CHANGES IN ARTERIAL PRESSURE AND CARDIAC OUTPUT AFTER CONSTRICTION OF THE ABDOMINAL AORTA

M. V. Kon

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The hemodynamics and gas exchange in rabbits after constriction of the abdominal aorta were studied before and after denervation of the carotid sinus and cardio-aortic reflexogenic zones. These zones were shown to limit the increase in arterial pressure and to produce the slowing of the pulse developing during constriction of the abdominal aorta. However, the minute volume of the heart, the arterio-venous difference of O_2, and the oxygen consumption showed similar changes during constriction of the aorta in intact and denervated rabbits.

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Investigations [2, 4, 7, 12, 13] have shown that in coarctation of the aorta persistent arterial hypertension develops in the upper half of the trunk. The literature on changes in the cardiovascular system in experimental animals after simulation of this defect is extensive [1, 3, 5, 6, 8-11]. However, it is not yet clear to what extent the reflexogenic zones of the cardiovascular system located above the point of constriction of the aorta (aortic and carotid sinus zones, the depressor zone of the left ventricle) participate in regulation of the minute volume of the heart and gas exchange.

In the present study a simultaneous investigation was made of changes in the hemodynamics, oxygen consumption, and blood gas composition during the first minutes after interruption of the blood flow along the descending aorta in intact rabbits and in rabbits with denervated aortic and carotid sinus reflexogenic zones.

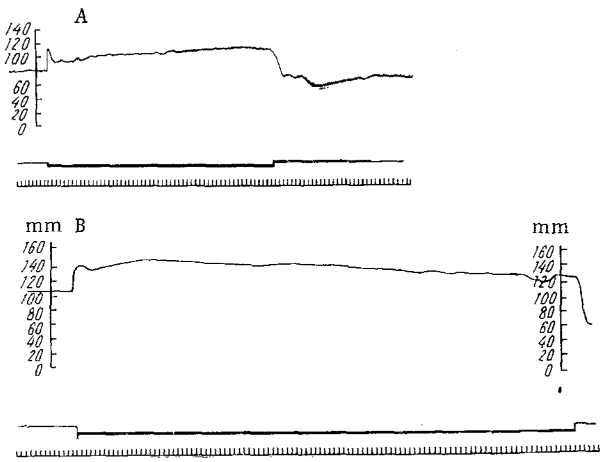

Fig. 1. Constriction of aorta of intact rabbit (A) and rabbit with denervated corotid sinus and aortic reflexogenic zones (B). From top to bottom: AP curve, marker of constriction and release of aorta, time marker 5 sec.

EXPERIMENTAL METHOD

Experiments were carried out on rabbits of both sexes weighing 2.3-4 kg anesthetized with urethane (1.1-1.5 g/kg body weight). Throughout the experiment the total oxygen consumption was measured continuously by means of a closed system. The mean arterial pressure (AP) was recorded in the carotid artery. The minute volume of the heart was calculated by the Fick method. To obtain mixed venous blood a polyethylene catheter was introduced into the right heart through the right external jugular vein. The blood oxygen saturation was determined by means of a type 0-57 oxymeter. Laparotomy was performed through a midline incision and the abdominal aorta was mobilized. Between the superior mesenteric and celiac arteries a ligature was passed beneath the aorta and its ends brought out through a tourniquet. The aorta was gradually constricted by drawing the ligature tight for an assigned time. Denervation was carried out by dividing the aortic and carotid sinus nerves. The ECG was recorded to determine the heart rate.

Physiological Laboratory, A. V. Vishnevskii Institute of Surgery, Academy of Medical Sciences of the USSR, Moscow (Presented by Active Member of the Academy of Medical Sciences of the USSR A. A. Vishnevskii). Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 67, No. 1, pp. 13-16, January, 1969. Original article submitted April 26, 1968.

TABLE 1. Changes in Hemodynamics and Gas Exchange during Constriction of Abdominal Aorta in Intact Rabbits, M ± m

Index	Before constriction of aorta	During constriction of aorta	P
O_2 consumption (in ml/min)	19±1,1	11,9±0,9	<0,01
Arterio-venous difference			
%HbO_2	34,5±1,6	23,2±1,4	<0,01
vols.%O_2	4,3±0,2	2,9±0,2	
Minute volume of heart			
ml/min	472,9±36,9	435,7±40,1	≈0,1
ml/min/kg	169±14,3	161,8±16,9	
AP (in mm Hg)	95,7±4,3	123,8±4,2	<0,01
Pulmonary ventilation (in ml/min)	542±36	458±32	<0,01
Respiration rate	45,7±2,3	45,1±4,4	≈0,5
Heart rate	260±5	237±7,4	<0,01
Systolic volume (in ml)	1,76±0,13	1,80±0,14	≈0,9

TABLE 2. Minute Volume of the Heart and Gas Exchange before and after Denervation and during Constriction of Aorta, M ± m

Index	Initial (I)	After denervation (II)	P I and II	During constriction of aorta (III)	P II and III
Arterio-venous difference					
%HbO_2	34.2 ± 2.9	34.2 ± 3.0	–	21.3 ± 2.8	< 0.01
vols. %O_2	4.4 ± 0.3	4.4 ± 0.4		2.8 ± 0.4	
O_2 consumption (in ml/min)	19.3 ± 1.5	17.9 ± 1.1	≈ 0.1	11.1 ± 1.1	< 0.01
Minute volume of heart					
ml/min	451 ± 45	430 ± 56	≈ 0.1	440 ± 65	≈ 0.7
ml/min/kg	172.6 ± 15.5	165 ± 18		169.1 ± 23	
AP (in mm Hg)	93.3 ± 4.9	89.6 ± 5.9		136.4 ± 4.8	< 0.01
Pulmonary ventilation (in ml/min)	460 ± 14	411 ± 12	≈ 0.01	320 ± 10	< 0.01
Respiration rate	52.3 ± 3.7	52.6 ± 4.2		53.3 ± 4.5	≈ 0.4
Heart rate	264 ± 12	264 ± 13	–	263 ± 13	≈ 0.6
Systolic volume (in ml)	17 ± 0.2	1.6 ± 0.2	≈ 0.6	1.6 ± 0.1	

EXPERIMENTAL RESULTS

In the experiments of series I (20 animals) changes in the hemodynamics and gas exchange were studied in intact rabbits during constriction of the abdominal aorta. In series II (14 rabbits) the same changes were determined after denervation of the reflexogenic zones.

Interruption of the blood flow along the aorta was accompanied by a rapid increase in AP which reached a maximum after 3-4 min (Fig. 1A). Of the 15 experiments in which the aorta was constricted for 15-25 min, in 8 the maximal AP persisted for 7-10 min, after which it fell slightly although still remaining 23% above its initial level at the end of constriction. In 2 animals the AP rose to its maximum and remained at the same level until the end of occlusion. Only in 5 rabbits did the AP begin to fall after reaching a maximum, so that after 10-13 min it was equal to or even a little below the initial level, despite continued occlusion of the aorta.

During constriction of the aorta the O_2 consumption fell distinctly, as a result of exclusion of the circulation in the lower half of the trunk (Table 1). After restoration of the blood flow through the aorta, this disturbance disappeared completely.

The oxygen saturation of the arterial blood remained unchanged, while the saturation of the mixed venous blood was increased on the average by 20%. As a result, the arterio-venous difference was reduced. The hemoglobin concentration in the blood remained constant. Small fluctuations were observed in the minute volume of the heart, but on the average it remained almost unchanged after constriction of the aorta (Table 1). The heart rate fell on the average from 260-237 beats/min, while the systolic volume of the heart, although varying slightly from one experiment to another, on the average remained almost unchanged.

The almost complete equality of the cardiac output before and after interruption of the blood flow through the aorta is evidence, it must be stressed, of a sharp increase in the blood flow in the upper half of the trunk. This can also be seen by examination of data for the degree of oxygen saturation of the mixed venous blood: its increase indicates an increase in the ratio between blood flow and metabolism (an increase in oxygen consumption).

After division of the aortic and carotid sinus nerves, the AP and heart rate rose sharply at once, to 110.8 mm Hg and 275 beats/min respectively, and remained increased for 2-3 min, after which they returned to values close to their initial level. After denervation the O_2 consumption, minute volume of the heart, and arterio-venous difference were practically unchanged (Table 2).

Constriction of the aorta in the denervated rabbits, just as in the intact animals, reduced the O_2 consumption and arterio-venous difference, while the minute volume of the heart also remained substantially unchanged. The heart rate in the denervated animals, by contrast with the intact, remained the same as before occlusion. The main difference was a more marked increase in AP during occlusion of the aorta in the denervated rabbits. The shape of the curve of the increase in AP was also modified slightly in these animals (Fig. 1B).

The changes in O_2 consumption, arterio-venous difference, minute volume of the heart, and pulmonary ventilation during occlusion of the aorta are thus independent of denervation of the aortic and carotid sinus zones. At the same time, the dynamics of the AP in the denervated animals differed sharply from the intact rabbits. The reflexogenic zones limit the increase in AP and are responsible for the decrease in the heart rate during occlusion of the aorta.

It can be concluded that regulation of the cardiac output, the blood supply to the upper half of the trunk, and the AP during occlusion of the aorta takes place in different ways: the reflexogenic zones investigated participate only in regulation of the AP. The increase in blood supply in the upper half of the trunk and the decrease in the arterio-venous difference of O_2 persist completely after denervation of the carotid sinus and aortic zones.

LITERATURE CITED

1. S. A. Gasparyan and V. G. Akopyan, in: Problems in Surgery of the Mediastinal Organs and the Great Vessels [in Russian], Moscow (1962), p. 183.
2. G. A. Glezer, Kardiologiya, No. 3, 76 (1965).
3. A. G. Kartseva, Changes in the Hemodynamics and Regional Vascular Tone during Occlusion of the Abdominal Aorta, Author's abstract of candidate dissertation [in Russian], Kiev (1965).
4. A. Kh. Kogan and V. I. Babinkov, Pat. Fiziol., No. 2, 77 (1965).
5. A. Temeshvari, D. Adam, P. Kesler, et al., Khirurgiya, No. 8, 35 (1954).
6. N. Alexander and T. Goldfarb, Circulat. Res., 10, 11 (1962).
7. E. Allbaugh and S. Horvath, Am. J. Physiol., 180, 1451 (1955).
8. H. Barcroft and P. Formijne, J. Physiol. (Lond.), 82, 377 (1934).
9. M. Beznac, Canad. J. Biochem., 34, 791 (1956).
10. J. Kouzo and J. S. Meer, Circulat. Res., 19, 726 (1966).
11. W. C. Sealy, Ann. Thorac. Surg., 3, 15 (1967).
12. S. H. Taylor and K. Donald, Brit. Heart J., 22, 117 (1960).
13. L. Tonelli, F. Balsi, and E. Malizia, Acta Med. Scand., 148, 35 (1954).