

# La montagne çà vous gagne ou pas !

*Dr Marie COUDURIER*

**J20**

**Chambéry**  
Centre de Congrès  
Le Manège  
28 et 29  
septembre 2023





# Maladaptations à l'altitude



dans nos Montagnes  
Et pour nos patients

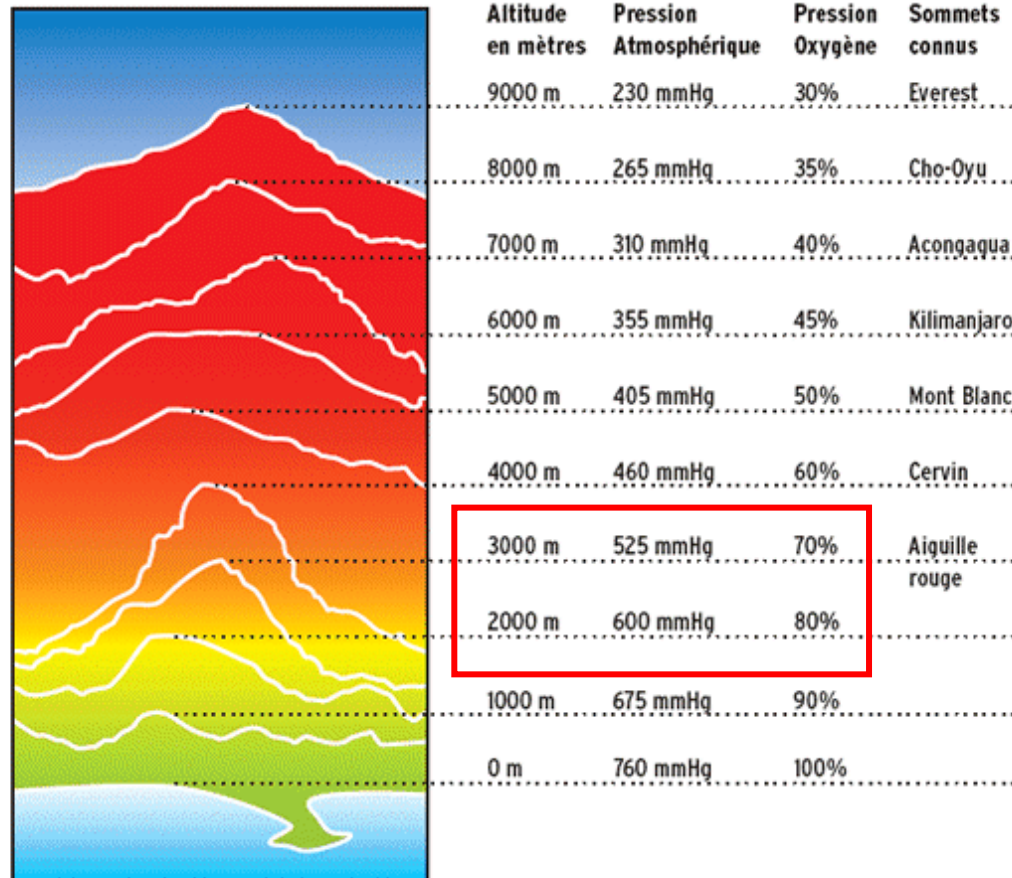
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- Altitude : adaptations physiologiques
- Mal adaptations à l'altitude
  - MAM Mal Aigu des Montagnes
  - OPHA Œdème Pulmonaire de Haute Altitude
  - OCHA Œdème Cérébral de Haute Altitude
- MAM et OPHA en moyenne montagne
- Patients pneumologiques et altitude

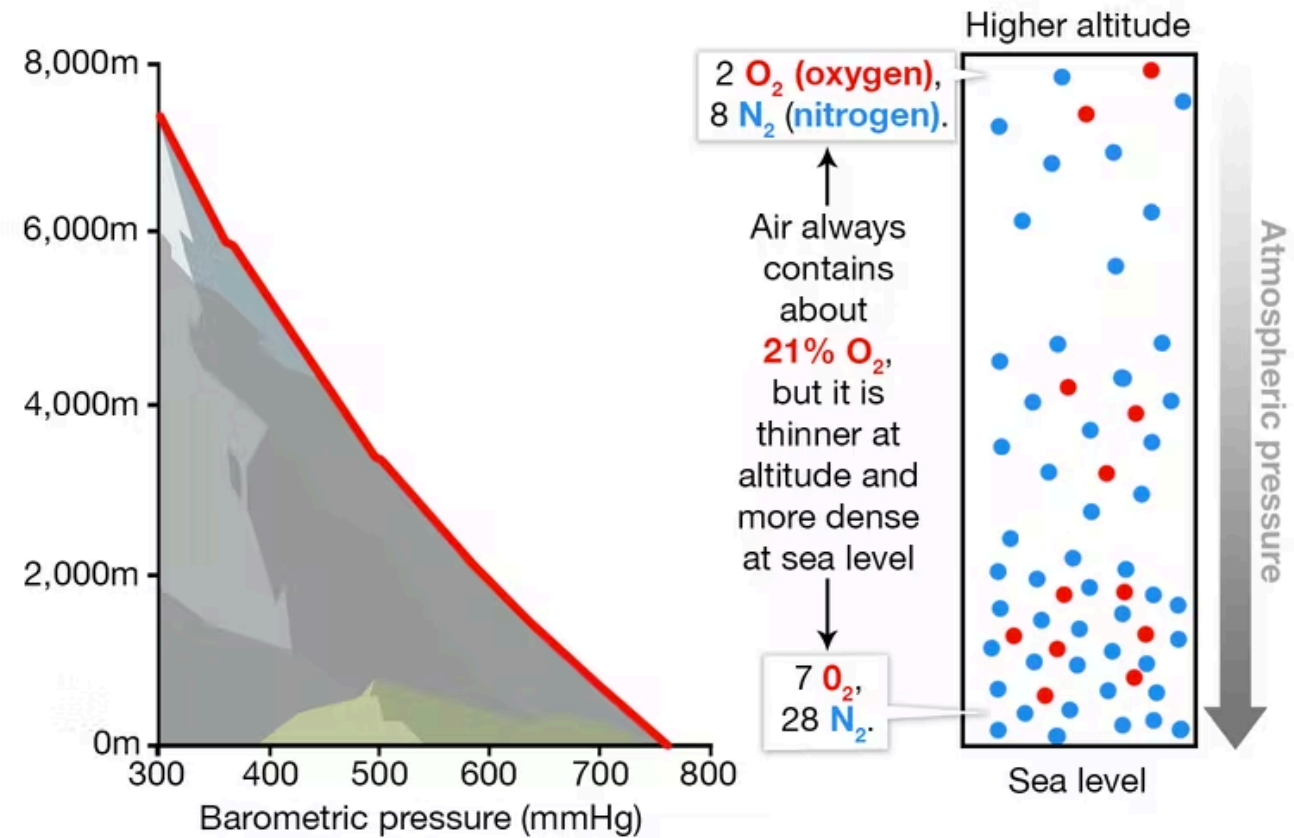


# Altitude = Hypoxie Hypobare

## TABLEAU DE PRESSION EN ALTITUDE



## The impact of altitude on oxygen levels





# Physiologie adaptative à l'hypoxie

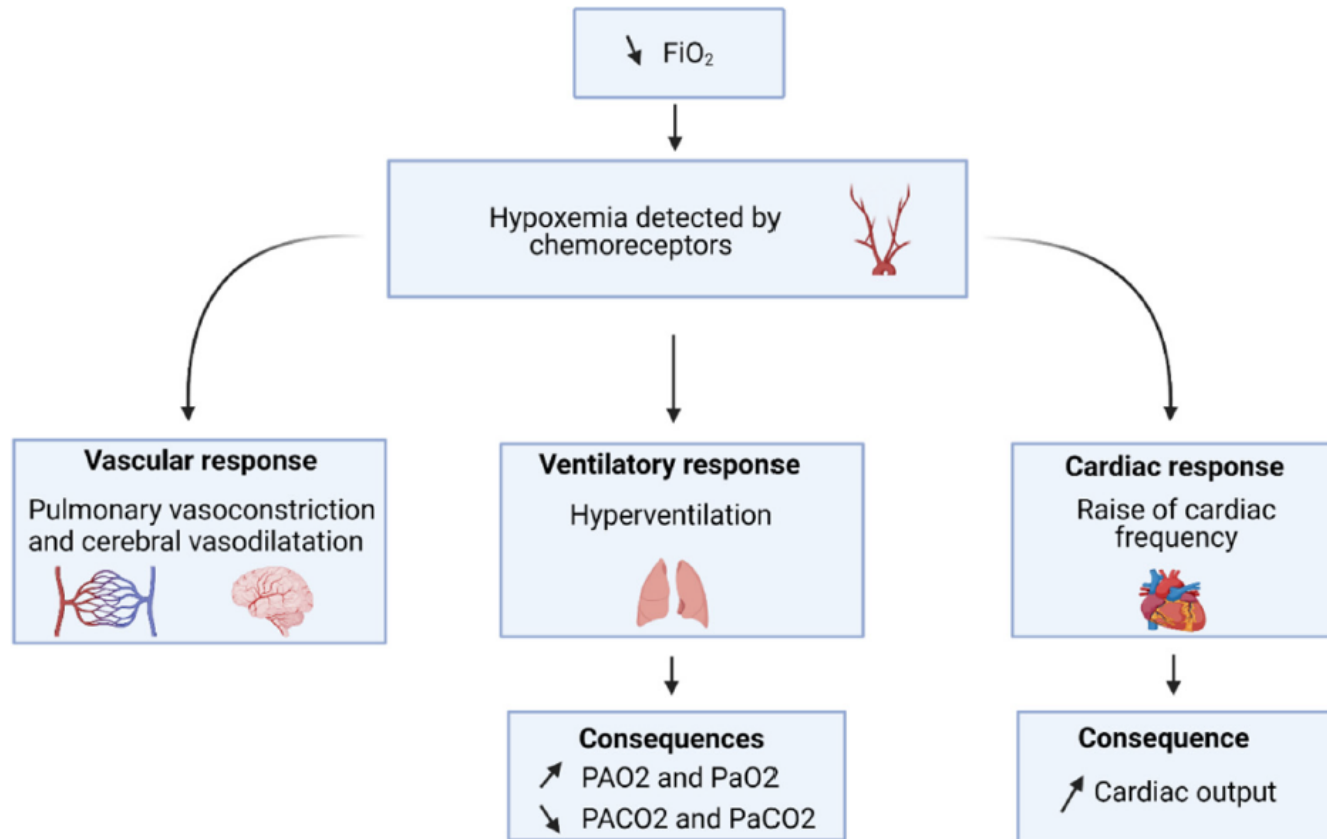


Figure 1. Cardio-circulatory and respiratory systems initial response to hypoxia.

Review

## Effects of Altitude on Chronic Obstructive Pulmonary Disease Patients: Risks and Care

Thomas Georges <sup>1</sup>, Camille Le Blanc <sup>1</sup> , Sophie Ferreol <sup>1</sup>, Pierre Menu <sup>1,2,3,4</sup>, Marc Dauty <sup>1,2,3,4</sup>† and Alban Fouasson-Chailloux <sup>1,2,3,4,\*</sup>

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- † These authors contributed equally to the manuscript.

**Abstract** Air travel and altitude stays have become increasingly frequent within the overall population but also in patients suffering from chronic obstructive pulmonary disease (COPD), which is the most common respiratory disease worldwide. While altitude is well tolerated by most individuals, COPD patients are exposed to some serious complications, that could be life-threatening. COPD patients present not only a respiratory illness but also frequent comorbidities. Beyond oxygen desaturation, it also affects respiratory mechanics, and those patients are at high risk to decompensate a cardiac condition, pulmonary hypertension, or a sleep disorder. Recently, there has been considerable progress in the management of this disease. Nocturnal oxygen therapy, inhaled medications, corticosteroids, inspiratory muscle training, and pulmonary rehabilitation are practical tools that must be developed in the comprehensive care of those patients so as to enable them to afford altitude stays.



Citation: Georges, T.; Le Blanc, C.; Ferreol, S.; Menu, P.; Dauty, M.; Fouasson-Chailloux, A.

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# Pathologies liées à l'altitude

- Dans les 5°jours
- Altitude > 2500m
- **Mal aigu des montagnes**
  - Céphalées, fatigue, nausées
  - Généralement après la 1° nuit
  - Prévalence 40-90% à 4500-6000m
  - chez des sujets non acclimatés
  - avec des ascensions de + 500m par jour



SERIES  
SPORTS-RELATED LUNG DISEASE

## Acute high-altitude sickness

Andrew M. Luks<sup>1</sup>, Erik R. Swenson<sup>1,2</sup> and Peter Bärtsch<sup>3</sup>

Number 5 in the Series "Sports-related lung disease"  
Edited by Yochai Adir and Alfred A. Bove

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# Epidémiologie MAM

- FRD mineur
  - Faible réponse ventilatoire à l'hypoxie
  - Obésité (hypoventilation diurne/nocturne)
  - Migraine
- Pas de différence homme/femme
- Plus de risque chez les sujets jeunes adultes que 40-60 ans
- Rôle controversé de l'activité physique

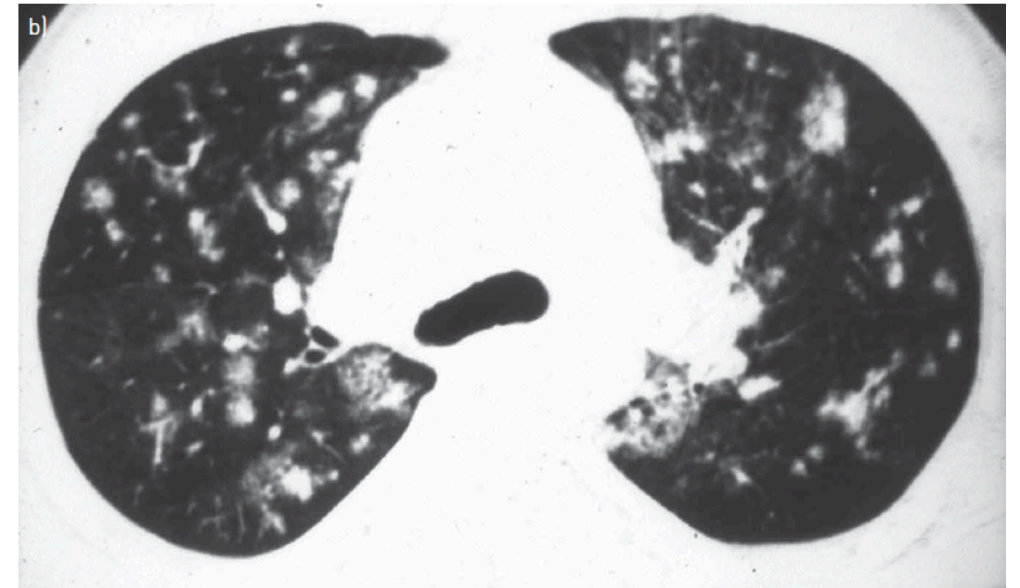
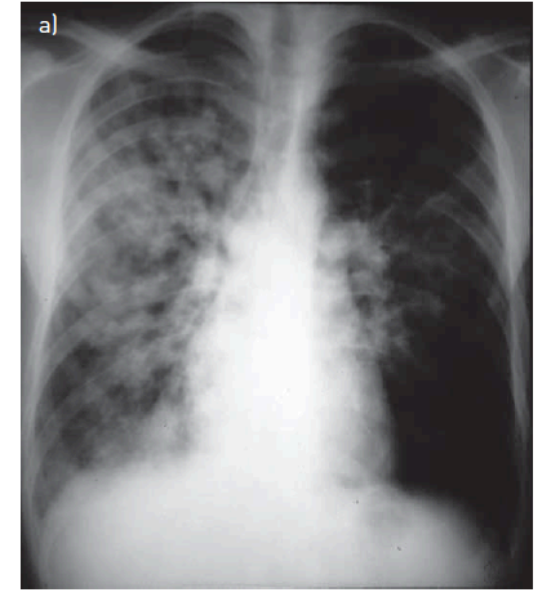
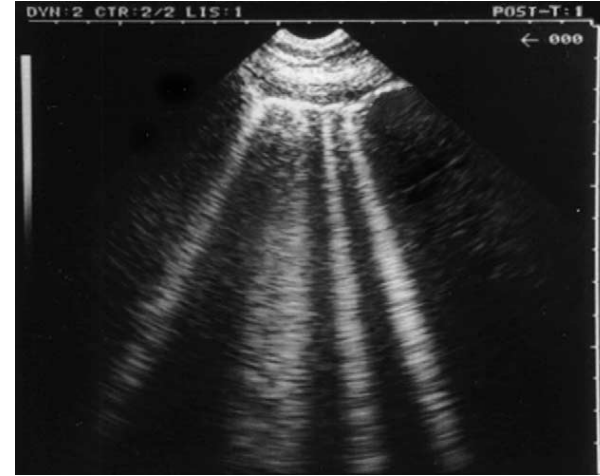


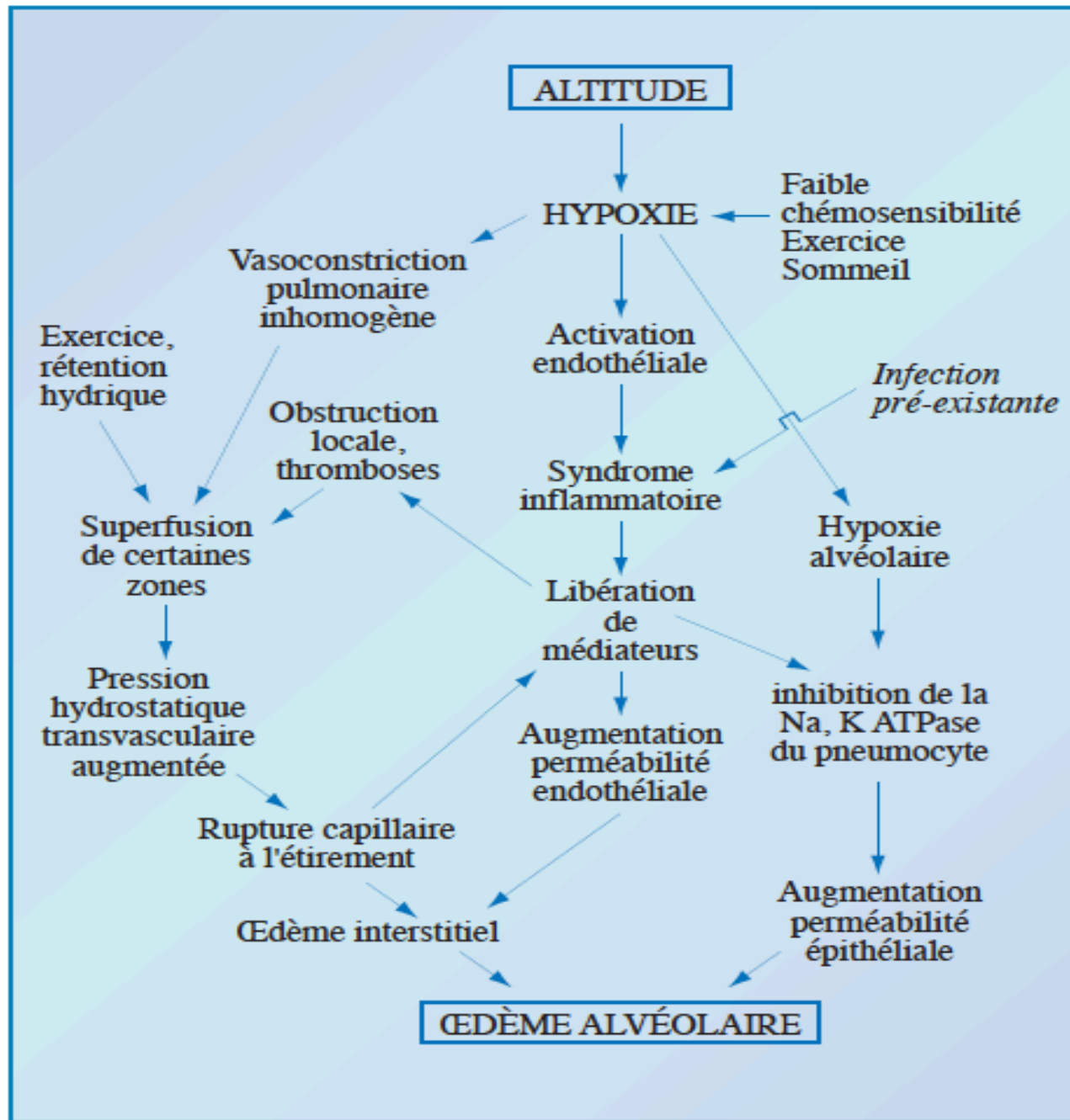


# Pathologies liées à l'altitude

- **Œdème pulmonaire d'altitude**

- Dyspnée, toux, baisse performance ...
- Œdème pulmonaire non cardiogénique
- **Secondaire vasoconstriction artérielle pulmonaire hypoxique excessive**
- Apparaît généralement > 2500-3000m
- Sujets sains, jeunes
- Généralement précédé par symptômes de MAM





## Poumon et altitude

La Lettre du Pneumologue - n° 1 - octobre 1998

J.P. Richalet\*

Figure 2. Physiopathologie de l'OPHA.



TABLE 1 Arterial blood gas analysis at 4559 m

	Subjects	$P_{aO_2}$ mmHg	$P_{aCO_2}$ mmHg	$P_{A-aO_2}$ mmHg
No AMS	14	39.6±4.5	30.0±3.6	7.9±3.7
Mild AMS	19	37.6±4.3	30.7±4.0	9.3±4.3
Moderate-severe AMS	10	33.9±4.0*	31.1±2.8	12.5±4.5*
HAPE	4	23.2±3.3***	28.4±3.5	26.0±2.9***

Analysis of arterial blood obtained from a femoral artery a few hours after arrival at the Margherita hut (Monte Rosa, Italy) in subjects with no acute mountain sickness (AMS), mild AMS (score 2–3 points according to HACKETT *et al.* [103]), moderate-to-severe AMS (>3 points) or high-altitude pulmonary oedema (HAPE) (verified using chest radiography).  $P_{aO_2}$ : arterial oxygen tension;  $P_{aCO_2}$ : arterial carbon dioxide tension;  $P_{A-aO_2}$ : alveolar-arterial oxygen tension difference. \*:  $p < 0.05$ , compared with mild and no AMS; \*\*\*:  $p < 0.001$ , compared with all groups. Data from [32].

Swenson ER, Bärtsch P. High-altitude pulmonary edema. *Compr Physiol* 2012; 2: 2753–2773.

- 4559 m
  - $P_{aO_2}$  entre 35 - 45 mmHg dans le groupe sain
  - Contre 20 mmHg chez les OPHA +
  - Sat O<sub>2</sub> 70-85% contre < 50%

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# Evolutions de la Montagne

- Pratique de la montagne largement répandue
- Les personnes avec co morbidités pratiquent les sports de montagnes, ou séjournent en station de ski
  - Tignes/Val d'isere 1550m – 3456 m
    - Hôtels à Val Claret 2300m
  - Alpes d'Huez 1125m- 3330m
  - Les Arcs 1200-3226m

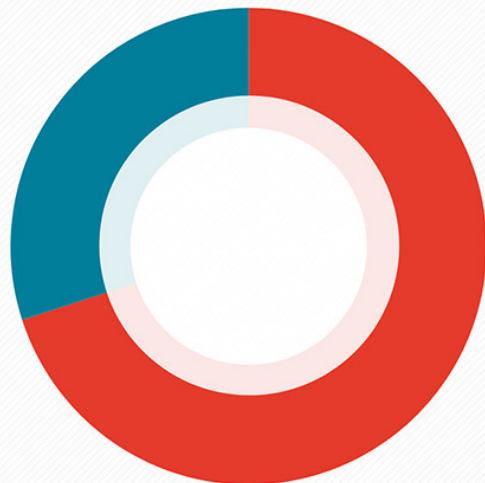




# Fréquentations

30%

de clients étrangers



10 Millions

de personnes fréquentent nos stations

13 %  
des Français déclarent faire du ski

7ème sport le plus pratiqué

derrière le vélo, la natation, la randonnée, le running, les jeux de boules et le foot



59 %



79 %

Activité Principale

# Journées skieurs vendues saison 2017/2018



54,5 millions



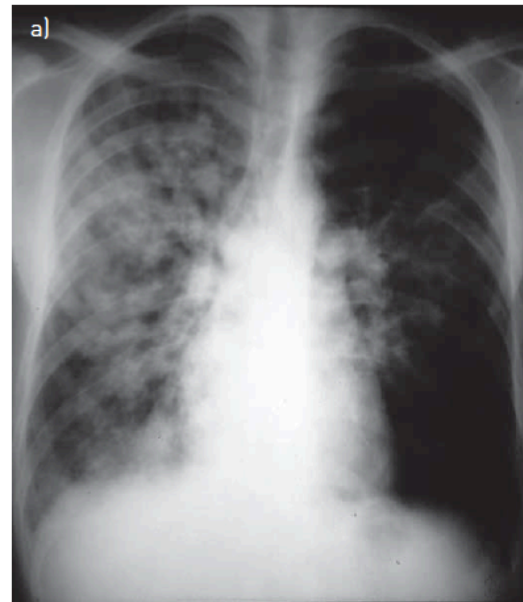
53,8 millions + 5,3%



53,3 millions

# Constations de terrain

- Chaque année en hiver, admission de skieurs avec tableau d'œdème pulmonaire cédant rapidement aux urgences, et/ou service de pneumologie / cardiologie





J1



LILLE





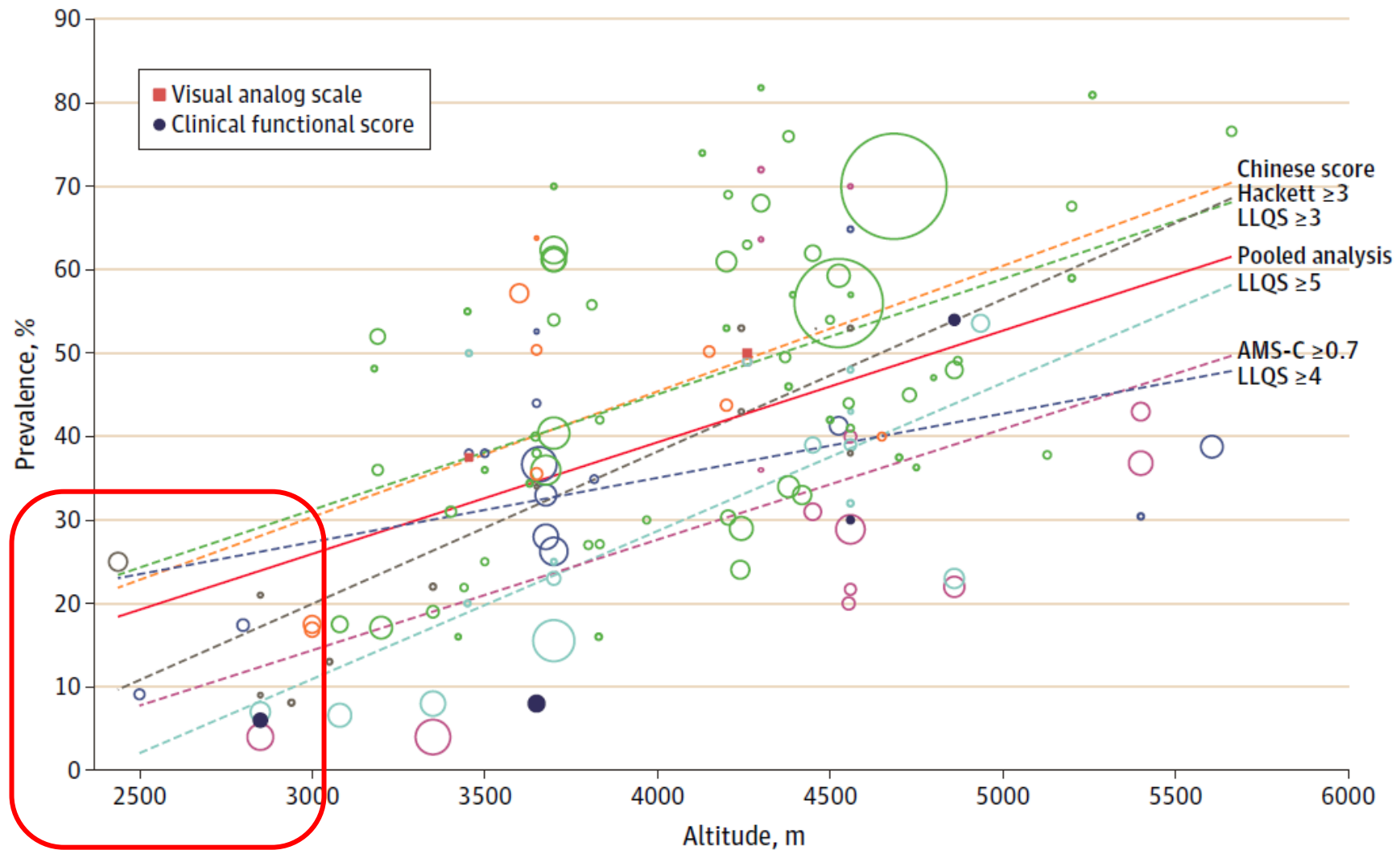
J2

MAM ou pas MAM ?



La Plagne

Figure. Random-Effects Meta-Regression of Prevalence of Acute Mountain Sickness According to Altitude



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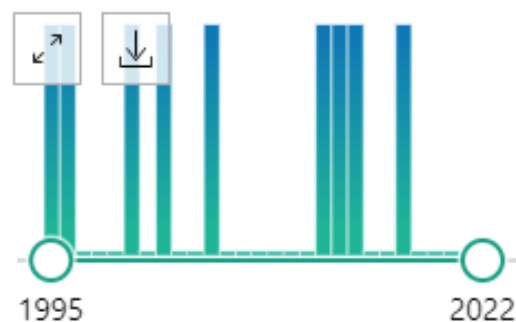
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Page 1 of 1

RESULTS BY YEAR



TEXT AVAILABILITY

Abstract

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Sea-level physical activity and **acute mountain sickness** at **moderate altitude**.

1 Honigman B, Read M, Lezotte D, Roach RC.

Cite West J Med. 1995 Aug;163(2):117-21.

Share PMID: 7571557 **Free PMC article.**

High **altitude** headache and **acute mountain sickness** at **moderate** elevations in a military population during battalion-level training exercises.

2 Norris JN, Viirre E, Aralis H, Sracic MK, Thomas D, Gertsch JH.

Cite Mil Med. 2012 Aug;177(8):917-23. doi: 10.7205/milmed-d-12-00007.

Share PMID: 22934370



# MAM de nos Montagnes



Val d'Isère

**alpe\*huez**



**LES ARCS**  
Paradiski

 **COURCHEVEL**  
1850

# Honigman 1993 Annals of Internal Medicine

## Acute Mountain Sickness in a General Tourist Population at Moderate Altitudes

Benjamin Honigman, MD; Mary Kay Theis, MA; Jane Koziol-McLain, RN, MS; Robert Roach, MS; Ray Yip, MD, PhD; Charles Houston, MD; and Lorna G. Moore, PhD

■ **Objective:** To determine the incidence of acute mountain sickness in a general population of visitors to moderate elevations, the characteristics associated with it, and its effect on physical activity.

■ **Design:** A cross-sectional study.

■ **Setting:** Resort communities located at 6300 to 9700 feet elevation in the Rocky Mountains of Colorado.

■ **Participants:** Convenience sample of 3158 adult travelers, 16 to 87 years old (mean age  $\pm$  SD),  $43.8 \pm 11.8$  years).

■ **Results:** Twenty-five percent of the travelers to moderate elevations developed acute mountain sickness, which occurred in 65% of travelers within the first 12 hours of arrival. Fifty-six percent of those with symptoms reduced their physical activity. The odds favoring acute mountain sickness were 3.5 times as large for visitors whose permanent residence was below 3000 feet elevation as for those whose residence was above 3000 feet; 2.8 times as large for visitors with previous symptoms of acute mountain sickness; and twice as large in travelers younger than 50 years. Women, obese persons, those in poor or average physical condition, and those with underlying lung disease also had a higher occurrence of acute mountain sickness ( $P < 0.05$ ).

■ **Conclusions:** Acute mountain sickness occurs in 25% of visitors to moderate altitudes and affects activity in most symptomatic visitors. Persons who are younger, less physically fit, live at sea level, have a history of acute mountain sickness, or have underlying lung problems more often develop these symptoms.

Rapid ascent from low to high altitude is often followed by headache, fatigue, shortness of breath, sleeplessness, and anorexia, a symptom complex called acute mountain sickness. Although some of these symptoms may occur as a result of travel not associated with altitude, only 5% of adults traveling at sea level report similar symptoms (1). A long-standing interest has existed in the study of acute mountain sickness because it affects a large number of mountain visitors (2-4) and can progress to the life-threatening conditions of high-altitude pulmonary edema or high-altitude cerebral edema (5). Previous estimates of the incidence of acute mountain sickness have been obtained primarily from small groups of physically fit young men going to altitudes above 12 000 feet (2-4, 7-9). Little information exists on the frequency and severity of the disorder in the general population at moderate altitudes, yet the population at risk is large. For example, more than 13 million persons visited the Colorado mountains in 1990 for business, conferences, or recreational activities including skiing, climbing, hiking, hunting, and fishing (10).

More needs to be learned about the incidence of acute mountain sickness at moderate altitudes in the general population and about the characteristics of those most likely to be at risk for symptom development. We therefore surveyed groups of persons visiting resorts in the Colorado mountains for conferences and seminars. Specifically, we sought to determine 1) the incidence of acute mountain sickness in visitors exposed to moderate elevations; 2) the effect of acute mountain sickness on physical activity; and 3) the visitor characteristics associated with the development of acute mountain sickness. This information would be useful for developing strategies to minimize symptoms in travelers to moderate altitudes.

### Methods

The study cohort consisted of 4212 adults attending 45 conferences at resorts located at elevations of 6300 to 9700 feet in the Rocky Mountains of Colorado from July 1989 to May 1991. Resorts were chosen on the basis of the willingness of conference organizers to participate. Conferences whose schedules required all participants to attend a meeting within 48 hours of arrival when the study questionnaire could be distributed were included. Study personnel attended these meetings, briefly introduced the study, and distributed the questionnaires. Questions by participants concerning acute mountain sickness or the effects of altitude on health were not answered until all questionnaires were collected. Completion of the survey usually took less than 10 minutes. The participants in each meeting were counted to calculate the response rate.

The questionnaire was completed by 3158 (75%) of the persons registered for these conferences, and information satisfactory for analysis was obtained from 99% of those completed. Visitors ranged in age from 16 to 87 years (mean age  $\pm$  SD),

*Annals of Internal Medicine.* 1993;118:587-592.

From Colorado Altitude Research Institute, Keystone, Colorado; University of Colorado Health Sciences Center and University of Colorado Department of Anthropology, Denver, Colorado; Lovelace Medical Foundation, Albuquerque, New Mexico; and the Centers for Disease Control, Atlanta, Georgia. For current author addresses, see end of text.

- 3158 voyageurs participants à des conférences
  - Colorado Rocky Mountain
  - 2000-3000m
- 25% des sujets présenteront un MAM
  - dans 65% des cas le MAM survient dans les 12<sup>h</sup> heures
  - 44% des sujets ne réduisent pas leurs activités physiques
- 2,8 plus de risque de MAM
  - si ATCD de MAM
- 3,5 plus de risque de MAM
  - si résidence < 900m
- Mais aussi
  - Femmes, obèses, maladies respiratoires chroniques

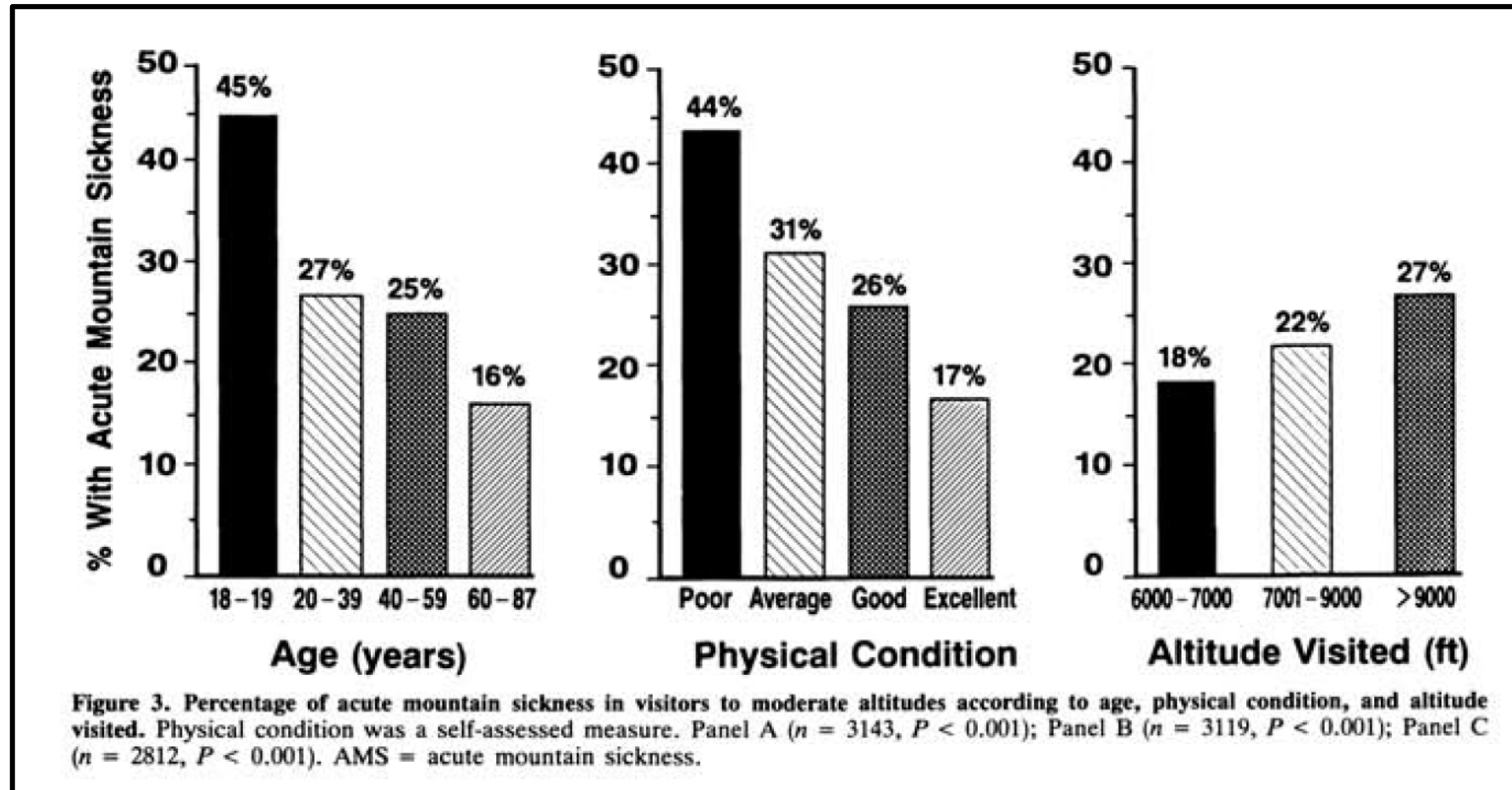
# Honigman 1993 Annals of Internal Medicine

**Table 1. Characteristics and Incidence of Acute Mountain Sickness in Visitors to Areas of Moderate Altitude\***

Characteristics	Total	Acute Mountain Sickness	<i>P</i> Value
	<i>n</i>	<i>n</i> (%)	
Gender ( <i>n</i> = 3140)			
Male	2159	510 (23.6)	0.01
Female	981	274 (27.9)	
Residence ( <i>n</i> = 3108)			
Sea level	2774	750 (27.0)	<0.001
>3000 feet	334	28 (8.4)	
Season ( <i>n</i> = 3129)			
Winter	2603	636 (24.4)	0.049
Nonwinter	526	150 (28.5)	
Stop over ( <i>n</i> = 2035)†			
Yes	565	127 (22.5)	<0.02
No	1470	405 (27.5)	



# Honigman 1993 Annals of Internal Medicine



6000-7000 feet = 1800-2100m

7000-9000 = 2100-2700

# Montgomery JAMA 1989

## Brief Reports

### Incidence of Acute Mountain Sickness at Intermediate Altitude

A. Bruce Montgomery, MD; John Mills, MD; John M. Luce, MD

The incidence of acute mountain sickness was determined by questionnaire in 454 individuals who attended week-long continuing medical education programs at ski resorts in the Rocky Mountains with base elevations of about 2000 m. As a control group, 96 individuals who attended continuing medical education programs at sea level in San Francisco completed similar questionnaires. Study subjects were classified as having acute mountain sickness when they reported three or more of the five possible cardinal symptoms: headache, insomnia, dyspnea, anorexia, and fatigue. Only symptoms with an intensity of at least grade 2 (moderate) out of 5 were analyzed. Acute mountain sickness-like symptoms occurred in 25% of subjects at 2000 m compared with 5% of subjects at sea level. The incidence of acute mountain sickness at 2000 m was greatest among subjects who had come from lower altitudes. Half of the subjects with symptoms took medication. The duration of symptoms was short, with 90% of all symptoms that were reported occurring in the first 72 hours. Acute mountain sickness is common at intermediate altitudes, and it is frequently severe enough to prompt self-medication.

(JAMA 1989;261:732-734)

ACUTE mountain sickness (AMS) is a syndrome of headache, insomnia, dyspnea, anorexia, and fatigue that has been described in many persons who

See also p 734.

ascend rapidly to high altitudes.<sup>1,4</sup> Although anecdotal reports suggest that AMS does occur among sojourners to intermediate elevations between 2000 and 4000 m, there are no studies regarding the incidence of AMS at these altitudes. We had an opportunity to compare the incidence and severity of symptoms attributed to AMS among individuals who attended continuing medical education programs at Rocky Mountain ski resorts and at sea level in San Francisco. The results of our investigation form the basis of this report.

From the Medical Service, San Francisco General Hospital Medical Center, and the Department of Medicine, University of California at San Francisco. Dr. Montgomery is now with the State University of New York at Stony Brook.

Reprint requests to the Department of Medicine, Health Services Center, T17-040, State University of New York at Stony Brook, Stony Brook, NY 11794 (Dr. Montgomery).

#### Subjects and Methods

The subjects for the altitude group were recruited from physicians and other health professionals who attended continuing medical education programs at Steamboat Springs, Colo (base elevation, 2100 m), and Park City, Utah (base elevation, 2090 m), during January and February 1985. Both programs had a five- or six-day schedule of four hours of lectures per day; during the remaining time, most participants performed moderately vigorous exercise in the form of Alpine or Nordic skiing. Virtually all participants arrived at the resort during the day before the program began, in most cases, either by air or by ground transportation from the airports in Denver or Salt Lake City, and stayed at the base altitude of the ski area at night for the duration of the programs. All individuals who attended the courses were asked to participate in this study and those who accepted were asked to complete a questionnaire.

On the last day of classes and skiing, study subjects were asked their birth date, their time of arrival at the ski area, and the altitude of their usual residence. They were asked to describe

whether they had headache, insomnia, dyspnea, anorexia, or fatigue and on what day(s) these symptoms occurred; they were also asked to estimate the severity of these symptoms using an ordinal scale of 0 (none) to 5 (extreme). The subjects were not asked their sex or their level of exertion, although these factors may be important in AMS. Their average alcohol consumption was quantified by five possible selections: 0 mL (0 fl oz), less than 30 mL (1 fl oz), 30 to 60 mL (1 to 2 fl oz), 90 to 120 mL (3 to 4 fl oz), and more than 120 mL (4 fl oz) each day. In addition, the subjects were asked if they took medications for their symptoms, whether they were pregnant, whether they had any coexistent illnesses, such as upper respiratory tract infections or gastroenteritis, and whether they had menstrual symptoms. Study subjects were classified as having AMS when they reported three or more of the five possible symptoms with an intensity of at least grade 2 (moderate) on a single day.

The sea-level control group consisted of physicians and other health professionals who came from outside California, in all cases by air, to attend one of three week-long continuing medical education courses at San Francisco (altitude, 30 m) in the spring of 1987. These subjects also were asked to fill out an identical questionnaire during the last day of the programs.

This study was approved by the Committee on Human Research, University of California, San Francisco. Consent was inferred by the voluntary return of the questionnaires. Statistical analysis was done by  $\chi^2$  test, Fisher's exact test, Student's *t* test, or analysis of variance as noted. We accepted a *P* value of less than .05 as indicating statistical significance.

#### Results

Questionnaires excluded from analysis included questionnaires with greater than 10% of the data missing, question-

- Questionnaire donné 454 sujets
  - en séminaire 2000m Colorado
- Contre 96 sujets
  - séminaire 30m San Francisco
- MAM
  - chez **25%** des sujets 2000m
  - contre 5% à 30m
- D'autant plus que les sujets vivaient en plaine
- **90%** des symptômes apparaissent **72°h**

# Œdème Pulmonaire de Haute Altitude OPHA de nos Montagnes



Val d'Isère



alpe\*huez



LES ARCS  
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# A. Gabry X.Ledoux M.Mozziccinaco C.Martin Chest 2003

- *OPHA < 2500m est classiquement considéré comme rare*
  - *mais probablement sous estimée en moyenne altitude*
- 52 patients admis pour OPHA
  - Séjour en altitude ski 1400-2400m
  - 1992-2000
  - Hôpital Moutiers 500m
  - Critères cliniques et radiologiques d'œdème pulmonaire
  - ETT à chaque patient, infections pulmonaires et EA BPCO écartées

## High-Altitude Pulmonary Edema at Moderate Altitude (< 2,400 m; 7,870 feet)\*

### A Series of 52 Patients

André Louis Gabry, MD; Xavier Ledoux, MD; Monique Mozziconacci, MD; and Claude Martin, MD, FCCP

**Study objectives:** To describe a group of patients who acquired pulmonary edema at a moderate altitude of 1,400 to 2,400 m.

**Design:** Observational, retrospective chart review (1992-2000) of a series of 52 consecutive patients admitted for high-altitude pulmonary edema (HAPE) that occurred at 1,400 to 2,400 m.

**Setting:** Emergency department of a community hospital in the French Alps (altitude, 500 m).

**Patients:** Vacationing skiers who met criteria for altitude-related pulmonary edema, and in whom other causes (infectious, cardiogenic, neurogenic, and toxic) were excluded.

**Measurements and results:** All patients presented with signs of pulmonary edema. Diagnoses of infectious, cardiogenic, neurogenic, or toxic edema were ruled out in each patient. All patients were hypoxemic and had radiographic signs of pulmonary edema. Virtually all patients (96%) had dyspnea, and most (77%) had moist rales. All patients were treated with supplemental oxygen (3 to 12 L/min), bed rest, moderate fluid restriction, and continuous positive airway pressure. All recovered fully and were discharged after  $4 \pm 2$  days (mean  $\pm$  SD).

**Conclusion:** This study suggests that HAPE at moderate altitudes is more frequent than usually reported. Patients are likely to be young, vacationing men, with no history of prior disease. The disease has a favorable prognosis, and requires simple treatment and a short hospital stay.

(CHEST 2003; 123:49-53)

**Key words:** acute mountain sickness; high-altitude illness; high-altitude pulmonary edema; pulmonary edema

**Abbreviation:** HAPE = high-altitude pulmonary edema

High-altitude pulmonary edema (HAPE) is a life-threatening condition that occurs in persons who ascend rapidly to heights of > 2,500 to 3,000 m.<sup>1-9</sup> HAPE refers to the pulmonary abnormalities of high-altitude illness, while acute mountain sickness and high-altitude cerebral edema refer to the cerebral abnormalities.<sup>4</sup> The occurrence of pulmonary edema at moderate altitude is very uncommon but is probably underestimated.<sup>2,3,7</sup> We report a series of 52 patients admitted for HAPE

occurring at moderate altitude (1,400 to 2,400 m) over a 9-year period in a community hospital in the French Alps.

#### MATERIALS AND METHODS

During the 9-year study period (1992-2000), 11,420 patients were admitted to the emergency department of Moutiers Hospital (altitude, 500 m), and 52 patients presented with HAPE. Patients' charts were extracted from the database of the emergency department after authorization from the Patient Chart

For editorial comment see page 5

\*From the Emergency Department (Dr. Gabry) and Department of Anesthesia and Intensive Care (Dr. Ledoux), Hôpital de Moutiers, Moutiers; and Department of Anesthesia and Intensive Care (Drs. Mozziconacci and Martin), Hôpital Nord, Marseille University Hospital System, Marseille School of Medicine, Marseille, France.

Manuscript received November 13, 2000; revision accepted June 3, 2002.

Correspondence to: Claude Martin, MD, FCCP, Hôpital Nord, 13915 Marseille cedex 20, France; e-mail: cmartin@ap-hm.fr

Review Board. All patients were on vacation in different ski resorts around Moutiers. Diagnosis of HAPE was suspected on the following criteria: tachypnea, dyspnea, cough, cyanosis, moist rales (unilateral or bilateral), decreased PaO<sub>2</sub> and arterial oxygen saturation (with normal or low PaCO<sub>2</sub>), and pulmonary infiltrate (unilateral or bilateral) on the chest radiograph.<sup>8</sup> In all patients, the diagnoses of infectious, cardiogenic, neurogenic, or toxic edema were ruled out on the following criteria: no signs of infection, negative blood culture results (drawn in each patient),

# A. Gabry Chest 2003

**Table 1—Clinical Characteristics of the 52 Patients\***

Characteristics	Data
Age, yr	37 ± 14 (13–72)
Female/male sex, No.	8/44
Body weight, kg	75 ± 16 (37–93)
Height, cm	175 ± 17 (154–187)
Arrival to onset of symptoms, d	1.7 ± 1.5 (12 h–5 d)
Onset of symptoms to hospital admission, d	1.8 ± 2.1 (3 h–5 d)
Maximal altitude, m	2,303 (1,400–2,400)
Sleeping altitude, m	1,300 (900–1,800)

\*Data are presented as mean ± SD (range) unless otherwise indicated.

**Table 3—Hultgren Stages of Radiographic Infiltrates**

Stages	Pulmonary Exudates	Patients, No.
I	Minor, less than half of one lung field	2
II	At least half of one field	7
III	Bilateral, at least half of each field	15
IV	Bilateral, over half of each field	28

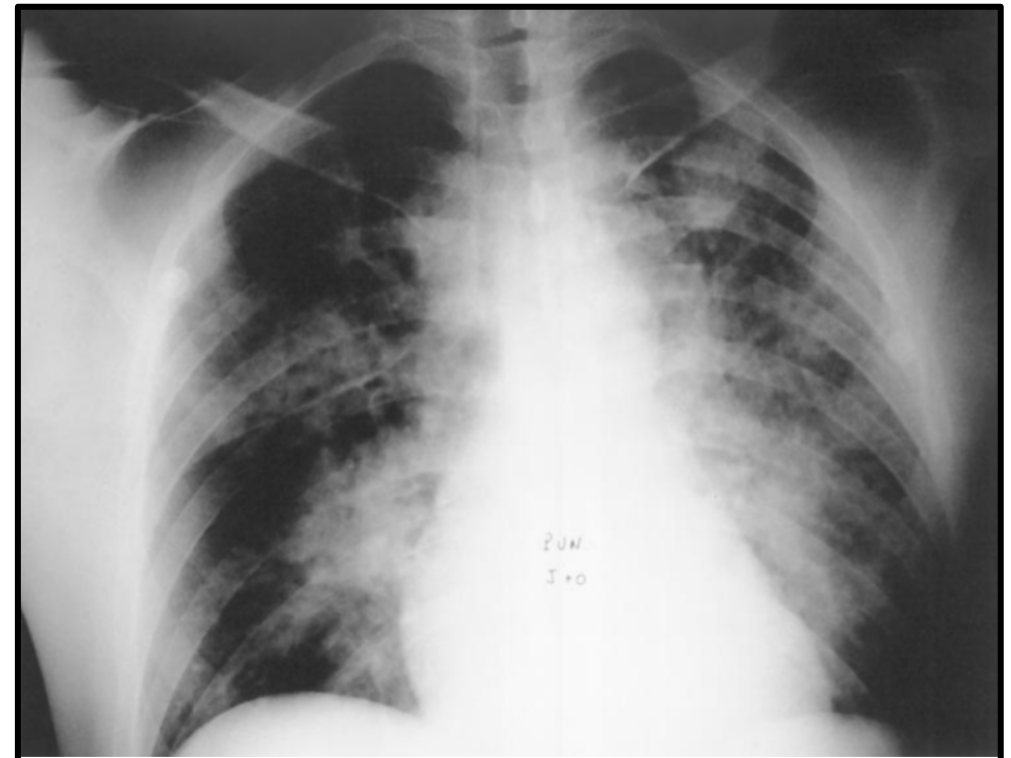


FIGURE 1. Chest radiograph of a patient with HAPE (Hultgren stage IV) that occurred at moderate altitude (maximum altitude reached, 2,200 m).

**Table 4—Arterial Blood Gas Levels Obtained at Room Air\***

Variables	Day 1	Day 2	Day 3
PaO <sub>2</sub> , mm Hg	52 ± 18 (49–74)	65 ± 13† (53–93)	75 ± 12† (59–98)
SaO <sub>2</sub> , %	82 ± 13 (73–90)	90 ± 9† (79–96)	94 ± 11† (88–98)
Paco <sub>2</sub> , mm Hg	34 ± 4 (29–37)	35 ± 3 (30–38)	37 ± 2 (34–41)
pH	7.44	7.43	7.42



# A. Gabry Chest 2003

- Traitement : descente, repos, restriction hydrique, O<sub>2</sub>tttie, CPAP 5-10cm H<sub>2</sub>O, **parfois Nicardipine per os**
- Sortie en 4j +/- 2
- Discussion
  - Pas d'analyses urinaires toxiques
    - amphétamine/cocaïne/opiacés
  - Pas de PCR virale
  - Accès facile à une altitude élevée
    - Avec pratique d'une activité physique vigoureuse
    - sans entraînement/adaptation

# En pratique ...

WILDERNESS & ENVIRONMENTAL MEDICINE 2019; 30(4S): S3–S18



WILDERNESS MEDICAL SOCIETY CLINICAL PRACTICE GUIDELINES

## Wilderness Medical Society Clinical Practice Guidelines for the Prevention and Treatment of Acute Altitude Illness: 2019 Update

Andrew M. Luks, MD<sup>1</sup>; Paul S. Auerbach, MD, MS<sup>2</sup>; Luanne Freer, MD<sup>3,4,5</sup>; Colin K. Grissom, MD<sup>6,7</sup>; Linda E. Keyes, MD<sup>8,9</sup>; Scott E. McIntosh, MD, MPH<sup>10</sup>; George W. Rodway, PhD, APRN<sup>11</sup>; Robert B. Schoene, MD<sup>12</sup>; Ken Zafren, MD<sup>2,13</sup>; Peter H. Hackett, MD<sup>14</sup>

<sup>1</sup>Division of Pulmonary, Critical Care and Sleep Medicine, University of Washington, Seattle, WA; <sup>2</sup>Department of Emergency Medicine, Stanford University School of Medicine, Stanford, CA; <sup>3</sup>Yellowstone National Park, WY; <sup>4</sup>Midway Atoll National Wildlife Refuge, Honolulu, HI; <sup>5</sup>Everest ER, Himalayan Rescue Association, Kathmandu, Nepal; <sup>6</sup>Division of Pulmonary and Critical Care Medicine, Intermountain Medical Center, Salt Lake City, UT; <sup>7</sup>Division of Pulmonary and Critical Care Medicine, University of Utah, Salt Lake City, UT; <sup>8</sup>Department of Emergency Medicine, University of Colorado, Denver, CO; <sup>9</sup>Boulder Community Health, Boulder, CO; <sup>10</sup>Division of Emergency Medicine, University of Utah, Salt Lake City, UT; <sup>11</sup>University of California, Davis School of Nursing, Sacramento, CA; <sup>12</sup>Division of Pulmonary and Critical Care Medicine, Sound Physicians, St. Mary's Medical Center, San Francisco, CA; <sup>13</sup>Himalayan Rescue Association, Kathmandu, Nepal; <sup>14</sup>Altitude Research Center, Division of Pulmonary Sciences and Critical Care Medicine, Department of Medicine, University of Colorado Anschutz Medical Campus, Aurora, CO

- Conférence experts US 2019
- « on ne peut pas exclure le diagnostic de MAM/OPHA, OCHA chez un sujet séjournant 2500m »

# En pratique ...

- Céphalées, insomnie, dyspnée, anorexie, asthénie dans les 1<sup>er</sup> jours d'arrivée en station doit faire évoquer le diagnostic de MAM
- Toute situation d'œdème pulmonaire dans les 1<sup>er</sup> jours d'arrivée en station doit faire évoquer le diagnostic d'OPHA
  - à exclusion des causes cardiogéniques, infectieuses, broncho pulmonaires





# En pratique ...

D'autant plus que

- Sujet jeune,
- en bonne santé,
- peu sportif,
- actif en altitude,
- vivant en plaine,
- obese,
- aux ATCD de symptômes similaires sur séjours en altitude



# En pratique ...

- Traitement MAM

- Descente
- Repos
- Acetazolamide DIAMOX
  - 250mg/12h
  - 2,5mg/kg/12h enfant max 125mg/prise
- Dexamethasone CELESTENE
  - 4mg/6 heures



- Traitement OPHA

- Descente
- Oxygène objectif de sat O2 > 90%
- ~~Caisson hyperbare~~
- Nifedipine ADALATE
  - 30mg/12h ou 20mg/8h



# Quelles recommandations pour les patients ?

- Proposer aux patients d'effectuer une consultation de médecine de montagne
  - Prise en charge si prescrite par le médecin traitant
- Ou au moins une consultation cardio/pneumologique
  - Shunt ?
  - Hypertension artérielle pulmonaire ?
  - Anomalies vasculaires pulmonaires ?





# Dépistage anomalies vasculaires pulmonaires

Case Reports > Pediatrics. 1985 Feb;75(2):314-7.

## High-altitude pulmonary edema with absent right pulmonary artery

B Rios, D J Driscoll, D G McNamara

PMID: 3969332

### Abstract

High-altitude pulmonary edema potentially is fatal. Adults with unilateral absence of a right pulmonary artery are particularly susceptible to high-altitude pulmonary edema. The occurrence of high-altitude pulmonary edema was documented in a child with congenital absence of the right pulmonary artery. Improvement occurred only upon descent to low altitude. Physicians should be aware of this life-threatening condition in children ascending to high altitude, particularly in individuals with unilateral absence of a pulmonary artery.

- Case report 1985
- OPHA enfant
- avec absence congénitale d'AP droite

# Dépistage anomalie vasculaire pulmonaire

MEDICAL INTELLIGENCE ARCHIVE

## High-Altitude Pulmonary Edema in Persons without the Right Pulmonary Artery

Peter H. Hackett, M.D., C. Edward Creagh, M.D., Robert F. Grover, M.D., Benjamin Honigman, M.D., Charles S. Houston, M.D., John T. Reeves, M.D., Aris M. Sophocles, M.D., and Mechteld Van Hardenbroek, M.D.

[Article](#) [Figures/Media](#)

HIGH-ALTITUDE pulmonary edema is an unusual and puzzling illness.<sup>1,2</sup> We have seen four patients without a right pulmonary artery, all of whom had high-altitude pulmonary edema at moderate altitudes (2000 to 3000 m) in Colorado. Both of these conditions are so uncommon that their association by chance is highly unlikely. The implications of this association were recognized by Dr. Houston when the first of our four cases was called to his attention by another member of the group. In each of the four patients edema developed in the left lung, which received the entire right ventricular output. This occurrence . . .

May 8, 1980

N Engl J Med 1980; 302:1070-1073

DOI: 10.1056/NEJM198005083021907

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- Colorado
- OPHA 2000-3000m
- 4 Patients Agénésie AP droite

# Dépistage anomalie vasculaire pulmonaire

Volume 122, Issue 4, October 2002, Pages 1471-1477

Selected Reports

## Isolated Unilateral Absence of a Pulmonary Artery: A Case Report and Review of the Literature

A. Derk Jan Ten Harkel MD, PhD <sup>a,\*,</sup> Nico A. Blom MD <sup>b,</sup> Jaap Ottenkamp MD, PhD <sup>b</sup>

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### Objective

The purpose of the present study was to determine the symptomatology, diagnostic procedures, and therapeutic strategies of patients with an isolated unilateral absence of a pulmonary artery (UAPA).

### Background

Isolated UAPA is a rare anomaly. Some case reports exist, but the best diagnostic





# Dépistage anomalies vasculaires pulmonaires

Volume 96, Issue 6, December 1989, Pages 1422-1424

Selected Reports

## Recurrent High-Altitude Illness Associated with Right Pulmonary Artery Occlusion from Granulomatous Mediastinitis

Kenneth G. Torrington M.D., F.C.C.P. <sup>a, b</sup> 

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<https://doi.org/10.1378/chest.96.6.1422> [Get rights and content](#)

While travelling across the intermountain West at an altitude of approximately 2,300 m, a 35-year-old man developed symptoms of HAPE. Delay in diagnosis and treatment was nearly lethal. Subsequent evaluation demonstrated unilateral pulmonary artery occlusion, presumably resulting from antecedent granulomatous mediastinitis. This case report supports the concept of evaluating anyone developing HAPE at relatively low altitude for an underlying predisposition.

- 1 homme 35 ans
- 2300m
- OPHA
  
- Épisodes récurrents
  
- Occlusion de l'AP unilatérale sur une mediastinite granulomateuse

# Dépistage anomalies vasculaires pulmonaires

Outline

Key Words

Abbreviations


CASE REPORT


DISCUSSION

REFERENCES

Cited By (42)

Figures (3)





Volume 110, Issue 1, July 1996, Pages 286-289

Selected Reports

## High-Altitude Pulmonary Edema With Primary Pulmonary Hypertension

Robert Naeije MD, PhD <sup>a</sup>, Daniel De Backer MD <sup>a</sup>, Jean-Luc Vachiery MD <sup>a</sup>, Paul De Vuyst MD, PhD <sup>a</sup>

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<https://doi.org/10.1378/chest.110.1.286> [Get rights and content](#)

A 43-year-old woman had two episodes of lung edema at moderate altitudes. She had taken slimming pills containing fenfluramine hydrochloride and diethylpropion hydrochloride. At sea level, catheterization of the right side of the heart showed a mean pulmonary artery pressure of 16 mm Hg, which increased to 34 mm Hg with mild exercise in a supine position. An extensive workup failed to identify a cardiac or a pulmonary cause of pulmonary hypertension. This patient experienced mild primary pulmonary hypertension related to the intake of anorexigens, which was revealed by high-altitude pulmonary edema.

- Femme 43 ans
- 2 OPHA altitudes modérées
- Dépistage d'une HTP
- secondaire à la prise d'anorexigènes
  - dérivés d'amphétamine et Isomeride

# Sommaire

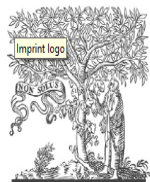
- Altitude : adaptations physiologiques
- Mal adaptations à l'altitude
  - MAM Mal Aigu des Montagnes
  - OPHA Œdème Pulmonaire de Haute Altitude
  - OCHA Œdème Cérébral de Haute Altitude
- MAM en moyenne montagne
- Patients pneumologiques et altitude





# Et les patients pneumologiques dans tout ça ?

Revue des Maladies Respiratoires 39 (2022) 26–33



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MINI-SÉRIE HYPOXIE D'ALTITUDE  
Coordonnée par A. Chambellan, S. Vergès

## Adaptation à l'altitude dans les maladies respiratoires

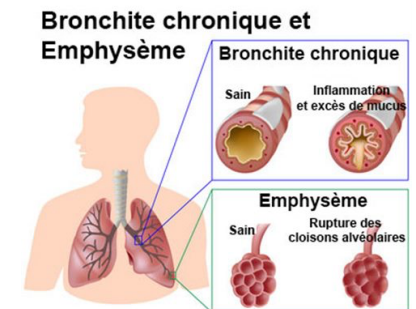
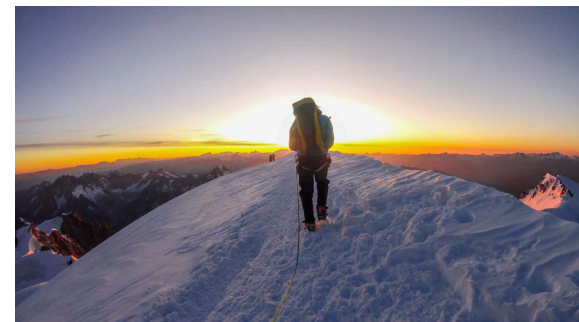


*Adaptation to altitude in respiratory diseases*

B. Wuyam, S. Baillieux, S. Doutreleau, S. Vergès\*

Laboratoire HP2, Inserm U1300, EXALT – Centre d'expertise sur l'altitude, UM sports et pathologies – CHU Grenoble Alpes, Université Grenoble Alpes, Avenue de Kimberley, 38434 Echirolles, France

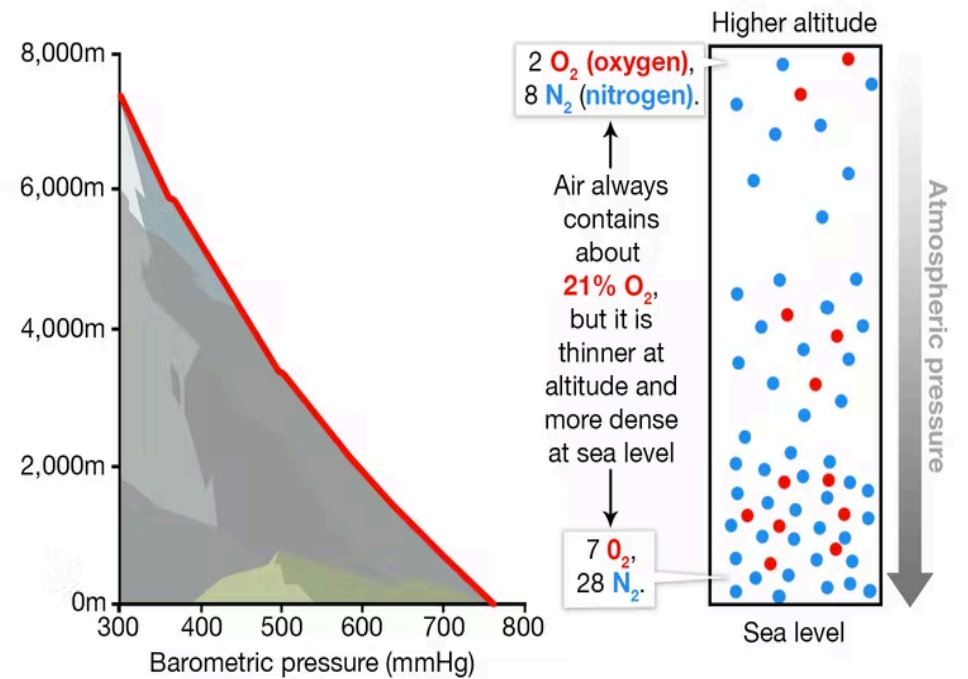
- 200 millions de voyageurs /an au delà de 1500m d'altitude
  - Dont une certaine proportion de malades respiratoires



# Particularités de la Haute altitude

- Haute Altitude
  - Froid
  - Air sec
    - Bronchostriction !
  - Peu allergènes
  - Moins dense
- Baisse de la pression barométrique
  - Baisse de la pression partielle en oxygène de la bouche à la mitochondrie

The impact of altitude on oxygen levels



# BPCO et altitude

- ↗ ventilation
  - Réponse ventilatoire hypoxique
  - Limitation ventilatoire BPCO à l'effort
    - Obstruction bronchique
    - Hyper inflation dynamique
    - Faiblesse des muscles respiratoires
  - Inconfort
  - ↗ travail inspiratoire
- Hypoxie alvéolaire
  - Inégalité VA/Q = plus grande hypoxémie ?
    - Moindre densité de l'air
      - = meilleure Ventilation alvéolaire
  - Vasoconstriction hypoxique dans certains territoires

15 SEPTEMBRE / 13 OCTOBRE 2022

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ORGANISATION O2&CIE

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TOUR 2022  
BPCO

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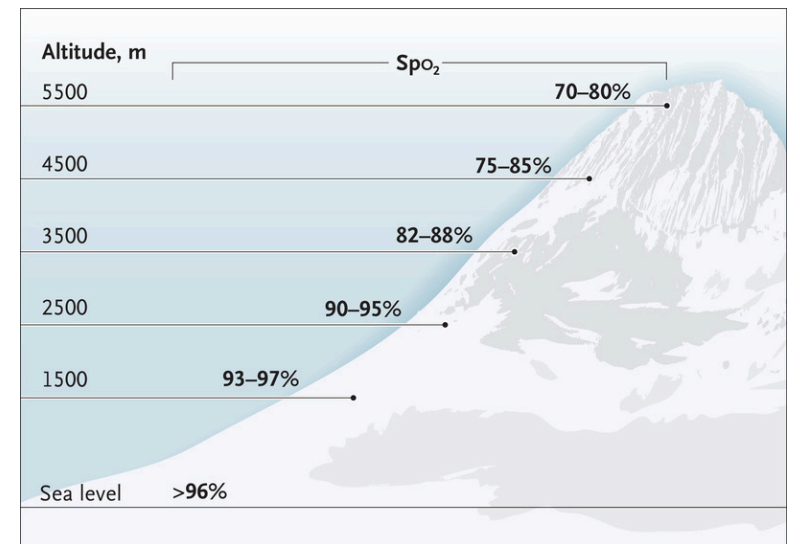
AGIR à dom. VIVISOL asten PHILIPS FRANCE GUYONNE pulmonX IVI BPCO

O2&CIE ORGANISATION O2&CIE / URGENCE BPCO



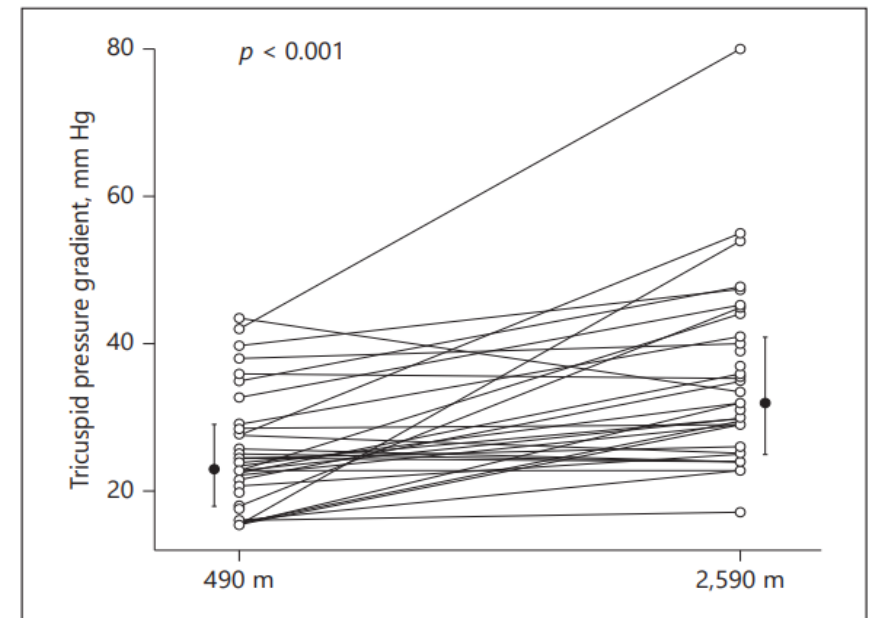
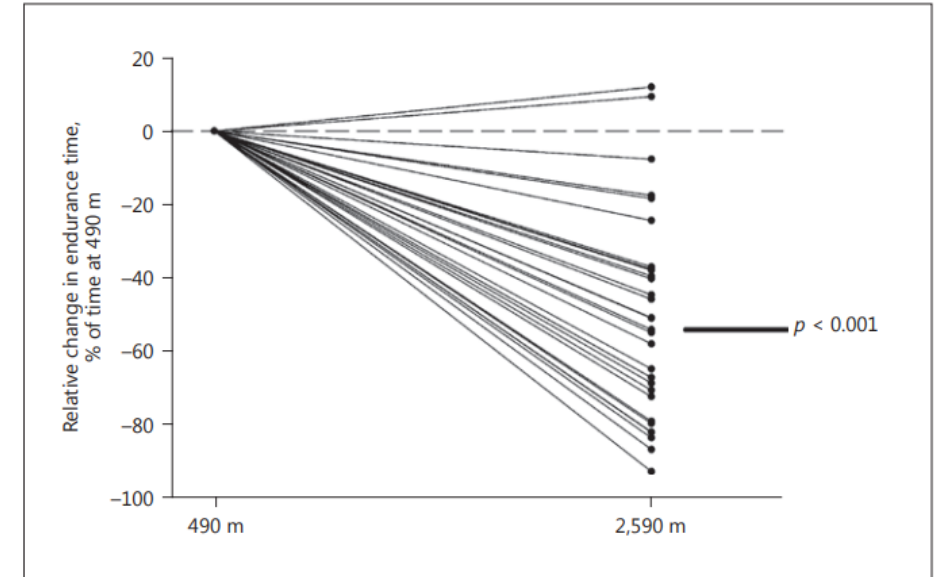
# BPCO et altitude

- < 3000m Furian Int J chron Obst Pul Dis 2018
  - 31 BPCO 66 ans VEMS 49-69% BMI 27,5
  - **490-1650m** Zurich
    - PaO<sub>2</sub> chute de 67,5mmhg à 60,7mmHg
  - **490-2590m** Davos
    - PaO<sub>2</sub> chute de 67,5mmhg à 51mmhg
    - avec 25% des sujets manifestations d'intolérance ( O<sub>2</sub> ou redescente)
- **Perte de 10mmHg à 2500m**



# BPCO et altitude

- **entre 490 et 2590m** (Zurich/Davos)
  - Furian 2018 Respiration
  - 31 BPCO VEMS 56%
  - Test en endurance 60% Pmax
    - $\searrow$  **50%** Temps d'endurance
    - et  $\nearrow$  ventilation (40 à 47L/Min)
    - $\searrow$  SpO2 (**92 à 81%**)
- Lichtblau 2018 Respiration
- 37 BPCO VEMS 57%
  - - 22m TM6 1650m
  - - **40m TM6** 2600m,
  - $\nearrow$  Gradient IT,  $\searrow$  FEVD

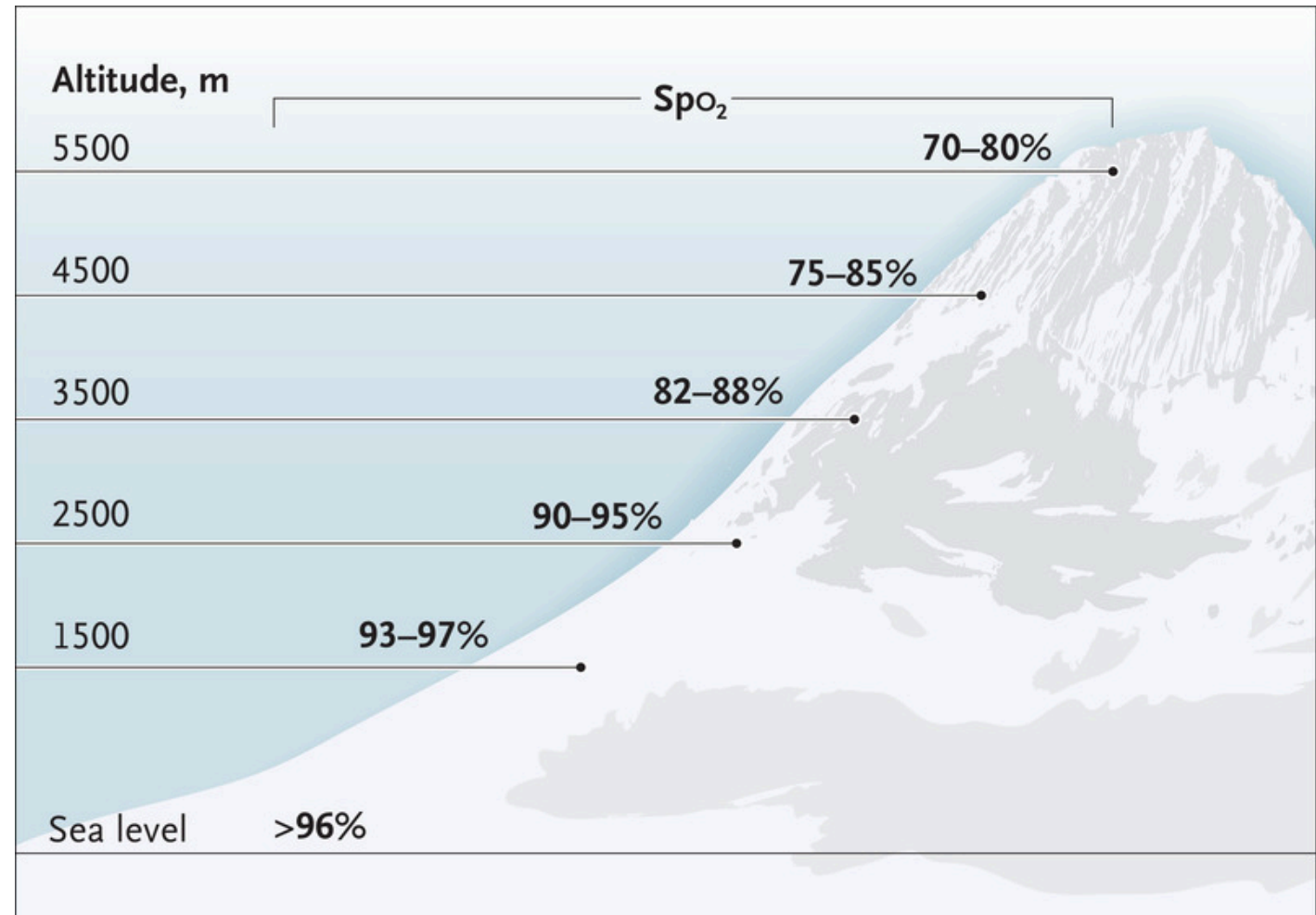


**Fig. 3.** Individual changes in transtricuspid pressure gradient.

# Contre indication altitude ?

BPCO et maladies respiratoires hypoxémiantes

➤ 2500m ?



Medical Conditions and High-Altitude Travel  
Andrew M. Luks, M.D., and Peter H. Hackett, M.D.  
n engl j med 386;4 nejm.org January 27, 2022



# Recommandations BPCO et altitude

K.Bloch, M.Furian 2023 High Altitude Medicine and Biology

- **Recommandations habituelles**

- ATCD Mam, migraine
- Vitesse d'ascension
- Recherche maladies CV
- Eviter les efforts intenses, respecter du repos

- si BPCO hypercapnique/ hypoxémique/ Obstruction sévère

- Pas d'études disponibles
- O<sub>2</sub> en haute altitude

- **O<sub>2</sub>ttie préventive la nuit**

- 2-3L/min
- Tan 2020
  - BPCO, sat > 92% plaine, VEMS 30-80%
  - Réduction de + 20% du risque de complications liées altitude à 2050m

- **Poursuivre VNI , O<sub>2</sub>, Ttt inhalés**

HIGH ALTITUDE MEDICINE & BIOLOGY  
Volume 24, Number 3, 2023  
Mary Ann Liebert, Inc.  
DOI: 10.1089/ham.2023.0053

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Clinician's Corner:  
Counseling Patients with Chronic Obstructive  
Pulmonary Disease Traveling to High Altitude

Konrad E. Bloch,<sup>1-3</sup> Talant M. Sooronbaev,<sup>2-4</sup> Silvia Ulrich,<sup>1-3</sup> Mona Lichtblau,<sup>1-3</sup> and Michael Furian<sup>1-3</sup>

# Recommandations BPCO et altitude

K.Bloch, M.Furian 2023 High Altitude Medicine and Biology

- **Etat stable**

- exacerbation > 1 mois

- Patients trop à risque doivent être découragés

- Exacerbation < 1 mois
- Comorbidités CV, neurologique instables

- **En altitude**

- **Si saturation repos < 85%** +/- symptômes de MAM
- Débuter O<sub>2</sub> la nuit et effort
- 2-3L/min
- Concentrateur avec débit continu
  - Obstruction nasale ou respiration buccale
  - = débit pulsé non indiqué
- Ou descente

# Recommandations BPCO et altitude

- **Acetazolamide en préventif**
  - Furian 2022
  - 176 BPCO
  - Normocapnique, sat > 92% et VEMS > 40%
  - 125.0.250mg
  - J-1 et durant le séjour
  - Réduction des complications à 3000m vs placebo
    - 76 à 49% d'évènements liés à l'altitude
- **Dexamethasone en préventif ?**
  - Données contradictoires
  - En curatif d'une exacerbation



# BPCO et altitude

- Avion
  - 1450-2500m d'altitude
  - Préconisation de test en hypoxie
    - Si sat < 95% repos
    - Si VEMS < 1-1,5l/min
    - Si DLCO < 50%
  - 2500m FiO<sub>2</sub> 15% 15-20min
  - O<sub>2</sub> pendant le vol
    - si paO<sub>2</sub> < 50 mmHg et sat < 85%
  - 2-4l/min



# Asthme et altitude

- Qualité de l'air meilleure
- Moins d'allergènes
  - Moindre réactivité allergénique
- Moindre HRB , amélioration VEMS enfants
  - moyenne altitude plusieurs mois
- Admis jusqu'à 5000m un asthmatique contrôlé/traité/ VEMS normal ne tolèrera pas moins bien l'altitude
  - Attention air froid en altitude avec risque BIE
  - Mais la densité de l'air pourrait participer à une moindre résistance à l'écoulement de l'air
- Bien prendre son ttt corticoïdes inhalés
- Avoir un plan d'action personnalisé
- Protection contre le froid

DOI: 10.1183/09031936.00052606  
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## REVIEW

### Travel to high altitude with pre-existing lung disease

A.M. Luks\* and E.R. Swenson<sup>#</sup>

**ABSTRACT:** The pathophysiology of high-altitude illnesses has been well studied in normal individuals, but little is known about the risks of high-altitude travel in patients with pre-existing lung disease. Although it would seem self-evident that any patient with lung disease might not do well at high altitude, the type and severity of disease will determine the likelihood of difficulty in a high-altitude environment. The present review examines whether these individuals are at risk of developing one of the main forms of acute or chronic high-altitude illness and whether the underlying lung disease itself will get worse at high elevations. Several groups of pulmonary disorders are considered, including obstructive, restrictive, vascular, control of ventilation, pleural and neuromuscular diseases. Attempts will be made to classify the risks faced by each of these groups at high altitude and to provide recommendations regarding evaluation prior to high-altitude travel, advice for or against taking such excursions, and effective prophylactic measures.

**KEYWORDS:** Acute mountain sickness, high altitude, high-altitude cerebral oedema, high-altitude pulmonary oedema, hypoxia, lung disease

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# SAOS/SOH et altitude

- SAS

- ↗ évènements centraux, aggravation hypoxémie nocturne
- = intérêt de poursuivre la PPC si possible
- Problème d'accessibilité électricité

- Obèse

- Prudence !
- Plus souvent une PAP un peu plus élevée = risque de décompensation droite
- Score MAM plus élevé ( chambre hypoxique 3658m)
- Dépister et traitement une Hypo Va nocturne
- Prévention MAM par ACTZ possible



# Maladies respiratoires et altitude

- Maladies vasculaires pulmonaires
  - Séjour en altitude déconseillé
    - Vasoconstriction hypoxique
    - Stress capillaire
    - Pas de seuil de PAP connu pour tolérance altitude
- Atteintes restrictives
  - Cyphoscoliose grave
    - Dépistage HTAP et HypoVa recommandé
    - +/- Nifedipine prévention de l'OPHA
    - Avis d'expert
- PID
  - Peu d'information !
  - Etudes sur altitude simulée
  - Recommandations pour le Vol avion chez les BPCO à appliquer

# Conclusions

- La survenue d'un MAM ou OPHA est possible dans nos stations
  - TTT = Descente, repos, Diamox MAM/nicardipine OPHA, O<sub>2</sub>, pas de diurétique
  - Proposer une consultation de médecine de montagne
  - Ou de cardio/pneumologie
    - pour recherche shunt, HTAP ou anomalie anatomique vasculaire pulmonaire
- BPCO et altitude
  - Jusqu'à 2500m-3000m
  - Moindre performance à l'effort
  - Risques liés aux Co morbidités cardio vasculaires
    - EFX avec GDS avant ?
- Au delà de 2500m chez des malades hypoxiques
  - *Contre indication ?*
  - *O<sub>2</sub> ?*
  - *Test en hypoxie ?*



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<https://www.exalt-association.org>

J20 Chambéry  
28 et 29  
septembre 2023



# EXALT



## **Acetazolamide DIAMOX**

250mg matin et midi

125mg matin et 250mg le soir

A débiter la veille de l'ascension et à poursuivre jusqu'à la descente

- A partir de 2500-3000m

Peut provoquer des Dysesthésies peri buccales/extrémités, gout métallique des boissons gazeuses, hypokaliémie

Ci allergies sulfamides, grossesse ++ 1° trimestre  
grossesse, ATCD colique nephretique

Si CI : DEXAMETHASONE 4mg matin et soir

