A tribute in life to the world icon of the cardiology of heights: Dr. Dante Peñaloza from Peru - 2017

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Dr. Dante Peñaloza always tells that his interest in science started when he was a primary school student. Peñaloza studied at the Anglo-Peruvian school (currently, *Colegio San Andrés*), where he finished first among these peers. **Figure 1.**

Figure 1

At 21, he started the career of medicine at the *Universidad Nacional Mayor de San Marcos*. This University was founded in the 16th century, on May 12, 1551, and it is the oldest one in America, and the one that has been in operation for the longest time uninterrupted since its foundation, and the only one of the American Universities founded during the 16th century that is still open today. **Figure 2.**

Figure 2

During the third course, the classes by professor Alberto Hurtado (who introduced scientific medicine to Peru) fascinated him. This interest maintained throughout his career and when he finished college, professors Hurtado and Carlos Monge got him a research scholarship in the famous ***Instituto Nacional de Cardiología de México* (INCM)**. In this institution, Peñaloza started to investigate vectorial electrocardiography. Scalar electrocardiography records only in 2 planes, contrary to the vectorial study, which makes it possible to analyze the trajectory of the electrical stimulus of the heart in the three planes of space, better adjusting to the 3D world where

we are immersed. During his stay in Mexico, he published in January 1955, his first manuscript in the prestigious American Heart Journal, along with João Tranchesi from Brazil [1].

Back in Peru, he started to work at the *Instituto de Biología Andina* (IBA) on topics related to the heart and pulmonary circulation in inhabitants of heights. "Back then, NASA was very interested on the modifications occurring in humans living at 4000 or 5000 meters above the sea. This fact led to the support we received." With the support of the US Air Force, Peñaloza and his collaborators could conduct electro-vectorcardiographic (ECG-VCG) studies, which were initially experimental and subsequently in humans native and living at great heights. These investigations showed that unlike what happens at sea level, natives from heights present physiological right ventricular hypertrophy since the postnatal period until adulthood. These investigations were presented in successive manuscripts [2-13].

In 1955, he joined the UNMSM as professor in the School of Medicine and as investigator at the IBA. In this stage of his scientific and academic activity, his conditions as a leader became evident and soon he was surrounded by a numerous group of young physicians and students of Medicine, eager to investigate and acquire knowledge on ECG-VCG and medicine in heights. This was the origin of a remarkable school of clinical cardiologists and investigators that today hold relevant positions in the country and abroad.

In 1961, professors Honorio Delgado and Alberto Hurtado –mentor to Peñaloza- presided a movement that led to the foundation of the currently called *Universidad Peruana Cayetano Heredia*. Dr. Peñaloza was a founding member and at 39 years he was appointed by competition main professor of Medicine. He was also appointed Chief

of the Cardiovascular Laboratory at the IIA), where he was accompanied by most of his collaborators at the IBA. As he started his activities at the IIA, Dr. Peñaloza presented an ambitious project and obtained an investigation grant given by the US National Institute of Health.

Later, a second stage of investigations started: this time, hemodynamic studies of the heart and pulmonary circulation in people living at great heights. Based on the ECG-VCG findings from the first stage, Dr. Peñaloza proposed a hypothesis according to which postnatal changes in pulmonary blood pressure and pulmonary vascular structure in people native from heights would be different from the findings described at sea level. The hypothesis was confirmed. Cardiac catheterization studies performed in children and adults native from heights showed postnatal persistence of pulmonary hypertension, and the pathology studies by Dr. Javier Arias-Stella and their team proved a persistence of thick distal pulmonary arteries, establishing a link between both findings. Peruvian investigators thus described for the first time, the mechanism of chronic hypoxic pulmonary hypertension. Additionally, the influence on the heart and pulmonary circulation of factors such as level of altitude, age, exercise, sleep and migration to sea level were discussed. These new findings were presented in international conferences and were published in scientific journals of the US and Europe, among them: American Journal of Cardiology, Circulation, British Heart Journal, Journal of Applied Physiology, and Pediatrics. **Figure 3.**

Figure 3

Years later, Peñaloza continued with a new stage of investigations when he led the Cardiovascular Laboratory of the High Altitudes Research Institute from Peruvian University of Medical and Biological Sciences, Lima, in Morococha Perú, where he performed clinical and hemodynamic investigations on diseases due to altitude maladjustment. These investigations were conducted. **Figure 4.**

Figure 4

Studies on chronic mountain sickness (CMS) or Monge's disease constituted the PhD thesis of Peñaloza, subsequently disseminated in scientific journals of international circulation. Figure 5 shows the master in the hemodynamic laboratory.

Figure 5

This investigation constitutes to this day, the fundamental reference for studies related to CMS. After the invitation by the editors of the prestigious Circulation Journal, Dr. Peñaloza has published a systematic review on CMS, including the recent investigations made in China and Russia [13]. In this systematic review, Peñaloza informed us that more than 140 million of people in the world live above the 2500 m over sea level, and from them, 80 million live in Asia and 35 million in the Andean mountains. The last region has its largest population density on the wall above 3500 m. Peñaloza analyzed the physiology, pathology, pathogenesis and characteristics of the heart, and circulation of the lungs in the healthy members of families and in patients. Pulmonary hypertension in healthy people refers to a delayed postnatal remodeling, observed in the pulmonary

arteries. The magnitude of pulmonary hypertension increases with the level of altitude and the degree of exercise. There is no reversion for the incidence of hypertension after prolongation of stay at sea level. Peñaloza defines CMS when there is loss on the capacity to adjust to altitude with emphasized hypoxemia and polycythemia. The heart and pulmonary circulation in the areas of great altitude present different characteristics in comparison to individuals living at sea level. “This is a problem of public health in the Andean mountains and other mountains around the world. Therefore, the dissemination of preventive and therapeutic measures is essential.” Figure 6 shows an ECG-pressure correlation.

Figure 6

These investigations, thanks to the Peñaloza school, originated the knowledge on Monge’s disease [14], which consists on a loss of tolerance to great heights after a prolonged exposition and is characterized by extreme polycythemia, exaggerated hypoxemia, associated to a reduction in mental and physical ability, which is relieved by descending. The entity is known as erythremia and chronic soroche.

The clinical and hemodynamic study on High-Altitude Pulmonary Edema (HAPE) performed by Dr. Peñaloza collaborating with Dr. Sime, constitutes one of the few investigations on HAPE performed in the world with cardiac catheterization. The hemodynamic observations conducted in Peru by Peñaloza and this team constitute the HAPE study performed at highest altitude and with the greatest degrees of pulmonary hypertension and hypoxemia. In this stage, also a clinical and hemodynamic study was made on Patent Ductus Arteriosus (PDA), a congenital heart disease that has a high

prevalence at great altitudes. A current review on HAPE and PDA in altitudes has been published in September 2008 by Dr. Peñaloza et al, in the specialized journal High Altitude Medicine and Biology, including the recent studies on these topics made in children that live in mountainous areas from other geographical areas. Until recently Dr. Peñaloza still delivered lectures in the main schools of medicine of Lima and provided counseling to PhD students devoted to the investigation of cardiovascular physiology and pathology in altitudes, and even visited his former work center at the San Felipe clinic in Lima, and currently he lives next to his two dear daughters, Liliana and Marisol, in his house in San Borja, Lima (Figure 7).

Figure 7

References

1. Penaloza D, Tranchesi J. The three main vectors of the ventricular activation process in the normal human heart. I. Its significance. Am Heart J. 1955;49(1): 51-67.
2. Penaloza D, Echevarria M. Electrocardiographic observations on ten subjects at sea level and during one year of residence at high altitudes. Am Heart J 1957;54(6): 811–22.
3. Penaloza D, Gamboa R, Dyer J, Echevarria M, Marticorena E. The influence of high altitudes on the electrical activity of the heart. Electrocardiographic and vectorcardiographic observations in the newborn, infants, and children. Tech Doc Rep SAMTDR USAF Sch Aerosp Med. 1960;60-79:1-20.
4. Penaloza D, Gamboa R, Dyer J, Eschevarria M, Marticorena E. The influence of high altitudes on the electrical activity of the heart. I. Electrocardiographic and vectocardiographic observations in the newborn, infants, and children. Am Heart J 1960;59:111–28.

5. Penaloza D, Gamboa R, Marticorena E, Echevarria M, Dyer J, Gutierres E. The influence of high altitudes on the electrical activity of the heart. Electrocardiographic and vactorcardiographic observations in adolescence and adulthood. Am Heart J. 1961;61:101-15.
6. Penaloza D, Sime F, Banchero N, Gamboa R. Pulmonary hypertension in healthy man born and living at high altitudes. Med Thorac 1962;19:449–60.
7. Penaloza D, Sime F, Banchero N, Gamboa R, Cruz J, Marticorena E. Pulmonary hypertension in healthy man born and living at high altitudes. Am J Cardiol. 1963;11(2):150–7.
8. Penaloza D, Arias-Stella J, Sime F, Recavarren S, Marticorena E. The heart and pulmonary circulation in children at high altitudes: physiological, anatomical, and clinical observations. Pediatrics. 1964;34:568–82.
9. Penaloza D, Sime F. Circulatory dynamics during high altitude pulmonary edema. Am J Cardiol. 1969;23(3):369–78.
10. Penaloza D, Sime F. Chronic cor pulmonale due to loss of altitude acclimatization (chronic mountain sickness). Am J Med. 1971;50(6):728–43.
11. Penaloza D, Sime F, and Ruiz L. Cor pulmonale in chronic mountain sickness: present concept of Monge's disease. In: High Altitude Physiology: Cardiac and Respiratory Aspects, edited by Porter R and Knight J. London: Churchill Livingstone; 1971. Pp. 41–60.
12. Penaloza D. Effects of high-altitude exposure on the pulmonary circulation. Rev Esp Cardiol (Engl Ed). 2012; 65(12):1075-8.

13. Penaloza D, Arias-Stella J. The heart and pulmonary circulation at high altitudes: healthy highlanders and chronic mountain sickness. Circulation. 2007;115(9):1132-46.
14. Sime F**.** Dormir en los Andes: contribución del sueño en la etiopathogenia de la enfermedad de Monge. Acta Andina 1995;4:13–24.

Figure legends

Figure 1

It shows the façade of the current *Colegio San Andrés*, located in the Avenue Du Petit Thouars 179, Lima, Peru, where Dante Peñaloza studied.

Figure 2

Main square of the "College Campus" of the *Universidad Mayor de San Marcos*; at the left, the "Jorge Basadre" Rector's Office; at the right, the central library "Pedro Zulen"; at the center, the monument for Friar Tomás de San Martín.

Figure 3

Javier Arias-Stella MD, at the left, and Dante Peñaloza MD at the right, visiting Colorado's high country on the occasion of the Aspen conference, in the state of Colorado, held in 1962 and organized by Robert Grover MD (Courtesy of Dr. Grover).

Figure 4

Clinical and hemodynamic investigation laboratory for diseases due to altitude maladjustment in Morococha district located at a height of 4,500 m.

Figure 5

Dante Peñaloza watching a cardiac monitor during catheterization (courtesy by Dr. Sime and Peñaloza).

Figure 6

It shows an ECG-pressure correlation graph, conducted in a 5-year-old child living at great heights (4,540 m) during wakefulness, transition and sleep. Acute hypoventilation during sleep emphasizes hypoxemia and pulmonary hypertension. (Picture belonging to Dr. Sime).

Figure 7

Dr. Dante Peñaloza with this wife Lily and his daughters Liliana and Marisol. (Family picture, courtesy of Marisol Peñaloza).