ACUTE HIGH ALTITUDE DISEASES

T.H. RAVENHILL, MOUNTAIN SICKNESS, AND PERUVIAN CONTRIBUTIONS TO HIGH-ALTITUDE PULMONARY EDEMA

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RESUMEN: T.H. Ravenhill, Mal de Montaña y las Contribuciones Peruanas al Edema Pulmonar de Altura

Thomas Holmes Ravenhill (1881-1952) fue una figura clave en la historia del mal de montaña pero la importancia de sus contribuciones sólo se ha apreciado recientemente. El fue quien brindó las primeras descripciones convincentes del edema pulmonar de altura y del edema cerebral de altura, y su clasificación del mal de montaña es la que utilizamos actualmente. Sin embargo, luego de su publicación en 1913, su artículo fue prácticamente olvidado durante 50 años. Mientras tanto, el edema pulmonar de altura fue independientemente descrito con exactitud y detalle en el Perú, pero desafortunadamente la información no fue conocida fuera de América del Sur. Fue recién a partir del viaje de Herbert N. Hultgren, M.D. a La Oroya en 1953 que el mundo de habla no hispana tomó conocimiento de estos importantes avances.

Palabras claves: Mal de montaña; Historia; Edema pulmonar de altura

RÉSUMÉ: T.H. Ravenhill, Mal des Montagnes et contributions péruviennes à l'oedème pulmonaire de haute altitude.

Thomas Holmes Ravenhill (1881-1952) est une figure clé de l'histoire du mal des montagnes, mais l'importance de ses contributions n'a été reconnue que récemment. C'est lui qui fit les premières descriptions réellement convaincantes de l'oedème pulmonaire et de l'oedème cérébral de haute altitude et sa classification du mal des montagnes est celle qui est utilisée de nos jours. Cependant, après sa publication en 1913, son article fut pratiquement oublié pendant 50 ans. Pendant ce temps, et indépendamment, une description exacte et détaillée de l'oedème pulmonaire de haute altitude fut faite au Pérou. Malheureusement l'information ne fut pas divulguée hors d'Amérique du Sud. Ce n'est qu'à partir du voyage d'Herbert N. Hultgren, M.D. à La Oroya en 1959 que l'avancement important des connaissances dans ce domaine parvint au monde non hispanophone.

Mots-clés : Mal des Montagnes, Histoire, Oedème pulmonaire de haute altitude.

SUMMARY: Thomas Holmes Ravenhill (1881-1952) was a key figure in the history of mountain sickness but the importance of his contributions has only recently been appreciated. He gave the first convincing clinical descriptions of high-altitude pulmonary edema and high-altitude cerebral edema, and his classification of mountain sickness is the one we use today. However after its publication in 1913, his paper dropped out of sight and was essentially forgotten for 50 years. In the meantime, high-altitude pulmonary edema was independently described with accuracy and detail in Peru but unfortunately the information was not known outside South America. It was not until Herbert N. Hultgren, M.D. visited Oroya in 1959 that the non-Spanish speaking world were made aware of these important advances.

Key Words : Mountain sicness, History, High altitude pulmonary edema

THOMAS HOLMES RAVENHILL (1881-1952)

T.H. Ravenhill was a key figure in the history of mountain sickness but the significance of his contributions has only recently been fully appreciated. He was born in Birmingham, England where his father was a surgeon and obtained his medical degree at the University of Birmingham in 1905 (1). In 1909 he went to the Poderosa and Collahuasi mines in north Chile for two years as medical officer or "Surgeon" as the position was then called. These mines are in a remote part of north Chile close to the Bolivian border and Ravenhill gave their altitudes as 15,400-16,200 ft (4690-4940 m) though these were slight

overestimates. It is not clear what prompted Ravenhill to go to the mines but there were very strong links between Britain and the Chilean mining industry at that time. Furthermore, the mines were growing fast because the railway link between Ollague (on the main Antofagasta-La Paz line) and Collahuasi had just been completed.

As a results of his period there, Ravenhill wrote a landmark paper "Some Experiences of Mountain Sickness in the Andes" (2). The paper contains the classification of mountain sickness that we still use, and also vivid, accurate descriptions of what we now know as acute mountain sickness, high-altitude pulmonary edema, and high-altitude cerebral edema.

Ravenhill used the term "puna" for mountain sickness because that was the local word. His classification of mountain sickness was as follows:

A) Acute mountain sickness (puna of a normal type)

B) Two divergent types of the disease

1. High-altitude pulmonary edema (puna of a cardiac type)
2. High-altitude cerebral edema (puna of a nervous type)

This is the classification that we use today. The term "divergent" is a particularly happy one because it is difficult to think of a better term. It is somewhat misleading to refer to highaltitude pulmonary edema and high-altitude cerebral edema as complications of acute mountain sickness because they occasionally occur in its absence.

Acute mountain sickness. Ravenhill's clinical description of acute mountain sickness is accurate and vivid. Here is part of it.

> It is a curious fact that the symptoms of puna do not usually evince themselves at once. The majority of newcomers have expressed themselves as being quite well on first arrival. As a rule, towards the evening the patient begins to feel rather slack and disinclined for exertion. He goes to bed, but has a restless and troubled night, and wakes up next morning with a severe frontal headache. There may be vomiting, frequently there is a sense of oppression in the chest, but there is rarely any respiratory distress or alteration in the normal rate of breathing so long as the patient is at rest. The patient may feel slightly giddy on rising from bed, and any attempt at exertion increases the headache, which is nearly always confined to the frontal region.

Of course there have been many descriptions of acute mountain sickness before Ravenhill's but very few of them ring as true as his.

High-altitude pulmonary edema. Ravenhill describes three cases of "puna of a cardiac type" and here is part of the description of the first case.

He seemed in good health on arrival, and said that he felt quite well, but nevertheless he kept quiet, ate sparingly, and went to bed early. He woke next morning feeling ill, with symptoms of the normal type of puna.

As the day drew on he began to feel very ill indeed. In the afternoon his pulse rate was 144, respirations 40. Later in the evening he became very cyanosed, had acute dyspnea, and evident air hunger, all the extraordinary muscles of respiration being called into play. The heart sounds were very faint, the pulse irregular and of small tension. He seemed to present a typical picture of a failing heart. This condition persisted during the night; he coughed up with difficulty. He vomited at intervals. This condition persisted during the night; he had several inhalations of oxygen; strychnine and digitalis also were given. Towards morning he recovered slightly, and as there was luckily a train going down to Antofagasta in the early morning, he was sent straight down.

I heard that when he got down to 12,000 ft. [3660 m] he was considerably better, and at 7,000 ft. [2130 m] he was nearly well. It seemed to me that he would have died had he stayed in the altitudes for another day.

The third case described by Ravenhill was interesting because it was of a young man, aged 23, who had lived in the mining areas for some months but had descended to sea level for some weeks and then developed puna of the cardiac type after returning to high altitude. This "re-ascent" high altitude pulmonary edema has been described many times since.

One of the remarkable features of Ravenhill's paper was how it disappeared from sight and was essentially forgotten before it was discovered some 50 years later. It was not until 1964 that William H. Hall, M.D. was doing an extensive literature search and brought the paper to general notice. In the meantime, however, high-altitude pulmonary edema was described independently in Peru but again these descriptions were unknown outside South America until 1960, just before Ravenhill's description was rediscovered.

Peruvian Contributions to High-Altitude Pulmonary Edema

One of the first articles in the Peruvian literature to refer to pulmonary edema at high altitude was-that by Alberto Hurtado in 1937. This was a small booklet (*Aspectos Fisiólogicos y Patológicos de la Vida en la Altura*) (3) which now is extremely difficult to find outside Peru. On page 29 he states (in English translation):

> There is undoubtedly a type of Soroche [mountain sickness] which is quite rare and infrequent, and is characterized by the presence of intense congestion and edema of the lung. Possibly in these cases there is a prior cardiac condition of myocardial disease, and the acute and severe episode on arrival at altitude can be best classified as a state of circulatory insufficiency rather than a true high altitude sickness.

Hurtado then went on to describe a 48 year old man who was a native of Junin and of indigent race, and who had resided at altitude for the last 29 years. He went down to Lima for three days but on returning to Oroya by train he became very dyspneic, had a severe headache and some mental confusion. Examination showed orthopnea, intense cyanosis, and there were crepitations at the bases of the lungs. The sputum contained blood. The patient descended to Lima and improved slowly. When he returned to high altitude after two months there were signs of circulatory insufficiency including dyspnea, congestion of the lung bases, and edema of the extremities. Thus this patient is not typical of high-altitude pulmonary edema because the continuation of signs of circulatory insufficiency suggest that there was underlying cardiac disease.

However a few years later a number of clinical descriptions in Peru leave no doubt that high-altitude pulmonary edema was clearly recognized there. The first descriptions came from the Chulec General Hospital in Oroya (3750 m) where Leoncio Lizárraga Morla (4) described 7 cases of high-altitude pulmonary edema seen between July 1951 and August 1952. Previously Einar A. Lundberg, Chief of Medicine at Chulec General Hospital, had presented 6 cases to the Asociación Médica de Yauli but these cases were not published.

Lizárraga described his cases in detail with summaries of their clinical history, physical examination, hematology, chest radiography, electrocardiography, treatment and outcome. He described the condition both in individuals making their first ascent to high altitude, and also in people who had been at high altitude for some time, had descended to sea level for a few days, and then returned to high altitude. The patients typically had severe dyspnea and rales in their lungs. The chest radiograph showed increased shadowing but the heart size was normal. The electrocardiogram showed right axis deviation and sometimes P waves were prominent suggesting cor pulmonale. Most cases responded well to rest, though oxygen and digitalis were sometimes administered.

Following Lizárraga's classical paper, Arturo Bardález Vega (5-7) described 12 additional cases in Morococha (4500 m) which he saw between August 1953 and November 1955. Again the descriptions were detailed along with the clinical history, physical examination, chest radiology, hematology, electrocardiography, and outcome. Bardález stated that a frequent complication was bronchitis or bronchopneumonia and he recommended the administration of penicillin or some other chemotherapeutic agent.

It is remarkable that the detailed studies by Lizárraga and Bardález were essentially unknown outside South America. The only report in the English-speaking literature was a brief "Foreign Letter" *in the Journal of the America Medical Association* (8). However this was generally overlooked, partly because of its brevity and partly because the readers were not prepared for this new disease.

Introduction of the Peruvian Studies to North America

In February and March of 1959 Herbert Nils Hultgren (1917-), a cardiologist at Stanford University School of Medicine and a mountain climber, visited Chulec General Hospital and was astonished to find that high-altitude pulmonary edema was a well-known condition which had been accurately described on many occasions. When he returned to California he wrote an account with Dr. Warren Spickard under the title "Medical Experiences in Peru" which was published in the *Stanford Medical Bulletin* in March 1960 (9). After some general remarks about Peru, and Lima in particular, they stated, "During the two weeks spent at the Chulec General Hospital, the authors had the opportunity to review the clinical records of 41 patients who had experienced acute pulmonary edema shortly after their arrival on the hill." The clinical features were described and were much as reported by Lizárraga (4) and Bardález (5-7). Hultgren and Spickard pointed out that the mechanism of the disease was unknown. However the normal cardiac size and absence of murmurs or gallop sounds suggested that left ventricular failure was absent. In addition there was evidence of physiological pulmonary hypertension and right

ventricular hypertrophy. This partly came from electrocardiographic studies refereed to above, but they also cited the work of Rotta *et al.* (10) who had recently demonstrated pulmonary hypertension in 4 native residents of Morococha.

In retrospect this important paper by Hultgren and Spickard did not make the impact that might have been expected. Partly this was because the *Stanford Medical Bulletin* is not widely read, and also the authors implied that a fuller account of the patients with high-altitude pulmonary edema would be published later. This is regrettable because this classical paper was the first full account of high-altitude pulmonary edema published in English. Not only did the authors review a large series of cases and clearly report the salient clinical and investigative findings, but they also gave useful insights into possible mechanisms of the disease.

In the event, the most influential publication in the rediscovery of high-altitude pulmonary edema in the English-speaking literature was by Charles Snead Houston (1913-). In January 1959 he saw a 21 year old college student who had begun a cross-country ski trip from Aspen, Colorado about 4 days before and had become so ill with severe dyspnea, weakness and cough that he had to be evacuated to the nearest hospital. On examination there was cyanosis, marked orthopnea and dyspnea, and both lungs were filled with coarse to medium rales. A chest radiograph showed mottled infiltration especially on the right side. The diagnosis was initially unclear and the case was first reported as "Pneumonia or Heart Failure?" (11). However later the diagnosis was changed and the case was written up for the *New England Journal of Medicine* under the title "Acute Pulmonary Edema of High Altitude" and published in the September 8, 1960 issue (12). The pathogenesis was uncertain and the conclusion was that, "The condition is attributed to the combined stresses of cold, exertion and the anoxia occurring at 12,000 feet." The Peruvian studies were not cited although the text included the statement, "More recently, Hultgren examined the records of a large number of patients with acute pulmonary congestion believed to be due to acute exposure to high altitude." However the *New England Journal of Medicine* is widely read throughout the world and Houston's article brought the condition of high-altitude pulmonary edema into great prominence.

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