EFFECT OF MODERATELY HIGH ALTITUDE ON THE PATTERN OF LUNG DISEASE

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In high altitude areas, inspired atmospheric oxygen decreases proportionally to the vertical distance from sea level. Population in these areas acquire some adaptive mechanisms to cope with the relatively hypoxic environment. This study compares populations who live in highland areas (2500 meters above sea level) with those in lowland areas (close to sea level). No differences were observed in the prevalence or mortality rate of respiratory diseases between these two groups. It is concluded that even if adaptive mechanisms can be observed in dwellers of moderately high altitude (<3000 m above sea level), such altitude does not adversely affect the pattern of respiratory disease in these populations. However, partial pressure of oxygen (PaO₂) tends to be lower in individuals of high altitude areas, leading to marked oxygen desaturation when such individuals encounter a significant respiratory illness. Physicians are advised to introduce early and effective therapeutic measures before such deterioration occurs. *Ann Saudi Med* 1994;14(4):297-299.

High altitude areas have a low barometric pressure that leads to a decrease in the inspired atmospheric partial pressure of oxygen (PO₂) in proportion to the altitude level.^{1,2} Adaptation to such changes by dwellers of high altitude is thought to be an acquired phenomenon that is achieved by secondary erythrocytosis, increased respiratory rate and blunted response to hypoxia.³ Little data are available on the effects of high altitude on lung health and it is not entirely clear whether high altitude aggravates lung diseases or contributes to their exacerbations.

In Al-Baha, Saudi Arabia, which is a partially high and partially low altitude area, there is a common impression among clinicians that lung disorders are probably more prevalent than in other parts of the country. Indeed, a report studying 833 subjects in low and high altitude towns in Colorado, USA suggested that lung diseases were more common at high altitudes. Furthermore, the mortality from lung diseases was found to be increased in high altitude residents.^{4,5} To our knowledge, no previous studies on the problem of high altitude have been conducted in the Al-Baha region, which seems to be a suitable area for such an investigation.

Material and Methods

The Al-Baha region is partly situated at a maximum altitude of 2480 meters above sea level with a barometric pressure of about 560 Torr (atmospheric PO₂ of around

177 mm/Hg), and partly a low altitude close to sea level (atmospheric PO₂ of around 160 mm/Hg). A total population of 210,000 is distributed between these two areas at a ratio of 1:2 in low and high altitude (70,000 and 140,000) respectively. The area has numerous local primary health care facilities and small local hospitals that refer patients to King Fahad Hospital (KFH), a well equipped 600 bed secondary referral hospital.

Medical records of all patients admitted to KFH over a 12 month period from the beginning of June 1990 to the end of May 1991 with a discharge diagnosis of any respiratory disease were reviewed. The international classification of diseases for medical records (ICD 9 CM) was followed to extract diagnoses of respiratory diseases comprising code numbers from 460 to 519.⁶

The diagnosis of a case was extracted from the notes written by the consultant on the discharge summary. However, when radiologic or laboratory evidence of another diagnosis was noted in the patient's file, which may have been added after writing the discharge summary, then the final diagnosis was modified accordingly. A data collection form was used which included information on age, sex, residence, and type of respiratory disease as well as the results of investigations and diagnoses. Type and frequency of lung diseases in the two areas were obtained and factors that could precipitate and/or contribute to lung health were also evaluated. They included length of stay in the hospital, outcome, number of admissions, oxygen saturation and hemoglobin concentration. Information was then pooled in a unified data base statistical computer program. *P* of <0.05 was considered significant, comparing frequency and features of lung disease in low and high altitude areas.

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Results

A total number of 551 patients were admitted to the study hospital during the research period. There were 195 (35.4%) and 356 (64.6%) from low to high altitude areas respectively, giving a distribution ratio of roughly 1:2. There was no difference in the distribution of the age and the sex in the hospitalized patients from the two different areas. Table 1 shows P value >0.05 , but there was a higher non-Saudi population in high altitude areas (HAA) compared to low altitude areas (LAA), $P<0.05$. Table 2 shows the pattern of respiratory diseases in areas of different altitudes. Pneumonias were the single most frequent illness encountered by physicians in both areas, approaching 88% and 81% in LAA and HAA respectively. Asthma was the second most frequent illness and appears to be more common in HAA, making up 8% of the admitted respiratory cases compared to 4.6% of cases from LAA, although this did not reach statistical significance. Acute

TABLE 1. Characteristics of the population in relation to altitude level.

Characteristics	Low Altitude		High Altitude	
	No.	(%)	No.	(%)
<i>Age - years</i>				
< 2	77	(39.5)	114	(32)
2 - 7	44	(22.6)	84	(23.6)
8 - 15	20	(10.3)	21	(5.9)
16 - 30	13	(6.7)	27	(7.9)
31 - 45	12	(6)	34	(9.6)
46 - 60	13	(6.7)	23	(6.4)
>60	16	(8.2)	53	(14.9)
Total	195	(100)	356	(100)
<i>Sex</i>				
Male	119	(61)	211	(59.3)
Female	76	(39)	145	(40.7)
Total	195	(100)	356	(100)
<i>Nationality</i>				
Saudi	187	(95.9)	325	(91.3)
Non-Saudi	8	(4.1)	31	(8.7)*
Total	195	(100)	356	(100)

*= $P<0.05$

TABLE 2. Respiratory diseases necessitating hospitalization in areas of different altitudes.

Types of Respiratory Diseases	Low Altitude		High Altitude	
	No.	(%)	No.	(%)
Bronchial asthma	9	(4.6)	28	(7.9)
Acute bronchitis	2	(1)	12	(3.4)
Asthmatic bronchitis	1	(0.5)	5	(1.4)
Chronic bronchitis	1	(0.5)	8	(2.2)
Bronchiectasis	3	(1.5)	2	(0.6)
Pneumonias	171	(87.7)	290	(81.4)
Others	8	(4.1)	11	(3.1)
Total	195	(100)	356	(100)

bronchitis, asthmatic bronchitis, chronic bronchitis, and bronchiectasis were variably represented but no differences were seen in the two areas.

The effect of high altitude on severity of respiratory disease is shown in Table 3. The length of stay in the hospital was similar in the two groups and was not affected by the patient's residence. The majority of patients (68.7% in LAA and 60.7% in HAA) stayed between four and 14 days in the hospital. The outcome of hospitalization was similar in the two groups of patients. Recovery rate was 93.4% and 92.2% in LAA and HAA respectively ($P>0.1$). As a direct result of chest disease, nine patients died from LAA and 10 patients died from HAA during the period of the study. Furthermore, no difference was demonstrated between the two groups in the form of requirements for repeated admissions to the hospital because of a respiratory illness.

Table 4 shows the effect of high altitude on hemoglobin (Hb), partial pressure of oxygen (PaO_2) and oxygen saturation (SaO_2). Patients in HAA tend to have higher levels of hemoglobin compared to LAA. Only 2% of patients from LAA had Hb > 16 g/dL, while 8% of HAA had Hb > 16 g/dL, $P>0.1$. However, when measured in the two groups, oxygen saturation was not different whether in patients with normal oxygen saturation of $>85\%$ or in hypoxic patients with oxygen saturation of $<86\%$. Admission PaO_2 was found to be lower in patients from HAA compared to patients from LAA.

Discussion

Although clinical cases seen in hospitals do not necessarily reflect the true prevalence of diseases in a community, it may give a fairly good idea about disease

TABLE 3. Effect of altitude on severity of respiratory disease.

	Low Altitude		High Altitude	
	No.	(%)	No.	(%)
<i>Length of stay</i>				
< 4	40	(20.5)	94	(26.4)
4 - 14	134	(68.7)	216	(60.7)
>14	21	(10.8)	46	(12.9)
Total	195	(100)	356	(100)
<i>Outcome</i>				
Death	9	(4.6)	10	(2.8)
Transfer	2	(1)	9	(2.5)
Self-discharge	2	(1)	9	(2.5)
Recovery	182	(93.4)	328	(92.2)
Total	195	(100)	356	(100)
<i>Previous admissions for RD</i>				
None	166	(85.1)	294	(82.6)
Once	20	(10.3)	34	(9.6)
Twice or more	9	(4.6)	28	(7.8)
Total	195	(100)	356	(100)

TABLE 4. Effect of high altitude on hemoglobin, PaO_2 , and oxygen concentration.

	Low Altitude		High Altitude		<i>P</i> value
	No.	(%)	No.	(%)	
<i>Hemoglobin (g%)</i>					
< 12	40	(74)	81	(59.1)	< 0.1
12 - 16	13	(24)	45	(32.9)	< 0.1
>16	1	(2)	11	(8)	< 0.1
Total	54	(100)	137	(100)	
<i>PaO₂ mm/Hg</i>					
< 60	109	(55.9)	261	(73.3)	< 0.05
>60	86	(44.1)	95	(26.7)	< 0.05
Total	195	(100)	356	(100)	
<i>Oxygen saturated (%)</i>					
< 85	120	(61.5)	240	(67.4)	0.16
>85	75	(38.5)	116	(32.6)	0.16
Total	195	(100)	356	(100)	

RD=respiratory disease.

patterns in the community. The two study groups were similar in age, sex and in the percentage representation of their population. The slightly higher non-Saudi population in HAA is not surprising, since this area is more prosperous economically and attracts more foreign labor population compared to LAA. Contrary to the belief of local physicians at the Al-Baha area, this study showed that there is no higher number of patients with severe respiratory diseases admitted to the hospital in this part of the country, a moderately high altitude area.

Several reports in the literature have shown that high altitude is associated with higher prevalence and higher mortality of lung disease.⁴ Other reports have shown that the higher the altitude, the more it adversely affects humans.⁵ The maximum altitude of our study area is 2480 meters above sea level and that is probably the reason there is no clear difference between respiratory disease pattern and frequency between low and high altitude areas.

While pneumonias were the most common illness in both areas, bronchiectasis, which is commonly a sequela of many respiratory illnesses, particularly tuberculosis, was an uncommon problem. Diagnosis of tuberculosis was not encountered in this study because during the period of data collection, all patients with tuberculosis were being transferred to a nearby tuberculosis center. Teklu reported a different experience on the pattern of lung disease in a similarly high altitude area (Asir, Saudi Arabia).⁷ The difference may be explained by the fact that Teklu's study

was conducted on an outpatient population who would obviously have a less severe and different pattern of illness.

Although the mortality rate from respiratory disease was reported to be higher in altitudes above 3000 meters, our data did not show any statistical differences in mortality rate between low and high altitude areas (Table 3).⁴ Furthermore, in a moderately high altitude such as the Al-Baha region, (less than 2500 meters above sea level) severity of respiratory disease does not seem to be increased when compared to near sea level areas.

Table 4 shows an interesting physiological phenomenon: While hemoglobin concentrations tend to be higher in HAA, oxygen saturation is similar between the two groups. Adaptation to high altitude is achieved by a constant erythropoietic response and increased hemoglobin that leads to an increase in oxygen content and oxygen delivery needed in a relatively hypoxic environment.⁸⁻¹⁰ It is also clear from the same table that partial pressure of oxygen (PaO_2) is significantly lower among patients admitted with respiratory illness in high altitude areas compared to those from a low altitude. Such patients (from HAA) tend to desaturate to a critical level more quickly than patients from LAA. Therefore, it would be of importance to the clinician to note such differences and introduce effective therapeutic measures early enough, even in apparently stable patients, who may quickly deteriorate to a dangerous state of hypoxic respiratory failure.

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