

## Pediatric Gastrointestinal Disorders Related to High Altitude: Two Case Reports and A Review of the Literature

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### Abstract

Upon ascending above 2,500 meters above sea level, the human body undergoes a series of physiological changes, which have been studied during recent years. These changes affect various systems, including the gastrointestinal tract, with diverse clinical manifestations, most mild and therefore little reported and underdiagnosed. We present two pediatric patients who attended the Pediatric Gastroenterology, Hepatology, and Nutrition Unit (Gastronutriped) in Bogota, for whom we documented symptoms associated with high altitude that affected the gastrointestinal tract. With respect to these cases, a review of the available literature focusing on the physiology, clinical manifestations, and feasible treatment was carried out. The ultimate aim of this article is to alert health care professionals working in cities located at high altitudes to the possibility of considering this entity as a differential diagnosis in children from places with a lower altitude.

### Key words

Altitude sickness; Digestive signs and symptoms; Pediatrics

**Abbreviations:** Masl: Meters above sea level

### Introduction

More than 50 years ago, the physiological changes related to altitude were begun to be described [1]. Therefore, a branch of medicine was born that was dedicated to investigating, studying, and describing some alterations that occur upon ascending above 2,500 masl, among them, serious manifestations in the nervous system (cerebral edema) and in the respiratory system (pulmonary edema) [1, 2]. A great part of the work has been done in aeronautics and extreme sports [3]. In the same vein, in the decade of the 80's, gastrointestinal manifestations above 2,000 masl were observed and were added to the list. The aim of this article is to present two pediatric patients from cities with a lower altitude (320 masl), who came for a consultation to the pediatric gastroenterology and nutrition unit (Gastronutriped) in Bogota (2,500 masl) with gastrointestinal symptoms associated with the ascent, as evidence of this subject.

### Case 1:

Female patient, aged 3 years and 4 months, from Cucuta (320 masl), who came for a consultation to Gastronutriped in Bogota (2,600 masl) due to a history of 18 months of evolution with chronic abdominal pain and daily Bristol 3 depositions with anal pain. In her native city, she required hospitalization for faecal impaction. At the initial physical exam, the abdomen was found to be globular and tympanic, with presence of colonic stools, that is correlated with the marked distension of the loops and abundant faecal material that was seen in the simple X-ray of the abdomen. Her nutritional state was normal. Hypothyroidism was discounted through the laboratory exam results she brought with her. A diagnosis of chronic functional constipation

was confirmed, which required faecal desimpaction via the rectum with a phosphate enema, followed by maintenance with polyethylene glycol without electrolytes and nutritional guidance by the clinical nutritionist. In the follow-ups, therapeutic adherence was observed, with an improvement of depositions, and the abdominal pain disappeared, although the marked distension and decrease in height age percentiles was notable, so that tests of pancreatic faecal elastase, anti-transglutaminase antibodies, and faecal calprotectin were ordered, which returned normal results. The parents declared that the abdominal distension only occurred on arriving in Bogota ("in Cucuta her abdomen is flat"). This began suddenly and progressively 20 minutes after landing until it became very noticeable, was not accompanied by nausea nor vomiting, and persisted during her stay in Bogota. Upon returning to Cucuta, around 40 minutes after landing, the child began to experience a large degree of flatulence and with this the abdominal distension completely ceased. Independent of the control of the constipation, on each trip to Bogota the abdominal distension reappeared. Presently, the child is under control, with a good evolution and normal nutritional state.

### Case 2:

Male patient, 1 year and 9 months of age, from Cucuta, with a history of 9 months of consistent evolution of diarrhea alternating with normal depositions, colicky abdominal pain, and perianal erythema. He required two hospitalizations for diarrhea and dehydration, previous treatments with oral antibiotics, zinc sulfate, multi-strain probiotics, complete nutritional supplement, and lactose-free infant formula. He continued to experience symptoms and decreased growth rate in weight and height, for which reason they came for a consultation at Gastronutriped. At the physical examination, the patient was in good general condition, with a soft abdomen, without pain. Because of anthropometrics, secondary compensated chronic malnutrition was diagnosed. Important aspects of the clinical history are: colic, recurrent croup, and treatment with oxcarbazepine due to suspicion of convulsive episodes. Chronic diarrhea was diagnosed,

with initial treatment of suspension of juice (fructose), sucrose and lactose. Additionally, malabsorption studies were ordered. Faecal calprotectin, anti-transglutaminase antibodies, alfa-1-faecal antitrypsin, and faecal pancreatic elastase-1 were normal. The E specific immunoglobulins (ImmunoCAP specific IgE) and the skin prick test for frequent allergens were negative. Afterward, the parents discovered an increase in the symptoms with the consumption of dairy products and their derivatives, for which reason a diagnosis of allergic enteropathy was considered. A cow's milk restricted diet and an extensively hydrolyzed formula were prescribed, with an improvement of the diarrhea and the nutritional state. Nevertheless, the father said that 20 minutes after landing in Bogota, the child experienced intense colicky abdominal pain, pallor, sweating, and emesis, and adopted a fetal position with later lipothymia (syncopal episode) and abdominal distension. In a telephonic follow-up, the parents said that in all of their trips to or passing through Bogota and other cities above 2,000 masl, the child experienced similar symptoms of abdominal pain and lipothymia, which were interpreted as convulsions, for which reason he received oxcarbazepine. These symptoms were resolved upon descending to a lower altitude. Keeping in mind that the gastrointestinal symptoms appeared only in Bogota and other cities with an altitude greater than 2,000 masl, it was considered that the child suffered from gastrointestinal disorders associated with high altitudes. Presently, the patient is asymptomatic, with adequate growth and development, having overcome his food allergy, and he is not taking anticonvulsive medication.

## Discussion

During the last few centuries, the effects of altitude on the organism have been described. In 1783, the first manned hydrogen balloon ascended to 2,750 masl. During the journey, the pilot experienced a decrease in his temperature and an acute increase in ear pressure. Since then, multiple stories and studies have referred to different effects. In 1981, Auerbachy Miller reported a gastrointestinal syndrome called "HAFE" (high-altitude flatus expulsion) that consisted of an increase in the quantity, volume, and frequency of the expulsion of flatulence when they ascended to 3,350 masl, with spontaneous resolution of the symptoms upon descent. 2 On that basis, they postulated a theory that indicates that "when the atmospheric pressure decreases, the gas in the colon expands," an event that could be classified as a disorder associated with high altitude [2]. The atmosphere is composed of a variety of gases with a relatively uniform distribution up to an altitude of 21,000 meters. Nitrogen constitutes the greatest proportion (78.1%), followed by oxygen (20.9%), and in smaller percentages argon, carbon dioxide, hydrogen, neon and helium. The atmospheric or barometric pressure is the force or weight exercised by the gases at any point. The inverse relation that exists between the barometric pressure and the altitude can be seen. In order to understand the physiopathological phenomena that occur at high altitudes, it should be remembered that the volume of gas is inversely proportional to the pressure and directly proportional to the height. That is to say, the greater the height the lower the barometric pressure, an aspect that allows greater expansion of the gas. The relation between the altitude and the expansion of the gas can be seen. In accordance with this law, any closed body cavity (brain, stomach, intestines, middle ear, sinuses) subjected to height will run a greater risk of pneumothorax, pneumoencephalus, pneumointestine, and subcutaneous emphysema.

On the other hand, Dalton's law of partial pressure says that "as the altitude increases and the barometric pressure decreases", the total

pressure of the gases equals the sum of the partial pressures of each one, keeping in mind that the partial pressure for each gas depends on the number of moles. The greater the height, the less the quantity of oxygen; therefore, the delivery of oxygen to the tissues and the lungs is less for each breath, causing hypoxia. The greater volume of gas in the stomach, as a consequence of the changes in the barometric pressure, can cause abdominal pain (barogastralgia), as was seen in Case 2.

Under normal conditions, the stomach and the intestines contain approximately one fourth of the gas that exists in the whole organism. The expansion of the gas during ascent can cause discomfort, abdominal pain, belching, meteorism, nausea, vomiting, hyperventilation, and abdominal distension (described in the cases presented). When the distension is severe, it can cause venous obstruction and trigger fainting, coinciding with what was recounted in our second case, and which medically was confused with a convulsive crisis. For the same reason, barotitis media and externa, barosinusitis, and barodontalgia can be produced [1, 4]. The gastrointestinal symptoms most frequently associated with altitude are anorexia, nausea, and vomiting; they occur in up to 81% of patients with acute altitude sickness. The real incidence of these manifestations is unknown, because they are not reported and in the majority of the cases are not severe, nor are they life-threatening. Flatulence (present in case 1) and dyspepsia are the most frequent symptoms reported [3, 5]. Acute mountain sickness develops in minutes or in a few hours after arriving at a great altitude, and includes anorexia, nausea, vomiting, weakness, headache and malaise. The symptoms become more intense above 3,000 masl and affect men and women equally. There is evidence that children are more susceptible to suffering from it and have more severe manifestations at 2,500 masl and above, especially if the ascent is rapid [4]. The percentage of patients affected decreases considerably (from 75% to 25%) when the ascent is progressive, over two days or more, according to studies carried out in Chile and Nepal [5]. Therefore, it is recommended to avoid ascents of more than 500 masl daily. The changes in appetite are secondary to the alteration in the secretion of gastrointestinal hormones and the delay in gastric emptying. The stress of hypobaric hypoxia causes a greater release of leptin and colecistokine, as well as changes in the activity of the vagus nerve, which retard gastric cleaning, causing satiation and anorexia [6]. The reduction in the splanchnic flow, secondary to hypoxia, generates ischemia of the mucus, which can be aggravated by the dehydration that accompanies it on occasion, and produces dyspeptic symptoms [4,6,7].

When the height passes 4,000 masl, the lesion can cause petechial hemorrhaging, and even massive hemorrhaging, with hemodynamic compromise. The colicky abdominal pain and diarrhea that appear are usually attributed to bad environmental hygiene conditions in the places that are visited [7]. Nevertheless, the alteration in the microbiota concomitant with the changes in altitude and the secondary hypoxia are the object of research as the cause of these events. Studies on mice have shown a variation in the quantity and the relation between the species of the microbiota, with an increase of anaerobic and facultative anaerobic pathogens (*Escherichia coli*, *Clostridium*), and a decrease in aerobic species. This overpopulation of anaerobic species can lead to the excessive formation of gas, with flatulence, besides the potential risk of gastrointestinal infections [8].

Additionally, the fall in the atmospheric pressure and the hypoxemia induce microvascular dysfunction, with alteration of the cellular energetic pathways [9]. The mitochondrial function is affected and tissue dysoxia is produced (it diminishes the capacity for utilizing

oxygen). The available energy is depleted, with generation of free radicals and auto-oxidation. The excess of free radicals decreases the levels of antioxidants in the intestinal epithelium, leaving the lipid membranes unprotected and causing deterioration of the function of the mucus barrier [6,8].

This phenomenon coincides with that described in healthy Indian soldiers, in whom the aerobios/anaerobios relation of the microbiota was modified and the formation of gas increased from 3 ml/mg to 14.4 ml/mg. The concentrations of immunoglobulins (IgA and IgG) was raised significantly, an aspect that was considered secondary to the stimulation of the local immune system by bacterial overgrowth [7,8, 9].

Lastly, in individuals that live at great altitudes, gastrointestinal pathologies such as hemorrhoids, gastric cancer, malabsorption, steatorrhea, colelithiasis and portal thrombosis have been observed with increasing frequency. Although this topic goes beyond the motive of interest of the article.

## Conclusion

This manuscript constitutes the first report in Colombia with respect to the infantile gastrointestinal disorders associated with altitude. The gastrointestinal manifestations related to ascent can be more frequent than what is suspected, and therefore they are probably underdiagnosed. In Colombia and in other Latin American countries, there are cities located above 2,000 masl, among them Bogota. Trips to these destinations can become a predisposing factor for these disorders for natives and foreigners who come from cities with lower altitudes (500 masl). Children seem to be more susceptible to changes in altitude and pressure.

Therefore, health professionals dedicated to pediatrics should keep this phenomenon in mind as a differential diagnosis. Although these symptoms are not a reason for serious changes, in some patients, as the

in the second case described, the clinical symptoms are severe and can be confused with other pathologies. More studies are needed in order to identify the predisposing factors for these disorders, as well as with respect to the use of probiotics in their treatment and/or prevention.

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## References

1. Blumen IJ, Rinnert KJ (1995) Altitude physiology and the stresses of flight. *Air Med J* 14: 87-100.
2. Auerbach P, Miller YE (1981) High Altitude Flatus Expulsion (HAFE). *West J Med* 134: 173-174.
3. Anand AC, Sashindran VK, Mohan L (2006) Gastrointestinal problems at high altitude. *Trop Gastroenterol* 27: 147-153.
4. Moraga FA, Osorio JD, Vargas ME (2002) Acute mountain sickness in tourists with children at Lake Chungará (4400 m) in northern Chile. *Wilderness Environ Med* 13: 31-35.
5. Pradhan S, Yadav S, Neupane P, Subedi P (2009) Acute mountain sickness in children at 4380 meters in the Himalayas. *Wilderness Environ Med* 20: 359-363.
6. Angert D, Schaff EA (2010) Preventing injuries and illnesses in the wilderness. *Pediatr Clin North Am* 57: 683-695.
7. Shaw MT, Harding E, Leggat PA (2014) Illness and injury to students on a school excursion to Peru. *J Travel Med* 21: 183-188.
8. Adak A, Maity C, Ghosh K, Mondal KC (2014) Alteration of predominant gastrointestinal flora and oxidative damage of large intestine under simulated hypobaric hypoxia. *Z Gastroenterol* 52: 180-186.
9. Adak A, Maity C, Ghosh K, Pati BR, Mondal KC (2013) Dynamics of predominant microbiota in the human gastrointestinal tract and change in luminal enzymes and immunoglobulin profile during high-altitude adaptation. *Folia Microbiol (Praha)* 58: 523-528.