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Effect of Acute Anoxia on the Economy of Effort Index in Man.

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Sands and DeGraff[1] showed that a degree of anoxia, occasioned when dogs breathe gas mixtures containing less than 12% oxygen, exerts a stimulating effect on ventricular contraction. While thus stimulated, the ventricles eject their blood with a greater economy of effort, as judged by a criterion proposed by Wiggers and Katz.[2] It is important to obtain evidence whether the human ventricle responds in a similar manner.

Wright, Hallaran and Wiggers[3] adapted the procedure of W. and K. to a somewhat rougher estimation of the cardiac economy of effort in man. The procedure merely requires registration of optical subclavian pulses of reliable contour and an estimation of systolic and diastolic brachial pressures by the auscultatory method. Details of the procedure by which the ratio, dynamic effort/static effort, or economy of effort index is derived are given in papers quoted.[2, 3]

Procedure. It was our purpose to determine the changes in such an index while normal subjects were breathing air with progessively diminishing oxygen volumes. For this purpose, medical students rebreathed CO_2-free air from a segment respirometer[4] of 60 liters capacity. The subject was seated and rested for 30 minutes. After connection with the mouthpiece and while breathing room air in this way, a subclavian pulse was recorded by Frank capsules and brachial pressures were determined. Heart rate could be calculated from records. The subject was then connected to the respirometer in which the percentage of oxygen decreased progressively to 14% in about 5 minutes. At this point, the rebreathing mixture was kept constant by slow admission of oxygen while another set of pulse curves and brachial pressures were recorded. In a similar way, the oxygen was reduced to and stabilized at 12 and 10% respectively; recordings of pulses and blood pressure being again taken.

Results. Reliable records and data were obtained in 23 of a larger

1 Sands, J., and DeGraff, *Am. J. Physiol.*, 1925, **74**, 416.
2 Wiggers, C. J., and Katz, L. N., *Am. J. Physiol.*, 1928, **85**, 229.
3 Wright, G., Hallaran, W. R., and Wiggers, C. J., *Am. J. Physiol.*, 1939, **126**, 89.
4 Burlage, S. R., and Wiggers, C. J., *Am. J. Physiol.*, 1925, **72**, 192.

number of subjects studied. An analysis of these data revealed reactions characteristically found in the majority of normal human subjects during progressive anoxia. The heart accelerated 8 to 32 beats in different individuals, the acceleration being rather more than in those having initial slow rates. The diastolic pressure decreased in all but 2 subjects, in one of which no change and in the other a slow rise was found. The greatest scatter in degree of fall was around 8-15 mm Hg. Systolic pressure remained the same in 5, rose 5-15 mm Hg in 12, fell 3-5 mm Hg in 5, first rose and then fell in 2 subjects. With 2 exceptions a notable increase in pulse pressure occurred.

Tabulations of changes in the *efficiency index* show a general tendency to a slight increase when 14% oxygen is rebreathed and a more definite increase while rebreathing 12% oxygen in all but 3 cases (last 3 in Table I). Of the 20 cases showing a definite increase in the efficiency index, 12 showed a further increase when the oxygen was reduced to 10% (left-hand tabulations, Table I). The other 8 showed some tendency for the index to decrease but it was generally still above the initial values (right hand tabulations, Table I).

Comment. The results indicate that anoxia exerts a stimulating action on the heart in most normal subjects; and aided by lowering of diastolic pressure, the economy with which mechanical energy is utilized is enhanced. The possibility exists that the tendency for the economy of effort to increase or decrease when 10% oxygen is rebreathed may prove valuable as an adjunct to present tests for separating individuals who do and do not tolerate low atmospheric pressures. Unfortunately, opportunity for such correlated studies did not exist.

TABLE I.
Economy of Effort Indices at Various Oxygen Percentages.

Subject No.	Oxygen % in rebreathed air				Subject No.	Oxygen % in rebreathed air			
	20	14	12	10		20	14	12	10
4	.175	.293	.513	.675	12	.240	.288	.497	.472
19	.225	.302	.364	.490	9	.335	.395	.542	.462
18	.240	.483	.480	.512	10	.355	.462	.488	.450
15	.290	.381	.447	.583	16	.370	.488	.593	.512
8	.299	.297	.390	.467	17	.390	.407	.512	.480
7	.332	.401	.575	.670	1	.440	.475	.545	.532
3	.345	.493	.605	.637	5	.518	.512	.590	.510
20	.360	.430	.420	.602	2	.525	.585	.625	.532
6	.362	.450	.450	.515					
14	.390	.437	.518	.683	22	.181	.190	.186	.185
11	.400	.512	.687	.744	23	.285	.273	.280	.240
13	.437	.485	.600	.752	21	.585	.577	.590	.600

Summary. The effect of acute anoxia on the *economy of effort index* of Wiggers and Katz was studied on medical students by allowing them to rebreath decreasing oxygen mixtures and holding these mixtures at 14, 12 and 10% oxygen, respectively, long enough to record subclavian pulses and determine brachial blood pressures leisurely.

In 20 subjects, the index increased during rebreathing of 14 and 12% oxygen; in 12, it increased further when the oxygen percent was reduced to 10; in 8 it began to show slight signs of decreasing. Three subjects showed no significant increase or a slight decrease. The possible use of the method in testing favorable and unfavorable responses of individuals to low barometric pressures is mentioned.

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Limitations of Myocardial Recovery from Fibrillation Through Countershock.*

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In revival of the ventricles from fibrillation by use of countershock, stress is generally laid on the limited survival of the central nervous system, and particularly of the cerebrum. It is less commonly stressed that the myocardium likewise can survive the anoxia imposed by complete interruption of the coronary circulation for a very limited time.

Experiments were, therefore, carried out to determine how the duration of fibrillation influences recovery and to estimate the maximum period of fibrillation which may be followed by recovery without the aid of cardiac massage.

Procedure. In dogs under sodium barbital anesthesia, the heart was exposed under mild artificial respiration and aortic pressures were recorded optically by a Gregg manometer. Records were taken before and during fibrillation produced by application of a brief tetanic current and at various intervals after recovery following a series of A.C. countershocks. In these records, systolic and diastolic pressures were measured in representative cycles and plotted. Typical results are shown in Fig. 1.

Results. After fibrillation, less than 10 seconds in duration,

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