CONCERNING THE INFLUENCE OF THE BRAIN CORTEX ON CAPILLARIES

Z. M. Butkovskaya and R. A. Felberbaum

From the State Institute for Scientific Research in Work Hygiene and Occupational Diseases, Leningrad.

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According to the data of V. N. Chernigovsky [5], T. A. Grigoryeva [3] and others, the capillary bed is the reflexogenic field for many vascular and other visceral reflexes. T. A. Grigoryeva believes that the receptors located in the capillary bed are the tissue exchange receptors.

There are a series of works describing how the action of different stimuli on the capillaries and on their surrounding tissue changes the normal state of the capillaries.

O. A. Balandina [1] has indicated the presence of neuroreflex regulation of the capillary system.

We could find very little literature (except for V. A. Bondina's work [2]) concerning the reflex change which occurs in capillary lumen with the stimulation of remote receptor zones.

The purpose of this work was to study the influence of the cerebral cortex on the condition of capillaries. We examined both unconditioned and conditioned reflex changes in capillary lumen, caused by slight, painful stimulation of cutaneous receptor zones remote from the experimental region in order to effect this study.

EXPERIMENTAL METHODS

We examined four, generally healthy women, from 25 to 35 years in age, by using the method of capillaroscopy on the region of the nailbed of the third finger of the right hand. Painful stimulation was applied by means of a light prick with a needle near the base of the fifth finger of the left hand. A metronome with a frequency of 120 beats per minute was used as the conditioned stimulus. The experimental subjects were separated from the experimenters by two screens, one on each side, so that stimulation and capillaroscopy could be done unseen by the subjects.

The subjects were questioned as to their general condition before each examination. The original condition of the capillaries was first determined according to an established plan – the background, the number of capillaries in the main and most clearly evident group, the shape and tonicity of the capillaries and the character of the bloodstream. After stimulation had been applied, we determined how all the above-enumerated factors had changed, especially the tonicity and number of the capillaries, the latent period of the reaction, the duration of the reaction and the time of restoration. The reaction intensity was determined (expressed in pluses – one plus, two plus, etc.) from the sum total of all these changes. The stimuli were given 6-8 times in each experiment at intervals of 3-5 minutes varying in order to prevent the development of a conditioned reflex to time.

EXPERIMENTAL RESULTS

A light prick near the base of the third finger of the right hand caused the capillaries to constrict sharply (3-4 plus) and their quantity to decrease from 12-14 in the main group to 8-10 in all four subjects. The reaction lasted from 5 to 15 seconds depending on the force of the stimulus. Restoration of original capillary condition took from 5 to 15 seconds, also depending on the force of the stimulus applied. The latent period of the reaction was 3-5 seconds.

There was no specific difference between the right and left hand in the capillary reaction to the applied prick. The force of the stimulus, as in the previous case, affected the intensity of the capillary reaction and the quickness of restoration. In several cases, restoration of the capillar reaction was protracted and fluctuating when strong stimulation was applied to both hands. We did not observe in the daily examinations any adaptation to the pain stimulus either during the days of observation or towards the end of each experiment. The reaction remained the same.

We include a detailed case history of one experiment in this series (see Report of Experiment 3).

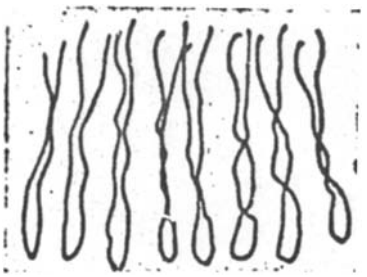

Fig. 1. Reflex constriction and quantity decrease of capillaries caused by the action of the unconditioned stimulus applied to the opposite hand. (All figures show only the main and most clearly evident group of capillaries).

Having concluded from the above experimental series that there is a reflex mechanism for capillary regulation, we began to develop in the subjects a conditioned reflex to the sound of a metronome with a frequency of 120 beats per minute, which was combined with a needle prick near the base of the fifth finger of the left hand. The capillary reaction to the action of the metronome was first erased. The first three combinations were done simultaneously, but later, the unconditioned stimulus was separated from the conditioned by 5 seconds. Conditioned reflex capillary constriction appeared in all the subjects after the 4th-5th combination and thereafter was observed in almost all the combinations. Capillary constriction, increased capillary tonicity and a decrease in capillary quantity from 12-14 to 6-10 were observed with the action of the unconditioned stimulus even before it was reinforced by the unconditioned, painful stimulus. The reaction intensity was recorded by 2-3 plus; the duration of the reaction was from 5 to 12 seconds; and the restoration time was 5 to 13 seconds. In other words, we obtained the capillary changes as with the unconditioned stimuli. According to the degree to which the conditioned reflex had been developed, the latent period of the conditioned reaction was somewhat shorter in all of the subjects than the latent period of the unconditioned capillary reaction and was 2-3 seconds long. The action of the conditioned stimulus alone, without the prick reinforcement, caused similar changes (Fig. 2).

Therefore, we were able to develop a conditioned reflex to change in capillary lumina, and this fact indicates that the cerebral cortex has a definite influence on capillary activity. In order to further examine the influence of the cerebral cortex on capillaries, we developed a differentiation and a capillary reaction to a verbal stimulus and examined the way in which the conditioned reflex was erased.

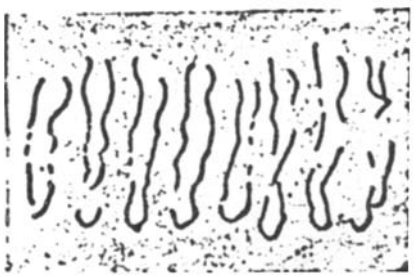

Fig. 2. Conditioned reflex constriction and decrease in quantity of capillaries in response to M_{120} stimulus (metronome with a frequency of 120 beats per minute).

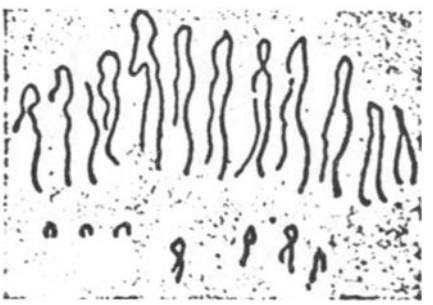

Fig. 3. Absence of capillary reaction to differentiation stimulus M_{60}.

Experimental Record No. 3, October 17, 1954, Subject – B

Time	Stimulus	No. of stimulus	Latent period (in seconds)	Condition of capillaries					Reaction intensity	Reaction duration (in seconds)	Restriction time (in seconds)
				Number in main group	Background	Shape	Tonicity	Bloodstream			
10:40	—	—	—	14	Pink	Convoluted	Normal	Homogeneous	—	—	—
10:45	Prick	1	4	10	"	"	Increased	"	+ +	8	12
10:50	"	2	4	10	"	"	"	"	+ +	10	12
10:57	"	3	5	10	"	"	"	"	+ + +	10	10
11:00	Light prick	4	5	10	"	"	"	"	+ +	10	10
11:04	Strong prick	5	3	8	"	"	"	"	+ + +	13	17+15 Fluctuating

Experimental Record No. 9, October 25, 1954, Subject – B

Time	Stimulus	No. of stimulus	Distance apart (in seconds)	Latent period (in seconds)	Condition of capillaries					Reaction intensity	Reaction duration (in seconds)	Restoration time (in seconds)
					No. in main group	Background	Shape	Tonicity	Bloodstream			
9:18	—	—	—	—	14	Pink	Convoluted	Normal	Granular	—	—	—
9:20	M_{120} + Prick	38	5	3	12	"	"	Increased	"	+ + +	6	7
9.25	M_{120} + Prick	39	5	3	12	"	"	"	"	+ + +	7	5
9:27	M_{60}	10	—	—	14	No reaction						
9.29	M_{60}	11	—	—	14	The same						
9:30	M_{60}	12	—	—	14	"						
9:31	M_{120} + Prick	40	5	6	10	Pink	Convoluted	Increased	Grainy	+ +	5	5
9:36	M_{120} + Prick	41	5	6	12	"	"	"	"	+ +	6	5
9:40	M_{120} + Prick	42	5	3	12	"	"	"	"	+ + +	5	
9:50	M_{120} + Prick	43	5	3	12	"	"	"	"	+ + +	5	4

As a differentiation stimulus, we used a metronome with a frequency of 60 beats per minute, not reinforced by a prick. The first few uses of this stimulus caused the same capillary changes as the M_{120} stimulus with the prick reinforcement, which fact seemed to us to indicate the generalization of the conditioned reflex. After the 6th-8th use, M_{60} caused no change in capillary condition (Fig. 3), while M_{120} continued to cause the changes already mentioned.

Analyzing this experiment, we not only observed a complete lack of capillary reaction to the differentiation stimulus but also a subsequent inhibition, which appeared after the third use of the differentiation stimulus and was expressed by an absence of the conditioned reaction to two conditioned stimuli used after the differentiation; the capillary reaction only appeared after reinforcement.

When the second signal system of stimuli, consisting of a verbal warning – " I am pricking " – without reinforcement by the unconditioned stimulus, caused a sharp capillary reaction, exceeding that which occurred in response to the combination "M_{120} + prick." The use of indifferent verbal stimuli – window, table, wire, etc. – did not cause any change in the capillary condition of the subjects.

Repeated nonreinforcement of M_{120} with a prick caused the intensity of the capillary reaction to gradually decrease until the complete and permanent disappearance of the reaction after 10-15 uses of the nonreinforced M_{120}. The erasure of the conditioned reflex fluctuated; along with the lack or sharp decrease in the capillary reaction to M_{120} during the erasure period, capillary constriction was sometimes quite pronounced.

Therefore, all the investigations conducted indicate that human capillaries react sensitively by conditioned and unconditioned reflexes to various environmental stimuli associated with the first and second signal systems and that they are always under the constant control of the cerebral cortex.

SUMMARY

Experimental data are presented on the presence of unconditioned and conditioned capillary reflexes to various stimulants, pertaining to the first and second signal system. It has been established that if the left wrist is stimulated, there is reflex constriction of capillaries of the right wrist. It appeared possible to elaborate a conditioned reflex of capillaries to pain stimulation with differentiation. Verbal stimulation, such as: " I'm pricking", evoked more pronounced reaction of capillaries than unconditioned or conditioned stimuli.

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