PHYSIOLOGICAL FEATURES OF THE OCULOCARDIAC REFLEX PRODUCED BY LIGHT PRESSURE ON THE EYE

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First publicized by Danini and Aschner [11], the oculocardiac reflex is widely used in clinical work and physiological experiment as an index of the functional state of the autonomic nervous system. The physiology of this reflex is not, however, completely understood. The palpatory method of eliciting the reflex, which is that most frequently used, and the lack of a record of the cardiac rhythm during the experiment make objective evaluation of the results impossible. Again, considerable pressure on the eye may be used to elicit the reflex, which means that an excessively strong stimulus is applied. If such methods are used to assess the functional state of the autonomic nervous system, we may arrive at an opinion, not on excitability as such (by which, of course, is meant primarily "threshold" excitability) but on the features of a reaction to a powerful agent.

The physiological characteristics of the oculocardiac reflex to stimulation of about threshold strength are still inadequately understood. An attempt is therefore made to clarify these features, which are of both theoretical and clinical interest.

EXPERIMENTAL

Instrumental methods of eliciting the oculocardiac reflex have been proposed from time to time [1, 3, 9, 12, 17], but have not been widely used. A modified apparatus suggested by the author (Fig. 1) consists of a closed pneumatic system, the pressure in which is raised by a valved rubber bulb and transmitted to the eyeballs without distortion through ordinary medical syringes. The pistons of the syringes are held at the level of the eyes by a metal band which is fixed on the head by straps. The pressure in the system is recorded by a tonometer or mercury manometer . A record of the cardiac rhythm during the experiment is made by means of an attachment to the electrocardiograph, suggested by the author [7], for continuous kymographic recording of the cardiac rhythm. A pressure of 30 mm Hg was used as a weak stimulus for production of the oculocardiac reflex as, in most subjects, this pressure resulted in the development of distinct changes in the cardiac rhythm. The pressure on the eye was maintained for 30 sec. The heart beats were counted from the kymograms at 15 sec intervals, starting 15 sec before the experiment (background) and continuing for 30 sec after; the counts were then converted into rates per minute. In all, 100 examinations were made on 65 healthy subjects between the ages of 20 and 25. A change of ±3 beats per minute was regarded as the minimum [8]. These changes were clearly recorded in the kymogram.

RESULTS

The nature and degree of changes in heart rate produced by light pressure on the eye are shown in the table. Slowing of the heart (type I reaction) was the most common reaction (38 to 100). The degree of slowing tended to vary,but the average reduction in the pulse rate was 8-10 percent. Reactions also developed at different speeds. It was either extremely rapid, in which case the rate was back to its original value within 30 sec after removal of pressure from the eye (form 1), of medium rapidity, (form 2), or extremely slow to develop, in which case, even after removal of the pressure, the bradycardia continue to increase and only reached its maximum towards the end of the test (form 3). It can be assumed that these three forms indicate a high degree of reflex excitability in the

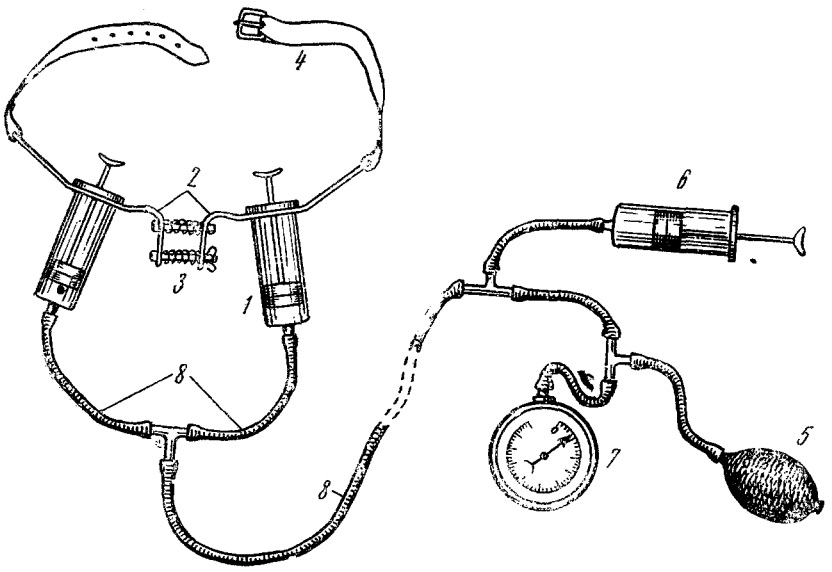

Diagram of manometric compressor for controlled pressure on eyes. 1) 5 cc Record syringe; 2) metal headband; 3) regulating screw; 4) strap for fixing band on head; 5) rubber bulb with valves; 6) controlling syringe; 7) tonometer; 8) connecting tubing.

parasympathetic nervous system, and that the speed at which they develop reflects the functional mobility or inertia of the reactions associated with the process in the parasympathetic nervous system. Slowing of the heart both during the period of pressure on the eye and for a time afterwards (form 4) in all proaability indicates a combined effect from both divisions of the autonomic nervous system. Combined action of the two divisions is clearly evident in type II and type III reactions. Here, the slowing of the heart was replaced by acceleration while pressure was still continuing (form 5) or, conversely, transient acceleration was followed by slowing (form 6). It may be assumed that these forms of reactions represent high reflex excitability in both divisions of the autonomic nervous system and good mobility. In one (type II) the parasympathetic system is more excitable, and in the other (type III), the sympathetic.

Acceleration of the heart (type IV) was observed almost as frequently (33 in 100 instances) as slowing of the heart rate as a result of gentle pressure on the eye. The increase in pulse rate ranged between 8 and 20 percent. The sympathetic reflex reactions could be divided into three forms, reactions developing slowly (form 8), at medium speed (form 9) and rapidly (form 10).

Statistical treatment of findings (variation method) indicated that these changes were significant in all cases with one exception, in which the number of observations was small (form 9).

Pressure on the eyes left the heart rate unchanged in 16 of the 100 examinations (type V), this being indicative of low levels of excitability in both divisions of the autonomic nervous system. This was confirmed by the fact that in these subjects increase of pressure on the eyes did produce distinct changes in the heart rate.

Light pressure on the eyes was thus followed by changes in heart rate, with transition from one type of reaction to the other, and with individual differences (in rate of development, magnitude and relative degrees of excitability in parasympathetic and sympathetic systems). As the reactions were of opposite trend in different cases, the average changes in cardiac activity in 100 observations as a whole were not statistically significant (see the table). The inferences to be drawn from this are: (1) pressure on the eyes is not a specific stimulus for the parasympathetic division of the autonomic nervous system alone; (2) the trend of change in heart rate is determined by individual relationships between the excitabilities of sympathetic and parasympathetic systems when stimulated simultaneously; and (3) in healthy subjects generally the reflex excitations produced by pressure on the eyes in the two divisions of the autonomic nervous system are about equal.

It is known [10, 13, 15] that pressure on the eyes results in some readjustment of autonomic control in all organs, and that this involves the participation of both divisions of the autonomic nervous system. Since the work of

Individual Differences in Oculocardiac Reflex to Light Pressure on Eyes

Type of reaction	Form of reaction	No. of cases	Heart rate per min: 15 sec before pressure	during pressure: 1st 15 sec	during pressure: 2nd 15 sec	after pressure: 1st 15 sec	after pressure: 2nd 15 sec	Max. deviation (%)	M	±m	P
I	1. Slowing with return to initial rate	17	81,9	75,3		82,1		−8,3	−6,6	±0,51	<0,001
	2. Slowing without return										
	3. Slowing in after-effect	9	82,9	74,1				−10,7	−8,8	±1,09	<0,001
			82,9			77,2		−7,0	−5,7	±0,60	<0,001
	4. Slowing during and after	5	80,0	74,6				−6,8	−5,4	±0,75	0,01
			80,0			71,6		−10,5	−8,4	±1,21	<0,01
		7	71,6	65,6				−10,4	−6,0	±1,20	<0,01
						70,6	66,0				
			71,6					−7,8	−5,6	±1,02	<0,01
II	5. Slowing with subsequent acceleration	7	77,1	72,1				−6,5	−5,0	±0,31	<0,001
			77,1		84,9			+10,2	+7,7	±1,47	<0,01
						81,4					
III	6. Acceleration with subsequent slowing	6	81,3	85,0				+4,7	+3,7	±0,49	<0,001
			81,3		76,0			−6,4	−5,2	±0,48	<0,001
						79,8					
IV	7. Acceleration during and after	8	75,1	83,4				+11,0	+8,3	±1,47	<0,001
			75,1		78,1	85,6	83,8	+14,0	+10,5	±1,39	<0,001
	8. Acceleration in after-effect	7	78,0	78,1	79,1	86,1		+10,4	+8,0	±1,39	<0,01
			78,0								
	9. Acceleration without return to original rate	3	65,3	71,3				+9,2	+6,0	±2,65	<0,2
			65,3		78,3			+19,9	+13,0	±0,04	<0,1
			65,3			79,0		+21,0	+13,7	±3,38	<0,1
	10. Acceleration with return	15	76,0	82,5		76,1		+8,6	+6,3	±0,85	<0,001
V	11. Unchanged	16	75,9	76,0				−0,4	−0,3	±0,29	>0,2
			75,9		75,6						
						76,0					
Average		100	78,1	77,4		78,0			−0,7	±0,45	>0,1
			78,1		77,4		78,7		+0,6	±0,58	>0,2

Aschner, however, it has been generally accepted that the only characteristic reaction is that of slowing, which would mean that the oculocardiac reflex is specific for the parasympathetic system only. Although cases of acceleration have been described, only a few authors [15, 16] assessed these observations objectively, whereas most investigators sought to explain this phenomenon either by hypothetical inversion of autonomic activity, if such were observed in patients [13], or by the development of psychogenic emotions [10, 14], or again, in the case of healthy subjects, by sensations of pain.

In these investigations healthy subjects experienced light pressure on the eyes but no pain. Nor is it likely that there was development of any particular emotions. The subject had time to become accustomed to the headband

before pressure was applied to the eyeballs and the heart rate was determined immediately before the application of pressure; it could therefore be inferred that the latter was the direct cause of change in the heart rate.

The increase in the frequency of cardiac contractions on light pressure on the eyes is thus the regular physiological form in which the oculocardiac reflex manifests itself. The change in heart rate produced by a standard light pressure on the eyeballs can be used as an index of the relationship existing between the reflex excitabilities of the two divisions of the autonomic nervous system.

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