmHg.

Before the experiment, 1,000 IU/kg of heparin was injected intravenously into the donor and host animals. Thereafter, a maintenance dose of 500 IU/kg was given to the donor animals every 30 min.

Production and maintenance of desired pressure within the segment was conducted by driving the roller pumps at the proximal and distal ends, if necessary.

Side pressure exertion experiments. Each series of side pressure exertion experiments was begun by setting the initial intrasegmental pressure of the mesenteric at either 0, 2, 6 or 10 mmHg and that of the femoral at either 2, 10, 18 and 26 mmHg, in random order, respectively. Then side pressure exerted on the common carotid artery was elevated in steps, and the series of experiments was ended by elevating the side pressure to 200 mmHg, which was high enough to occlude the blood supply to the brain (Figs. 3 and 4). The experiments with extremely high initial pressures, namely 14 and 18 mmHg in the mesenteric, and 34 and 42 mmHg in the femoral, were carried out in the last series of the experiments, because the exertion of such high pressures might put the segment in a paralytic state lasting for a considerable period. The complete interruption of blood supply to the head at the end of each series was terminated promptly after systemic arterial pressure attained its maximum, because it might cause considerable damage to the brain. Between each series, 10 and 15 min intervals were provided for recovery of the mesenteric and femoral segments, respectively. Then the next series at a different initial intrasegmental pressure was begun. Usually all the pressures were recorded through integrators with a time constant of 1 sec.

Pressure-volume relation of the segments. As the segment was restored to its original volume after the last series of experiments, its pressure-volume coefficient was measured by recording the elevation of intrasegmental pressure accompanying the injection of known amounts of isotonic saline solution into it. First, the pressure in the mesenteric and the femoral segments was set around 0 and 1 mmHg, respectively, while the systemic blood pressure of the host animal was kept at its respective control value. Then isotonic saline solutions of 2, 4 and 6 mm³, and 1, 2, 3 and 4 mm³ were injected in succession from the point indicated in Fig. 1 into the perfusion system of the mesenteric and the femoral segments, respectively, and the intrasegmental pressure was measured.

For the measurement of the volume of the segments at their initial intraseg-
mental pressures, a bubble of air which was large enough to block the segmental lumen was introduced into it. Then the bubble was displaced very slowly throughout the length of the segments by injecting blood behind it. The volume of the injected blood required for the transport of the bubble was regarded as the capacity of the segments.

The expected influence of the intra-abdominal pressure on the segment of the mesenteric vein was eliminated by exposing it to the atmosphere, covered with a piece of wet gauze. The temperature around the segments was kept at 38°C by irradiation of an infrared electric lamp or wrapping with a warming jacket.

RESULTS

1. Venous pressures under natural blood flow conditions before and during arterial pressure oscillation

The intravascular pressure of the superior mesenteric vein of the animal in a supine position was measured by inserting a pair of fine cannulae into the vein through its branches, which were situated approximately 30 mm apart, so that the distal and proximal pressures there under natural blood flow conditions were estimated. In 3 animals, the distal and proximal pressures were 4.9 and 4.6 mmHg, respectively, while the systemic arterial pressure was 89.3 mmHg. Similarly, the intravascular pressure of the femoral vein of the animal in the supine position was about 8 mmHg.

As the side pressure exerted on the common carotid was elevated to 40 or

![Fig. 3. Comparison of the pressure in the superior mesenteric vein under natural blood flow conditions and the pressure in the vascularly isolated segment of the same vein during systemic blood pressure oscillation. PVM: Pressure in the superior mesenteric vein under natural blood flow conditions. PS: Proximal pressure. DS: Distal pressure. SBP: Systemic arterial blood pressure. Panels A and B: Records obtained from the superior mesenteric vein under natural blood flow conditions. Panels C and D: Record obtained from a vascularly isolated segment of the superior mesenteric vein. SP: Side pressure exerted on the common carotid artery.](image-url)

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80 mmHg, arterial pressure became unstable and began to oscillate at a frequency of approximately 0.05 Hz (Figs. 3, 4A and B). This is in agreement with previous studies (MIYAKAWA, 1966a, b). At 40 mmHg side pressure, the intravenous pressures indicated a slight fall concomitant with the elevation of systemic arterial pressure (Fig. 3A). As systemic arterial pressure was further elevated, the pressures tended to increase. In accordance with arterial pressure oscillation, the proximal and distal pressures also indicated a slight undulation. During interruption and resumption of blood supply to the brain, the venous pressures under natural blood flow conditions indicated the same changes as those corresponding to one cycle of the arterial pressure oscillation but much larger in scale (Fig. 3B).

The elevation and undulation of the intravenous pressure in natural blood flow situations (Fig. 3A and B) was quite poor compared with the pressure changes in the vascularly isolated segment made from the same vein in response to similar side pressure application including the complete interruption of blood supply to the brain (Fig. 3C and D). Almost the same results were obtained from the other animals. This difference can be ascribed to the isovolumetric condition in the case of the experiment on the segment.

2. Intrasegmental pressure during systemic arterial pressure oscillation

The simultaneous records of the pressures within the mesenteric or femoral vein segments and systemic arterial pressure during the side pressure exertion experiment are presented in Fig. 4A and B. In accordance with the rise of systemic arterial pressure, the intrasegmental pressure of the mesenteric vein increased (Fig. 4A). As the systemic arterial pressure began to oscillate, the intrasegmental pressure also began to undulate. The wave height of the intrasegmental pressure undulation was almost in proportion to that of systemic arterial pressure oscillation. The level of the undulation also rose in parallel to that of systemic arterial pressure oscillation.

On the other hand, the intrasegmental pressure of the femoral indicated a gradual rise before it became steady under the exertion of side pressures of 70 and 80 mmHg (Fig. 4B). The pressure indicated only a small undulatory change accompanying arterial pressure oscillation, and the wave height of the undulation was far smaller than that of the mesenteric segment.

The relation between the mean intrasegmental pressure and the mean systemic arterial pressure were studied at six different initial intrasegmental pressures (Fig. 5). Mean pressure denotes the mean area, in mmHg, which is enclosed by the line of the oscillation or the undulation and respective base lines. When the initial pressure in the segment of the mesenteric was set in the neighborhood of its control value (4.9 mmHg), which was obtained under natural flow conditions, the slope of the curve was the largest (Fig. 5A). It was almost identical at initial pressures of 2, 6 and 10 mmHg, and was successively reduced in the order of 14, 18 and 0 mmHg. The mean intrasegmental pressure increased roughly in pro-
Fig. 4. The pressure in the segments of the superior mesenteric and femoral veins during blood pressure oscillation. In panel A, from top to bottom, pressure in the segment of the superior mesenteric vein (PMV) and systemic arterial blood pressure (SBP) of the host animal. In panel B, from top to bottom, pressure of the femoral vein (PFV) and systemic arterial blood pressure (SBP). The numbers at the bottom of each panel indicate the side pressure exerted on the common carotid artery.

portion to that of systemic arterial pressure during a series of side pressure exertion experiments.

The same kind of relation was obtained between the mean intrasegmental pressure of the femoral and the mean systemic arterial pressure (Fig. 5B). The intrasegmental pressure increased approximately in direct proportion to the rise of the mean systemic arterial pressure at all initial pressures. Some curves indicated slight upward convexities.

3. The quantitative relation between intrasegmental pressure undulation and systemic arterial pressure oscillation

Table 1 presents the wave heights of arterial pressure oscillation and the undulation of intrasegmental pressure at the stage in which the maximum wave height of the oscillation was obtained. The largest wave height of the intrasegmental pressure of the mesenteric was obtained at the initial intrasegmental pressure of 6 mmHg, while it was the smallest at the initial pressure of 18 mmHg. The wave
Fig. 5. Relation between mean intrasegmental pressure and mean systemic arterial blood pressure. Panel A: The relation of the segment of the superior mesenteric vein. Panel B: The relation of that of the femoral. N indicates the number of experiments. Values are expressed as mean ± S.E.

Table 1. Wave heights of systemic arterial blood pressure oscillation and intrasegmental pressure undulation at varied initial intrasegmental pressures of the superior mesenteric and femoral veins.

<table>
<thead>
<tr>
<th>Initial intrasegmental pressure (mmHg)</th>
<th>Mean systemic blood pressure (mmHg)</th>
<th>Wave height of blood pressure oscillation (mmHg)</th>
<th>Wave height of intrasegmental pressure undulation (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segment of superior mesenteric vein</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>137.0 ± 2.8</td>
<td>32.3 ± 4.4</td>
<td>1.40 ± 0.28</td>
</tr>
<tr>
<td>2</td>
<td>130.8 ± 3.1</td>
<td>31.9 ± 3.6</td>
<td>1.32 ± 0.21</td>
</tr>
<tr>
<td>6</td>
<td>129.5 ± 2.7</td>
<td>34.5 ± 2.8</td>
<td>2.07 ± 0.38</td>
</tr>
<tr>
<td>10</td>
<td>129.3 ± 3.4</td>
<td>35.1 ± 3.7</td>
<td>1.74 ± 0.23</td>
</tr>
<tr>
<td>14</td>
<td>131.6 ± 4.4</td>
<td>32.9 ± 2.9</td>
<td>1.10 ± 0.10</td>
</tr>
<tr>
<td>18</td>
<td>134.5 ± 2.8</td>
<td>40.0 ± 3.9</td>
<td>1.00 ± 0.12</td>
</tr>
<tr>
<td>Segment of femoral vein</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>124.9 ± 4.1</td>
<td>27.4 ± 4.4</td>
<td>0.40 ± 0.19</td>
</tr>
<tr>
<td>10</td>
<td>127.9 ± 3.1</td>
<td>29.0 ± 2.6</td>
<td>0.59 ± 0.12</td>
</tr>
<tr>
<td>18</td>
<td>138.8 ± 3.4</td>
<td>23.5 ± 2.0</td>
<td>0.50 ± 0.11</td>
</tr>
<tr>
<td>26</td>
<td>126.7 ± 4.1</td>
<td>28.7 ± 2.7</td>
<td>0.89 ± 0.21</td>
</tr>
<tr>
<td>34</td>
<td>131.3 ± 3.8</td>
<td>28.4 ± 4.3</td>
<td>0.42 ± 0.22</td>
</tr>
<tr>
<td>42</td>
<td>133.8 ± 3.0</td>
<td>17.4 ± 4.1</td>
<td>0.12 ± 0.08</td>
</tr>
</tbody>
</table>

Values indicate mean ± S.E.
height of intrasegmental pressure undulation was in inverse proportion to the initial value, despite the fact that the concomitant arterial pressure oscillation was the same in wave height. The wave height of the undulation of the mesenteric segment was as large as 1.3 and 2.1 mmHg at initial pressures of 2 and 6 mmHg, respectively. In the femoral segment, however, it was only 0.40 and 0.58 mmHg at initial pressures of 2 and 10 mmHg, respectively. The wave height of the undulation of the femoral segment at the initial pressure of 26 mmHg was the largest: 0.89 mmHg. On the other hand, it was only 0.12 mmHg at an initial pressure of 42 mmHg. In conclusion, the wave height of the mesenteric far exceeded that of the femoral.

4. **Relation in phase between intrasegmental pressure undulation and systemic arterial pressure oscillation**

Each wave of intrasegmental pressure undulation always appeared behind its corresponding wave of systemic arterial pressure oscillation. The time lag was $1.3 \pm 0.9$ (S.D.) sec at the top of the peak and $1.1 \pm 0.8$ sec at bottom of the glen in the mesenteric. It was $2.3 \pm 1.0$ sec at the top and $2.1 \pm 1.0$ sec at the bottom in the femoral. These time lags were not affected by differences in the initial pressure. The delay was larger by 1 sec in the femoral than in the mesenteric. The response of the femoral intrasegmental pressure to the abrupt interruption of blood supply to the brain was very sluggish. The time required for full response was $112.0 \pm 76.7$ (S.D.) sec, while that required by systemic arterial pressure was only $14.0 \pm 7.4$ sec. Upon the resumption of blood supply to the brain, it also took a much longer time for the intrasegmental pressure to be restored to its resting value than it took systemic arterial pressure. The times for the restoration of the femoral intrasegmental pressure and the systemic arterial pressure were $268.2 \pm 170.4$ (S.D.) sec and $45.3 \pm 24.4$ sec, respectively.

5. **Pressure-volume curves of the segments of the superior mesenteric and the femoral vein at varied neurogenic constrictions**

The elastic characteristic of the segment, including the perfusion system, was studied by recording the intrasegmental pressure elevations in response to injections of known amounts of saline solution into it, as shown in Fig. 6. The intrasegmental pressure responded almost with a square wave rise to the injection and was nearly stabilized 10 sec after the beginning of the injection. This stabilized value of pressure increase, which SIMON et al. (1975) called "delayed compliance," was used for making pressure-volume curves of the segment. The responses of the transitional stages, namely at the beginning and the end of the injection, were quite different between the proximal and distal ends of each segment. These differences can be ascribed to the absorption of the high frequency components by the viscoelastic elements of the segmental tissues. With successive injections of the saline solution, the intrasegmental pressure elevated from 0 to
Fig. 6. Stress-strain curves of the segment of the superior mesenteric vein. Physiological saline solution of 6 mm$^3$ was injected at point A and withdrawn B. Left and right panels are the records of initial intrasegmental pressures of 6 and 11 mmHg, respectively.

about 22 mmHg in the mesenteric, and from 1 to about 50 mmHg in the femoral, respectively. Thus, pressure-volume relations of the segments in a resting condition were obtained. The compliance of the system except the segment was so small that it scarcely affected the original values, but corrections were made. The pressure-volume curves at the bottom of Fig. 7A and B were obtained by plotting these corrected values.

The curves corresponding to varied systemic blood pressure were made as follows. The initial intrasegmental pressures in Fig. 5A and B were plotted on the above-mentioned pressure-volume curves in Fig. 7. Perpendicular lines were drawn from the points plotted on the curves. Then increments of the intrasegmental pressure accompanying successive 10 mmHg unit rises in systemic blood pressure were obtained again from the curves in Fig. 5A and B, and were plotted on the perpendicular lines in Fig. 7A and B, covering the range from 80 to 160 mmHg in the mesenteric and from 90 to 160 mmHg in the femoral. When points with the same systemic arterial pressure were connected, two families of curves were obtained as shown in Fig. 7A and B.

The volume of the segment of the superior mesenteric was $50.3 \pm 3.0$ (mean $\pm$ S.D.) mm$^3$ at $0.2 \pm 0.1$ mmHg. That of the femoral at $0.9 \pm 0.6$ (S.D.) mmHg was $88 \pm 31$ mm$^3$.

The decrease in the segmental volume during the side pressure exertion experiment was calculated from the results in Figs. 5 and 7 and Table 1. The decreases are shown in Table 2. When the initial intrasegmental pressures were set in the neighborhood of 6 mmHg in the mesenteric and 10 mmHg in the femoral, which were the respective medians of intravenous pressures under natural flow conditions, the segmental volume indicated their maximum decreases at the highest systemic arterial pressure. The maximum decreases were 29% in the mesenteric and 12% in the femoral, respectively. The femoral vein is stiffer than the superior mesenteric vein.
Fig. 7. Two families of pressure-volume curves of the segments. Panels A and B show those of the superior mesenteric and the femoral, respectively. Pressure-volume curve indicated upward shift with each 10 mmHg-step increase of mean systemic arterial blood pressure from 80 to 160 mmHg in the superior mesenteric and from 90 to 160 mmHg in the femoral. Arrows indicate the direction of increase of systemic arterial blood pressure.

Table 2. Calculated voluminal changes of the segments during the side pressure exertion experiment.

<table>
<thead>
<tr>
<th>Initial intrasegmental pressure (mmHg)</th>
<th>Initial volume (mm³)</th>
<th>Volume change during undulation (mm³)</th>
<th>Maximum decrease during interruption (mm³)</th>
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<tr>
<td>Segment of superior mesenteric vein</td>
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<tr>
<td>2</td>
<td>61.5</td>
<td>4.9</td>
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</tr>
<tr>
<td>6</td>
<td>79.9</td>
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<td>94.7</td>
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</tr>
<tr>
<td>14</td>
<td>107.7</td>
<td>8.4</td>
<td>18.2</td>
</tr>
<tr>
<td>18</td>
<td>117.3</td>
<td>8.1</td>
<td>15.4</td>
</tr>
<tr>
<td>Segment of femoral vein</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>110.4</td>
<td>1.0</td>
<td>13.2</td>
</tr>
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<td>127.0</td>
<td>1.0</td>
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<td>133.2</td>
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</tr>
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<td>139.2</td>
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</tr>
<tr>
<td>42</td>
<td>144.2</td>
<td>0.03</td>
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DISCUSSION

FURNESS and MARSHALL (1974) demonstrated the sympathetic innervation of the large veins, especially the veins in the splanchnic area. FUXE and SEDVALL (1965) investigated histologically the sympathetic innervation of the arteries and veins of the gastrocnemius and anterior tibial muscles. The problem is to know to what extent the innervation of the veins is actually involved in venoconstriction. ALEXANDER (1954) demonstrated an active constriction of the venous system of the canine intestinal loop by lowering the pressure in the carotid sinus to a level of 40 mmHg. In a perfusion experiment on vascularly isolated but innervated segments of the lateral saphenous and colic veins, IIZUKA et al. (1970) measured the change of the respective pressure gradients between their distal and proximal ends caused by bilateral common carotid occlusion. They found that the responses of the lateral saphenous and colic veins to the occlusion were equivalent to responses to nervous electrical stimulations of 1 and 4 Hz, respectively. DISALVO et al. (1971) failed to obtain significant responses of the veins in the forelimb and the large veins of the skeletal muscles by the same method. HAINSWORTH et al. (1975) measured an increase in the pressure gradient between the superficial metatarsal and the femoral veins as a response of the pressoreceptor reflex. They found that it was only one-fourth of the response to electrical stimulation of 1 cycle/sec of the sympathetic nerve to the veins. The above-mentioned results concern the response of the veins to pressoreceptor stimulation, which is far smaller than that to cerebral ischemia. Combination of the methods of vascularly isolated segment and the “side pressure exertion experiment” in this experiment revealed the characteristics of the superior mesenteric and femoral veins under nervous control in a more definite and indisputable form. The femoral vein indicated an active constriction against higher intrasegmental pressure than the superior mesenteric vein, though the response of the former was very small in magnitude compared with that of the latter. These results suggest that the sympathetic innervation of the veins in the lower limbs is not only histologically, but also functionally, very poor.

In addition, this experiment allows us to investigate the behavior of the veins under nervous control in relation to changes in systemic arterial pressure and to study the biological meaning of vein innervation. The intrasegmental pressure under the conditions of this experiment should be taken as a record of the force of isometric contraction of the smooth muscle in the wall of the vein. Under natural conditions, however, the contraction of the smooth muscle causes constriction of the vein, which changes its capacity and resistance to flow. If the volume change of the segment had been measured under isotonic conditions, it should have been greater than that calculated from the results obtained under the isometric conditions of this experiment (VANHOUTTE and LEUSEN, 1969). The actual volume decrease due to active constriction of the superior mesenteric vein is large enough to compensate for the reduction of the inflow by the con-
comitant constriction of the upstream arterioles during systemic arterial pressure oscillation, which is well demonstrated in this study. Otherwise, the severe drop in intravenous pressure would have produced a more marked reduction of blood flow to the liver. At the present stage of knowledge it is difficult to state beyond this the biological meaning of the relatively dense innervation of the veins in the splanchnic area.

In the rabbit in a normal standing position with the forelimbs extended and the hindlimbs flexed, the pressure inside the femoral vein is estimated to be approximately 18 mmHg. When the initial intrasegmental pressure was set in the neighborhood of this value, namely, in the range of 10 to 34 mmHg, a maximum rise of 9.3 mmHg was obtained as the systemic arterial pressure rose to its peak. The femoral vein is usually exposed to one of the highest intravenous pressures in the body. In this regard, the femoral vein is of lower compliance than the superior mesenteric vein. Though it might be explained by this fact, the femoral can constrict well against higher intravenous pressure of wider range than can the superior mesenteric. It can be concluded that the femoral vein is functionally designed to match the relatively high intravenous pressure due to the force of gravity. The relative lack of a phasic element in femoral vein constriction might be related to the so-called "muscle pump." The role of the venous wall in this respect might be played by the skeletal muscles around it.

The time delay of the response of the vein to electrical stimulation has already been observed by GERO and GERÓVÁ (1968) in dogs. The femoral vein began to constrict 2 or 3 sec after the beginning of the stimulation and reached a steady state of constriction about 1 min later. Such a delay was also obtained in our experiment. The delay of the femoral was larger by 1 sec than that of the superior mesenteric. The source of this delay should be investigated in the future. As shown in our experiments, the femoral vein was very sluggish in reaction. This result is in agreement with the observations of GERO and GERÓVÁ (1968).

It has been generally recognized that the pressure-volume curve of the segment of the vein depicts a sigmoid curve and it is shifted toward the left as it is subjected to nervous activation (ALEXANDER, 1954; VANHOUTTE and LEUSEN, 1969). The authors obtained the same results from the superior mesenteric and femoral veins by graded ischemic stimulation of the cardiovascular center.

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