Studies on the Structure of the Pulmonary Trunk

III. The Thickness of the Media of the Pulmonary Trunk and Ascending Aorta in High Altitude Natives

By MARIO SALDAÑA, M.D., and JAVIER ARIAS-STELLA, M.D.

VARIATIONS in the thickness of the tunica media of the pulmonary trunk have been reported by Heath, Wood, DuShane, and Edwards,\(^1\) both in normal conditions and in response to pulmonary hypertension or hypotension.

According to Heath et al., in the newborn the thickness of the media of the pulmonary trunk is the same as that of the ascending aorta. Normally in the course of life the pulmonary trunk increases its medial thickness at a minor ratio than the aorta. Thus, the relation:thickness of the media of the pulmonary trunk over that of the ascending aorta (P/A ratio) which is 1 at birth, falls to 0.6, with a range of 0.4 to 0.8, by the sixth month. These same values are observed for the rest of life.

In cases of pulmonary hypertension, either present from birth or secondary to an acquired heart disease, Heath et al. found that the pulmonary trunk exhibited a media as thick as that of the ascending aorta. On the other hand, a pulmonary trunk media of just 0.2 to 0.3 of the thickness of the aortic media was reported by these authors in cases of pulmonary arterial hypotension.

The evolution of the thickness of the media of the pulmonary trunk and ascending aorta, from birth to elderly life, in normal people from high altitudes and from sea level, is presented in this paper. This information is intended mainly to complement previous observations on the evolution of the elastic configuration of the pulmonary trunk at high altitudes.\(^2\)

Material and Method

Two hundred cases were studied. One hundred were persons born and living permanently in places situated between 11,300 to 14,900 feet above sea level. One hundred subjects from Lima (500 feet above sea level) served as control. Both high altitude and sea level cases were selected from previously studied material.\(^2\) Selection of these cases was done exclusively on the basis of comparable ages between cases from both groups. The same histologic sections utilized for observations on the elastic structure of the pulmonary trunk and ascending aorta\(^2\) were used in the present study.

Separation of high altitude cases in two level groups, as in a previous study,\(^2\) was not attempted because of the reduced number of cases suitable for measurements of the arterial media in certain ages.

The ages of the cases varied from birth to 78 years in the high altitude group and from birth to 80 in cases at sea level. According to ages, the cases were distributed in five groups: from birth to 11 months (17 cases at sea level and 17 at high altitudes); 1 to 9 years (20 cases at sea level and 20 at high altitudes); 10 to 29 years (25 cases at sea level and 25 at high altitudes); 30 to 49 years (22 cases at sea level and 22 at high altitudes); and 50 to 80 years (16 cases at sea level and 16 at high altitudes).

Measurements of the thickness of the media of the pulmonary trunk and ascending aorta were made with the aid of an ocular scale. Those portions of arterial wall exhibiting a fair regularity in thickness were subjected to measurements. Since variations of the thickness of the media in a single pulmonary trunk or ascending aorta may be frequently observed, a mean value for each of these arteries was obtained from three measurements at different places of the arterial wall. With the aforementioned values, the P/A ratio (thickness of media of pulmonary trunk/ thickness of media of ascending aorta) was calculated in every instance.

Mean values of the thickness of the media of the pulmonary trunk and ascending aorta and of P/A ratio were obtained in the five age groups. Comparisons between corresponding mean values of high altitude and sea level cases were done according to Fisher’s t-test,\(^3\) \(p\) values were obtained
from t tables, and the 2 per cent level of confidence was accepted as significant.

Results

The results are represented in figure 1. Our values for the thickness of the media of the pulmonary trunk and ascending aorta and for the P/A ratio, in the sea level group, agree closely with those of Heath’s et al. control cases, in comparable ages.

Thickness of the Media of the Pulmonary Trunk

In all five groups, the thickness of the media of the pulmonary trunk in high altitude cases was greater than that of sea level cases. The differences between mean values were highly statistically significant in four of the five groups ($p < 0.001$). In the 1- to 9-year age group a $p < 0.01$ value was obtained.

Thickness of the Media of the Ascending Aorta

In all five groups, the thickness of the media was greater in sea level cases than in high altitude ones. However, differences were significant only in the two oldest groups: 30 to 49 years ($p < 0.02$) and 50 to 80 years ($p < 0.001$).

P/A Ratio

Mean values were consistently higher in all five groups in high altitude cases. The differences between mean values were statistically highly significant ($p < 0.001$) in every age group.

Discussion

Our results show that people born and living permanently at high altitudes possess a pulmonary trunk media significantly thicker than that of sea level dwellers. High altitude pulmonary hypertension$^4$ appears to be, in all probability, the determining cause of such a characteristic. As previously mentioned, thickening of the media is a form of response of the pulmonary trunk to pulmonary arterial hypertension. Changes in the elastic structure of this artery at high altitudes,$^2$ which have been related to the existence of a mild degree of pulmonary arterial hypertension from birth, are in perfect accordance with the present finding.

A definitely higher pulmonary trunk/ascending aorta medial thickness relation (P/A ratio) in high altitude persons rather than in sea level ones, reflects in part a greater numerator, i.e., a thicker pulmonary trunk, and in part a lesser denominator—a thinner ascending aortic media.

There exists some hemodynamic information that may be of value in explaining why, in high altitude natives over 30 years of age, the ascending aorta media is thinner than that observed at sea level. In 1937, Torres,$^8$ in a carefully conducted work, made systemic blood pressure determinations by the indirect method in 200 normal subjects who were born and lived in places between 10,500 to 14,000 feet of altitude. The ages of these subjects varied from 16 to 50 years. Torres used a sea level group of 100 subjects, age 16 to 57 years, for comparison. He observed that the systolic pressure was slightly lower in the high altitude group than that at sea level (table 1).

Figure 1

Representation of the evolution of the thickness of the media of the pulmonary trunk, ascending aorta, and of the relation:thickness of the media of the pulmonary trunk/thickness of the media of the ascending aorta (P/A ratio), at high altitudes and at sea level.
This fact has been recently confirmed by Peñaloza, Sime, Banchero, Gamboa, Cruz, and Marticorena. These authors, in the course of right heart catheterization studies, made direct recordings of systemic blood pressure in 38 high altitude subjects ranging in age from 17 to 34 years. Torres and Peñaloza's et al. values for systemic pressures at high altitudes and at sea level, together with statistical significance of differences, are presented in table 1.

No convincing explanation has been advanced until now for the existence of lower systemic systolic pressures at high altitudes, when compared with those at sea level. This fact means indeed that, at high altitude, the ascending aorta is exposed with each ventricular ejection to a distending force of lesser degree than at sea level. It can be accepted that as a result of this lower mechanical stimulus, acting for many years, the ascending aorta, at high altitudes, develops a thinner media than at sea level.

Summary
Measurements of the thickness of the media of the pulmonary trunk and ascending aorta were made in 200 normal autopsy cases ranging in ages from birth to 80 years. One hundred cases were persons who were born and lived permanently in places between 11,300 to 14,900 feet above sea level. One hundred persons of comparable ages, born at sea level, served as control.

It is shown that at high altitudes the pulmonary trunk exhibits a thicker media than at sea level, in the course of the whole of life. This fact is explained by the occurrence, at high altitudes, of a mild degree of pulmonary arterial hypertension from birth.

The media of the ascending aorta of high altitude natives was found to be thinner than that of sea level inhabitants, after 30 years. This characteristic appears to be related to the existence of a lower systolic pressure at high altitudes than at sea level.

Acknowledgment
We express our thanks to Dr. Julio Cruz for his valuable help in the preparation of the statistical data.

References

Table 1
Systemic Blood Pressure Recordings (mm. Hg) at High Altitudes and at Sea Level

<table>
<thead>
<tr>
<th>Place</th>
<th>Indirect*</th>
<th>Direct†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Systolic</td>
<td>Diastolic</td>
</tr>
<tr>
<td>High altitudes</td>
<td>200</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td></td>
<td>73</td>
</tr>
<tr>
<td>Sea level</td>
<td>100</td>
<td>117</td>
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<tr>
<td><strong>P</strong></td>
<td>&lt;0.001</td>
<td>&lt;0.40</td>
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</tbody>
</table>

*Torres.
†Peñaloza et al.


Giovanni Battista Morgagni, the Founder of Pathologic Anatomy

When, in 1894, the octogenarian Rudolf Virchow addressed the International Congress at Rome, he selected Morgagni for his subject, considering him as the founder of pathology. In so doing, Virchow honored also a whole tradition of Italian scholars and original investigators—Mondino, Vesalius, Fallopius, Eustachio, Spigelius, Lancisi, and Pacchioni—of whom Morgagni was the most worthy offspring.

When Morgagni entered the field, the basic aims of scientific medicine and the methods by which it should be pursued had been established.

Thomas Bartholinus, in his De anatome practica ex cadaveribus morbos adornando consilium (1674), had already made clear the distinction between the anatomist who limits himself to the exploration of normal structure and the anatomist as a physician who derives information useful for his practice from the bodies of the sick. The Florentine, Antonio Benivieni (?1440-1502), had shown how a practicing physician could blaze this new trail.

If any doubt remained as to how far anatomy could promote the advancement of medicine, it was readily dissipated by the message of Marcello Malpighi (1628-1694):

Anatomy advances medicine by demonstrating the seat, the origin, and the cause of disease, as well as the mechanisms by which it is produced.

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