EFFECTS OF STAY AT HIGH ALTITUDE ON THE SERUM PROTEINS OF MAN

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Summary: Twenty human subjects were taken to 11,500 *ft* after recording their serum proteins, PVC, R.B.C. count, S.G.O.T. and S.G.P.T. levels at Delhi (S.L.). These parameters were again examined after 10(A10), 30(A30) and 300(A300) days of stay at high altitudes and then the subjects were brought down to Delhi and the parameters determined after 7 (RSL 7) and 28 (RSL 28) days.

At A10 both albumin and globulin showed a rise, but afterwards albumin gradually fell but the globulins remained high. The rise was mostly in the gamma globulin fraction. The A/G ratio progressively fell during the stay at HA. The recovery at RSL was slow. The P.C.V. rose progressively at A10, A30 and A300. The R.B.C. count rose only at A30 and A300. The SGPT and SGOT were within normal limits during the period of stay at HA. Simple haemoconcentration may partly explain the changes at A10, but later changes appear to be due to alteration in the rate of synthesis and degradation of proteins at HA.

Key words: serum proteins high altitude

Serum proteins in man have been reported to rise on acute exposure to high altitude. Hurtado *et al.* (3) have observed the rise within three hours of arrival at altitude. The increase observed was 2.9, 4.0, 5.3 and 7.9 per cent of the sea-level values at altitudes of 2,390, 3,140, 4,165 and 4,835 *m* respectively. This rise has been ascribed by them to be due to hemoconcentration. Increase in serum proteins, especially of globulins, has also been observed during flight (8). In high-altitude residents, however, the total serum proteins have been found to be within normal range, with a low A/G ratio due to increase in globulins and decrease in albumins (7). The fall in albumins has been attributed to marked increase in their degradation as well as decreased synthesis at high altitude (9&10). This view has, however, been contradicted by. Westergaard *et al.* (11). Studies have been made on serum proteins of Indian subjects periodically during their stay at an altitude of 3,500 *m* and the results are presented in this paper.

MATERIALS AND METHODS

The study was undertaken on 20 healthy subjects between the ages of 20-30 years. Their blood was initially examined at Delhi for sea-level values (SL) and they were then taken by air to a height of 3,500 *m* where they stayed for a period of 10 months continuously. At high altitude, their blood was examined after 10(A10), 30 (A30) and 300 (A300) days of stay. Thereafter, they were brought down to the base laboratory, and examined once again after 7 days (RSL 7) and 28 days (RSL 28) of their descent. The serum protein level was determined by micro-kjeldahl method and the proteins were fractionated by proper electrophoresis and densito-

metry (4). The dietary intake of proteins of these subjects, both at Delhi and at high altitude, was approximately 2 *gm* per *kg* body weight.

The blood was also examined for PCV and RBC count. The serum transminases (SGOT and SGPT) were determined by the method of Reitmen and Frankel (6).

RESULTS

The mean levels of serum protein and their fractions in these subjects after 10, 30 and 300 days of stay at high altitude and on their return to sea level are given in Table I. The total serum proteins from initial values of 7.02 *gm*% rose to a maximum of 8.99 *gm*% at A10 and then showed a fall at A30 to a value of 7.74 *gm*%. After A300, the values dropped to 6.62 *gm*%. On return to sea level, the mean serum protein values were 6.81 *gm*% at RSL 7 and 7.25 *gm*% at RSL 28. The rise in total serum proteins at A10 and A30 from the sea level values is significant statistically ($P<0.001$). The values at A300 are not significantly different from initial or regression SL values.

TABLE I: Mean serum protein (GM%) ± S.E. in 20 subjects at different periods of stay at HA and on return to S.L.

Initial	*Altitude*				*Regression sea level*	
Parameters studied	*S.L.*	A_{10}	A_{30}	A_{300}	RSL_7	RSL_{28}
Total proteins *gm*/100 *ml*	7.02 ±0.16	8.99** ±0.02	7.74** ±0.02	6.62 ±0.02	6.81 ±0.12	7.25 ±0.11
Albumins *gm*/100 *ml*	4.03 ±0.12	4.37 ±0.03	3.21** ±0.12	2.48 ±0.25	2.82* ±0.002	3.00* ±0.08
Globulins *gm*/100 *ml*	2.99 ±0.01	4.62* ±0.01	4.52** ±0.04	4.13* ±0.10	3.99* ± 0.10	4.25** ±0.10
A/G Ratio	1.34 ±0.05	0.94* ±0.03	0.71* ±0.02	0.60* ±0.02	0.70* ±0.04	0.73* ±0.06
Electrophoresis;						
Albumins%	57.42	48.83	41.58	37.57	42.10	41.40
Globulins%	42.58	51.17	53.42	62.43	57.90	58.60
	α_1 5.22	5.92	7.222	5.26	5.80	5.20
	α_2 5.42	7.88	9.00	8.81	10.00	9.30
	β 11.87	13.22	16.05	13.36	15.20	11.80
	γ 20.07	24.15	26.15.	35.00	26.90	32.30

Significance of differences from S.L. :—** $P<0.001$, $P<0.05$

Changes were noticed both in the albumin and globulin fractions. The intial S.L. albumin and globulin values were 4.03 and 2.99 *gm*% respectively. At A10, there was rise both

in the albumin) 4.37 *gm*% and globulins contents (4.62 *gm*%) but not of the same order. The rise in albumin was by about 8.4% and that of globulins by 54.5%. At A30 and A300 the values of albumin dropped to 3.21 and 2.48 *gm*% whereas globulins remained high, their mean values being 4.52 and 4.13 *gm*% respectively. The rise in globulin level at high altitude is statistically significant for different durations of stay. The electrophoresis of the proteins showed that the rise was mostly in the gamma globulin fraction and to some extent in the beta fraction (Fig. 1 and Table I).

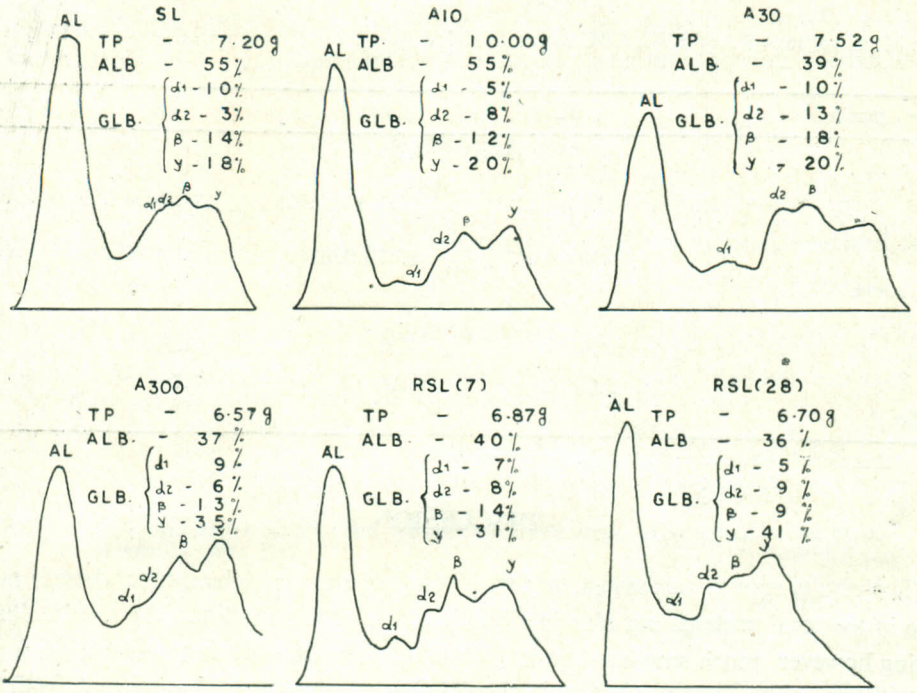

FIG. 1
SHOWING CHANGES IN THE ELECTROPHORETIC PATTERN OF THE SERUM PROTEINS OF ONE SUBJECT (NO.53) AT DIFFERENT PERIODS OF STAY AT HA AS COMPARED TO SL AND RSL.

The gamma globuins showed a progressive rise with stay at high altitude and the maximum value of 35.0% was reached at A 300. These remained high even 28 days after return from high altitude (RSL 28). The rise in globulins and fall in albumin after A10 resulted in changes in the A/G ratio, which progressively fell with stay. Initially the A/G ratio was 1.34 and it dropped to 0.94, 0.71 and 0.60 at A10, A30 and A300 days of stay at high altitude. The fall in the A/G ratio is significant at $P < 0.05$ during the stay at high altitude. After return to sea level, the recovery was slow; the globulins still remained high till 28 days and the albumins increased slightly.

The PCV showed a rise from initial sea-leavel values of 47.45 to 51.60, 54.70 and 58.30%

at A10, A30 and A300 days. The rise in the PCV at high altitude was statistically significant ($P<0.001$). The RBC did not show a rise at A10 from the initial sea-level value of 5.50 million/*cu. mm*, but thereafter it increased significantly to 5.83 and 6.09 million/*cu. cm.* at A30 and A300 days (Table II).

The serum transminase levels at high altitude remained within the normal values, the mean SGOT values being 10,15, 11.5 and 10.8, and the SGPT values 5.8, 6.8, 6.2 and 4.8 I.U/*Lit*/*Min* at SL, A10, A30 and A300 days respectively (Table II).

TABLE II: Mean values ± SE of PVC, RBC count, SGOT & SGPT at different periods of stay at HA, in 20 subjects.

Parameter studied	*SL*	*A10*	*A30*	*A300*
PCV %	47.45 ± 0.35	51.60* ± 0.32	54.70* ± 0.53	58.30* ± 0.69
RBC Millions/*cu.mm.*	5.50 ± 0.047	5.45 ± 0.028	5.83* ± 0.086	6.09* ± 0.080
SGOT IU/*Lit*/*min*	10.0	15.0	11.5	10.8
SGPT IU/*Lit*/*Min*	5.8	6.8	6.2	4.8

Significance of differences from S.L. :— $P< 0.001$*

DISCUSSION

The results show that during the first 10 days of stay at high altitude, there is not only an increase in the total proteins but also in albumin and globulin fractions, the rise in albumin fraction being however much smaller than in globulins. The PCV during this period shows an increase without showing any change in the RBC content. It can be inferred from this that during the first 10 days of stay at high altitude, there is heamoconcentration and that partially accounts for the rise in total serum proteins. There is, however, absolute rise in the globulins fraction also, as its mean values have been raised by 54.5% as compared to haemoconcentration of about 8.6% by which amount the albumin has been found to increase. The heamoconcentration has also been observed by Krzywicki (5) and Consolazio *et al.* (2) during the initial stay of subjects at high altitude. Increase in serum protein level has been observed also by Hurtado *et al.* (3) and Bertwell *et al.* (1), who have also ascribed it to the haemoconcentration. In their studies, the observations were made within 3 days of arrival at high altitude. The changes in serum proteins as a result of prolonged stay have, however, not been reported earlier. This study shows that the initial rise in plasma protein level no longer persists after the haemoconcentration disappears and is followed by progressive fall with stay. This fall is attributed purely to the albumin fraction. The globulins remain almost at the same high level as observed at A10. The fall in albumin may be due to higher rate of its degradation and/or its slower synthesis at high altitude

). It shows that there is altered protein metabolism at high altitude as suggested by Bertwell *t al.* (1).

The rise in globulins, especially the gamma globulins, and fall in synthesis of albumins can e regarded to be due to liver damage at high altitude. This, however, has not been substantiated y the serum transminase values which have not shown any change in these subjects. Further, n a large number of military personnel, who have stayed there for 2-3 years, no increase in in- idence of liver cirrhosis has been observed. The exact significance of rise in gamma globulins t high altitude is not well understood. It does not seem to be connected with the adaptation process, as its level remained high from A10 days onwards, without showing further increase with stay.

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