ON THE POSSIBLE INFLUENCE OF GREAT ALTITUDES ON THE DETERMINATION OF CERTAIN CARDIOVASCULAR ANOMALIES

Preliminary Report

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STUDIES carried out by Peruvian and other observers have demonstrated the influence on the human race of prolonged stay at high altitudes. There have been numerous publications on the biologic, clinical, radiologic and electrocardiographic peculiarities of the heart of the inhabitant of the Andean heights.1-5 Some preliminary observations suggest that prolonged stay at great altitudes has some influence on the development of the animal germ plasm.6,7 The present study deals with the effect that the altitude seems to have on the determination of certain anomalies of the heart.

OBSERVATIONS

The first three congenital anomalies of the heart diagnosed in 1944 in the Cardiology Outpatient Department of this hospital were two cases of patent ductus arteriosus and one of interatrial septal defect (two of them verified at autopsy), and it was noticed that all three had been born in the mining center of Cerro de Pasco or nearby at an altitude over 4,000 meters. Since that time, in order to find out if this was a fortuitous occurrence, in each case of cardiac anomaly the exact place of birth was determined, as well as the length of stay thereafter. After eight years the authors have some suggestive figures.

Ten thousand clinical histories from the Outpatient Department as well as from the private practice of one of the authors (V. A.) yielded 176 cases of cardiac anomaly. The diagnoses were based on clinical, radiologic and electrocardiographic observations; in many cases the circulation time was determined, and in some, information was obtained by catheterization of the right heart and angiocardiography. In 17 cases the diagnosis was confirmed at operation (15 patent ductus arteriosus and 2 tetralogy of Fallot), and in 8 cases at autopsy (2 patent ductus arteriosus, 3 interatrial septal defects, 2 interventricular communications and one Lutembacher syndrome).

Patients from the Outpatient Department, in contrast with private practice, are always adult males of modest means, largely mestizos, and since this service has provided over half the cases, little importance can be attached to the statistical significance of the age, sex and race of this group. On the other hand, the geographic location of the Outpatient Department, Lima, Peru, has provided over half the cases, and since this service has provided over half the cases, little importance can be attached to the statistical significance of the age, sex and race of this group.
Department and the large current of migration to Lima from the rest of the country make this a fairly representative sample.

In order to establish the validity of the suggestive observations, an effort was made to show whether these figures could have occurred by chance.

The place of birth of 1,000 consecutive admissions to this service was determined and from there the authors calculated the percentage of patients from each locality that were to be expected in each group.

It was found that 42.4% of this were born in the department of Lima, which includes Lima (39.3%), while only 6.9% were born in the departments of Junin and Pasco together, which includes the towns of Cerro de Pasco (1.7%), La Oroya (0.4%) and Morococha (0.1%). The vast majority of the remaining patients were born in other sections of the country whose maximum altitude seldom exceeds 3,000 meters, so that it can easily be said that no more than 15% of the patient population in this clinic should have been born above that altitude, no more than 9% above 3,500 meters, and certainly no more than 3% above 4,000 meters.

The fact that most of the patients were adults tends to lower the relative incidence of those malformations most likely to cause death in infancy and childhood, and consequently, the figures in this group are far from representative.

RESULTS

The 176 cases of cardiac anomaly have arbitrarily been divided into six groups.

1. Miscellaneous: thirty-nine cases, including dextrocardia, cardiopathies with cyanosis and abnormalities of the aortic arch. The authors could establish no correlation with altitude in this group.

2. Interventricular Communication: 29 cases. The places of birth of this group were widely scattered with no relation found to altitude.

3. Coarctation of the Aorta: 7 cases. In all of these the diagnosis was clear and only one was born above 3,500 meters, in Cerro de Pasco. This group is too small for any valid observation.

4. Pulmonary Stenosis: 8 cases. Here the diagnosis is only presumptive as none of these cases were catheterized or explored. However, 3 of the 8 were born above 4,000 meters. This, though suggestive, is not significant.

5. Interatrial Communications: 51 cases. The clinical diagnosis in this group can be made with a fair degree of exactitude. Of the 51, 9 (17.7%) were born above 4,000 meters and 4 more (7.8%) between 3,500 and 4,000 meters. This is significantly more than might have been expected.

6. Patent Ductus Arteriosus: 42 cases. This includes only cases with a clearcut clinical diagnosis, or proved at operation* or necropsy. It is interesting to note that not one of these cases came because of or had any signs of superimposed endocarditis. Of the 42 cases, 13 (30.9%) were born more than 4,000 meters above sea level, 5 (11.9%) between 3,500 and 4,000 meters and 8 (19.0%) between 3,000 and 3,500 meters. For all these altitudes, the differences between the expected and observed number of cases is statistically significant.

DISCUSSION

These figures indicate that a patent ductus arteriosus or interatrial defect is more likely

* Performed by Dr. C. A. Peschiera.
to be found in a subject born at high altitudes. It remains to be shown that this is true for other defects, particularly anomalies of the pulmonary artery. There is no reason to believe that rubella is more common at these altitudes and the few mothers who could be interviewed denied any history of eruptive illness during the pregnancy in question. Racial factors seem to have no influence in these figures.

The obliteration of the ductus arteriosus, as all morphogenetic processes, is due to various causes, not all of which are understood. It is presumed that in the first moments after birth a "functional" obliteration takes place because of an equilibration of the pressure at the pulmonary and aortic ends,\(^8\) due mostly to the initiation of respiration. It is interesting to note that Senac, in 1749, believed that the ductus arteriosus remained patent when respiratory function was impeded.\(^9\) The experimental work of Kennedy\(^10\) allows the supposition that oxygen is the major stimulus to this obliteration, acting even when injected through the umbilical vein. He has apparently demonstrated that pulmonary expansion by an inert gas is ineffective, but that obliteration takes place when the oxygen concentration is adequate.

The authors do not know what the intimate cause for the frequent persistence of the ductus arteriosus at high altitudes may be, but it seems probable that the mechanical factor in the pulmonary circulation as well as the oxygen tension are responsible.

It may be mentioned that functionally, at least, the foramen ovale behaves in many respects like the ductus arteriosus and that its anatomic obliteration often takes place months after birth.

It seems that the effect of high altitudes becomes clearly manifest at 3,000 meters or over.

**Summary**

Over a period of 8 years, 176 cases of cardiac anomalies have been found in over 10,000 consecutive admissions. The place of birth and its altitude have been recorded for each one of these causes.

Patent ductus arteriosus and persistent interatrial communications are more likely to be found in patients born at high altitudes.

It is suggested, but remains to be shown, that this is true for defects of the pulmonary artery. No apparent relation could be found in this series for other malformations.

It is presumed that mechanical factors tied to the pulmonary circulation and the lower oxygen tension both have a decisive influence.

**References**

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circulation through heart in adult and in fetus, and identification of ductus arteriosus, Am. J. Roentgenol. 47:678, 1942.

SPANISH ABSTRACT
Influencia Probable de las Grandes Altitudes Sobre la Determinación de Algunas Anomalías Cardiovasculares

Los autores han encontrado 176 casos de anomalías cardiacas en más de 10,000 admisiones consecutivas en un periodo de 8 años; el lugar de nacimiento y su altitud se han anotado para cada uno de estos casos. La persistencia del conducto arteriovenoso y la de las comunicaciones interauriculares se encuentran con mayor frecuencia en los nacidos a grandes altitudes; se sugiere que lo mismo pasa con los defectos de la arteria pulmonar aunque falta demostrarlo.
No han encontrado en esta serie ninguna relación aparente con otras malformaciones.
Se supone que tienen influencia decisiva los factores mecánicos debidos a la circulación pulmonar y la tensión más baja de oxígeno.

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