SHORT COMMUNICATION:

CORONARY CIRCULATION RESPONSE TO ALTITUDE

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Summary: Coronary haemodynamics were studied in 19 low landers (LL) at sea level and first four days at high altitude (HA) (12,000 feet above sea level) and 8 high landers (HL) at HA. The coronary blood flow and myocardial oxygen consumption decreased at HA both in LL and HL. The calculated external mechanical efficiency index of the left ventricle was increased. The myocardial lactate extraction was reduced inspite of high arterial values. These findings suggest the possibility of anaerobic cardiac metabolism at high altitude.

Key words: coronary blood flow; myocardial oxygen consumption; high altitude hypoxia; anaerobic myocardial metabolism

Among numerous intrinsic and extrinsic factors regulating coronary blood flow, hypoxia is one of the strongest stimuli affecting coronary flow (1). Whereas hypoxia of short duration has been shown to increase coronary blood flow in the experimental animals (2, 10) and man (11, 12), the response of prolonged hypoxia is controversial. For example, prolonged hypoxia has been reported to show no effect (15, 16) no effect or increase (6) or decrease (9, 17, 22) of coronary blood flow. The present study was designed to determine the response of coronary circulation to prolonged high altitude hypoxia in man.

MATERIALS AND METHODS

19 young male low landers and 8 male high landers (permanent residents at 12,000 feet altitude) of comparable age formed the clinical material for this study. The low landers were studied at sea level and again at high altitude (12,000) feet above sea level within 24-96 hours of arrival by air. The high landers were studied only at high altitude. All were studied in a fasting state without any premedication by standard right heart catheterization technique. Coronary blood flow was measured by the nitrous oxide desaturation method (7). The lactate content in the arterial and the coronary sinus blood was estimated by the enzymatic technique.* Other parameters were measured by the standard formulae (3).

RESULTS

The coronary blood flow and myocardial oxygen consumption per 100 *g* of left ventricle were significantly less in the high landers and the lowlanders at high altitude as compared to

*Kits supplied by M/s Boehringer Mannheim GMBH, Germany.

the lowlanders at sea level. The myocardial oxygen extraction coefficient was, however, no altered. The calculated external mechanical efficiency index of the left ventricle was increase at high altitude. Though the arterial lactate values increased significantly at high altitud both in low landers and high-landers, the myocardial extraction coefficient of lactae decrease (Table I).

TABLE I: Coronary circulation at high altitude.

No.	Parameter	Low-landers			High landers	
		Sea level data m, S.D. (1)	*H.A. data m, S.D.* (2)	'p' 1,2	*H.A. data m, S.D.* (3)	'p' 1,3
1.	No. of subjects	19	19		8	
2.	C.B.F.	83.6±7.6	75.6±7.5	<.01	71.9±7.5	<.05
3.	MVO_2	9.08±1.93	6.77±2.08	<.01	6.13±2.43	<.05
4.	MO_2EC	0.59±0.09	0.58±0.15	NS	0.57±0.10	NS
5.	LVWi	4.56±1.14	5.19±1.11	NS	4.44±0.57	NS
6.	MEILV	26.0±8.3	39.0±16.7	<.01	41.0±18.8	<.05
7.	AL	8.00±1.70	13.97±3.14	<.001	11.56±2.10	<.05
8.	CSL	5.01±1.84	11.34±3.57	<.001	9.10±2.79	<.05
9.	MECL	0.37±0.18	0.21±0.16	<.05	0.24±0.23	<.05

CBF=Coronary blood flow/100gLV/min., MVO_2=Myocardial oxygen consumption ml/100gLV/min; MO_2 EC= Myocardial oxygen extraction coefficient; LVWi=Left venticular work index *kg*.M/min/m², MEILV=Calculated external mechanical efficiency index of the left ventiricle. AL=Arterial lactate content *mg*%. CSL=Coronary sinus lactate content *mg*%, MECL=Myocardial extraction coefficient of lactate.

DISCUSSION

It is apparent from the data obtained that coronary blood flow and myocardial oxygen consumption decreased during high altitude hypoxia of 24 to 96 hours duration and after long stay at altitude. This response may appear paradoxical because hypoxia has been shown to be a potent coronary vasodilator (1). Whereas hypoxia of a few minutes duration has been shown to increase coronary blood flow (2, 10, 12), data on prolonged response of hypoxia is scanty. In chronic hypoxemia due to chronic obstructive lung disease, coronary blood flow is reported to be normal (15, 16) or slightly increased (6). This is in spite of hypercapnia which has been shown to increase coronary blood flow (5). It may, therefore, be presumed that chronic hypoxia decreases or does not alter the coronary blood flow. Other factors present during high altitude hypoxia like hypocapnia due to hyperventilation, polycythemia and alkalosis (20, 21) may also modify coronary blood flow. Whereas alkalosis increases the coronary blood flow (8), polycythemia (18) and hypocapnia (19) have been shown to decrease the coronary blood flow. It is interesting to note that Grover *et al.* (90) in low landers, Vogel *et al.* (22) in animals and Moret *et al.* (17) in high landers of Bolivian Andes also observed decreased coronary blood flow at high altitude, the exact mechanism of which was not clear to them.

Because the cardiac output and the systemic aterial pressures do not change significantly at high altitude (20, 21), the external work of the left ventricle does not alter at the altitude. The calculated external mechanical efficiency index of the left ventricle, which is a ratio of the left ventricular external work done and the myocardial oxygen consumption, increased at high altitude because of decrease in the latter parameter. This index will obviously give high values if anaerobic cardiac metabolism is present. The presence of anaerobic cardiac metabolism at high altitude is also indicated by the decreased myocardial extraction-coefficient of lactate in spite of high arterial values. Normally heart is an aerobic organ and anaerobic metabolism is said to play an insignificant role except in few situations like asphyxia (13), coronary artery disease during exercise (14) and anaemia (4). High altitude hypoxia seems to be another condition where anaerobic myorardial metabolism is present.

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