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Effect of Venous Flow on Frequency of Venous Vasomotion in the Bat Wing

By MARY P. WIEDEMAN, PH.D.

Investigations indicated that an elevation in venous flow caused an increase in the frequency of rhythmic contractions of the small veins in the bat wing.

RHYTHMIC contractions of veins are a prominent feature of the veins in the bat's wing. It has been suggested that the principle stimulus for this activity may be pressure within the vessel.¹ That the distending force of blood pressure excites the activity of vascular smooth muscle has been pointed out by others.²⁻⁴ This investigation was carried out to determine what changes in the frequency of vasomotion would occur as a result of increasing the volume of blood per unit of time delivered to a vein from the arterial vessels.

METHOD

Common brown bats (*Myotis* and *Eptesicus*) were prepared for observation as described by Nicoll and Webb.⁵

The frequency of venous vasomotion was counted and expressed in cycles per minute. Readings were made at a minimum of 3 sites and a maximum of 6 and the average rate was determined. A site is defined as a segment of the vessel between two valves.

To raise the volume of blood per unit of time carried by a vein, all large veins in the wing were tied off with the exception of one, which resulted in a single open pathway for venous outflow. The activity of this vessel was observed. Nembutal (4 mg./100 Gm.) was used in these experiments to reduce the possibility of vasomotor rate changes brought about by variations in heart rate or somatic muscular activity.

An increase in total circulating fluid volume was obtained by infusion into the tail vein of dextran (6 per cent in saline). A microinjector which delivered 0.1 ml./20 min. was used for the infusion. In these animals, one wing was denervated and the other left intact.

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RESULTS

Vasomotion in Venous Branches of Normal and Denervated Wings. In 10 animals the rate of vasomotion was determined hourly over a period of 4 to 5 hours to learn the variations in both denervated and intact wings when no experimental procedures were used. In 7 of the innervated wings, a decrease in rate occurred between the initial and final reading. The increase in the remaining 3 animals averaged 2.2 c.p.m. In the denervated wings 6 showed a decrease in rate and the average increase in the 4 wings was 2.4 c.p.m.

Vasomotion in Vessels Serving as Major Pathways. In a group of 11 animals, the frequency of vasomotion in a branch was counted after Nembutal to establish a control rate and found to average 12.7 c.p.m. After ligating 3 large veins, most of the venous drainage was diverted into the branch and counts were made at intervals up to 5 hours. A significant increase in vasomotion cycles was found in all animals, the average of the group being 15.9 c.p.m. or an average increase of 25.8 per cent over the control period (fig. 1). A statistical evaluation of the changes appears in table 1.

If flow within the vein is the principle stimulus for rhythmical contractions, it was thought that increasing the amount of blood flowing into a vessel would increase the frequency of contractions. Ligation of other venous pathways was selected as the best method for keeping the larger amount of blood the vessel carried within physiologic limits and eliminating pressure changes in the arteries. Nembutal was used to keep the animal in a stable state during the experiment.

Vasomotor Rates after Infusion of Dextran. Infusion of dextran was very slow to prevent any possible myogenic or reflex activity as the result of sudden changes in pressure or volume

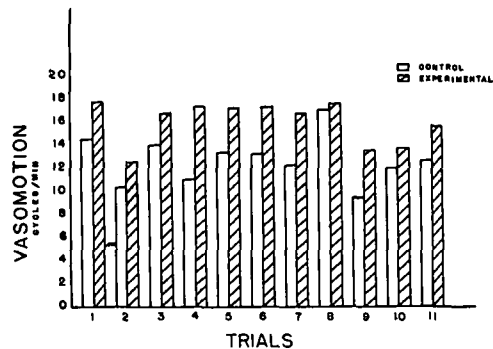


FIG. 1. Frequency change in vasomotion cycles after venous branch became major pathway for out-flow from wing.

TABLE 1.—Vasomotion in Venous Branch Serving as Major Pathway

Test	Cycles per minute	
	Control	Final
66	14.5	17.7
67	10.2	12.5
68	14.0	16.7
69	11.0	17.3
71	13.3	17.2
72	13.2	17.2
73	12.2	16.7
74	17.0	17.5
75	0.5	13.5
76	12.0	13.7
70	12.7	15.7
	Mean change = 3.2	
	t test = 7.0	
	p = 0.001	

in either veins or arteries. To exclude influences, if any, of central reflexes originating from increased cardiac output, one wing was denervated by sectioning the tegmental nerve near the shoulder. A remarkable increase in the diameter of arteries⁶ and veins following this procedure indicates effective removal from central control.

In a group of 10 animals, a control reading was made on a venous branch several hours after denervation of one wing and on a similar branch in the other intact wing. These animals were given 0.1 to 0.2 ml of a 6 per cent solution of dextran over a period of approximately one half hour. Frequency counts at the end of the

TABLE 2.—Vasomotion in Venous Branch after Dextran Infusion

Animal	Am't	Cycles per minute			
		Intact wing		Denervated wing-acute	
		Control	Final	Control	Final
91	0.15	17.0	20.3	16.3	19.6
93	0.20	11.0	14.3	13.6	16.3
97	0.10	11.6	17.0	13.3	16.0
98	0.15	11.6	15.3	13.3	15.0
90	0.20	14.0	18.6	15.6	17.3
101	0.15	12.0	15.6	15.6	16.6
120	0.15	13.6	16.3	15.0	15.0
122	0.15	12.0	14.0	10.3	12.6
123	0.15	10.3	13.3	12.3	14.0
127	0.10	10.0	11.0	13.6	15.6
		Mean = 3.36		Mean = 1.91	
		change		change	
		t test = 7.33		t test = 6.43	
		p = 0.001		p = 0.001	
		Intact Wing		Denervated wing-chronic	
		Control	Final	Control	Final
112	0.20	13.3	16.3	14.6	17.3
115	0.10	10.3	14.3	15.6	18.0
116	0.10	17.0	21.0	10.3	21.0
117	0.15	10.0	16.6	14.0	15.6
118	0.15	14.3	16.0	12.0	14.6
119	0.15	16.0	17.3	15.6	16.0
124	0.20	11.0	17.0	0.6	14.3
125	0.10	11.3	15.6	12.0	16.0
126	0.10	16.0	10.0	18.0	21.0
		Mean = 3.65		Mean = 2.567	
		change		change	
		t test = 6.54		t test = 6.31	
		p = 0.001		p = 0.001	

infusion period showed an increase in all animals: an average increase in the normal wing of 3.3 c.p.m. and a smaller increase of 1.9 c.p.m. in the denervated wing.

In 9 animals whose right wings had been denervated, after 1 to 3 days to allow time for the initial effects of nerve sectioning to wear off, 0.1 ml to 0.2 ml of a 6 per cent solution of dextran were given. In all of these animals an increase of vasomotion was shown. There was an increase in the intact wing averaging 3.6 c.p.m. while the denervated wing vessels showed an average increase of 2.5 c.p.m.

On statistical evaluation, all of the infusion experiments showed significant changes in rate of rhythmical contraction and relaxation of the venous branch under observation (table 2).

DISCUSSION

The results support the view that flow and, possibly, pressure within the veins is an effective stimulus for rhythmic contraction of veins. In the control group of animals observed hourly, a small increase or decrease in the vasomotion was seen to occur without apparent reason. Temperature recordings by thermocouples of room air and wings showed no correlation between temperature variations throughout the day (3 degrees centigrade maximum change) and vasomotion.

Transitory changes in rates were brought about when arterial inflow increased or decreased in the struggling animal. Care was taken to make all readings during quiet periods.

In the anesthetized animals, the venous vasomotion became faster when experimental procedures caused more venous blood to be directed into a single vessel. This would seem especially significant since the changes in volume and pressure were within physiologic limits, no artificial solutions were introduced, and the arterial vessels were not directly involved.

In the infusion experiments less change in the number of cycles per minute was seen in both the acute and chronic denervated wings than in the intact wing. The explanation for this may lie in the initial difference in the resting diameter of the vessels of the two wings. Because of the increased diameter and low tone of the denervated vessels, a larger volume of fluid would be needed to produce an effective distention and consequent stretch of the smooth muscle cells.

The increase in the number of rhythmic contractions and relaxations per unit of time can be explained on the basis of stimulating the activity of smooth muscle by flow or distention. This would support Folkow's conclusions^{2, 7} which showed, by measurements of pressure and flow, that an elevation of blood

pressure is excitatory to vascular smooth muscle. Nicoll and Webb¹ have stated that tone changes in all vessels vary directly with the stretch or tension on the cells and that this mechanism is the regulator of the active vasomotion in veins and venules. The increase in rhythmic contraction of venous vessels resulting from an increase in the volume of blood delivered to them from the arterial side must be a prominent factor in venous return.

SUMMARY

An increase in vasomotion cycles occurs in a vein when excess blood is diverted into it by the occlusion of neighboring veins. An increase in total circulating fluid volume accelerates vasomotion in veins of both denervated and contralateral intact wings, with greater changes occurring in the intact vessels. The results support the view that pressure within the small veins is an effective stimulus for rhythmic contractions. An elevation of pressure enhances this activity which acts as an aid to venous return to the heart.

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SUMMARIO IN INTERLINGUA

Un augmento del cyclos de vasomotion occurre in un vena si excessos de sanguine es divertite verso illo per le occlusion de un vena vicin. Un augmento del total volumine de fluido circulante accelera le vasomotion in alas enervate de vespertiliones e in alas intacte contralateral. Le alterationes in le vasos intacte es plus pronunciate. Le resultados supporta le conception que pression intra le parve venas es un efficace stimulo pro contractiones rhythmic. Un elevation del pression promove iste activitate que age como adjuta al retorno venose verso le corde.

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