

HAPE

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Useful sites

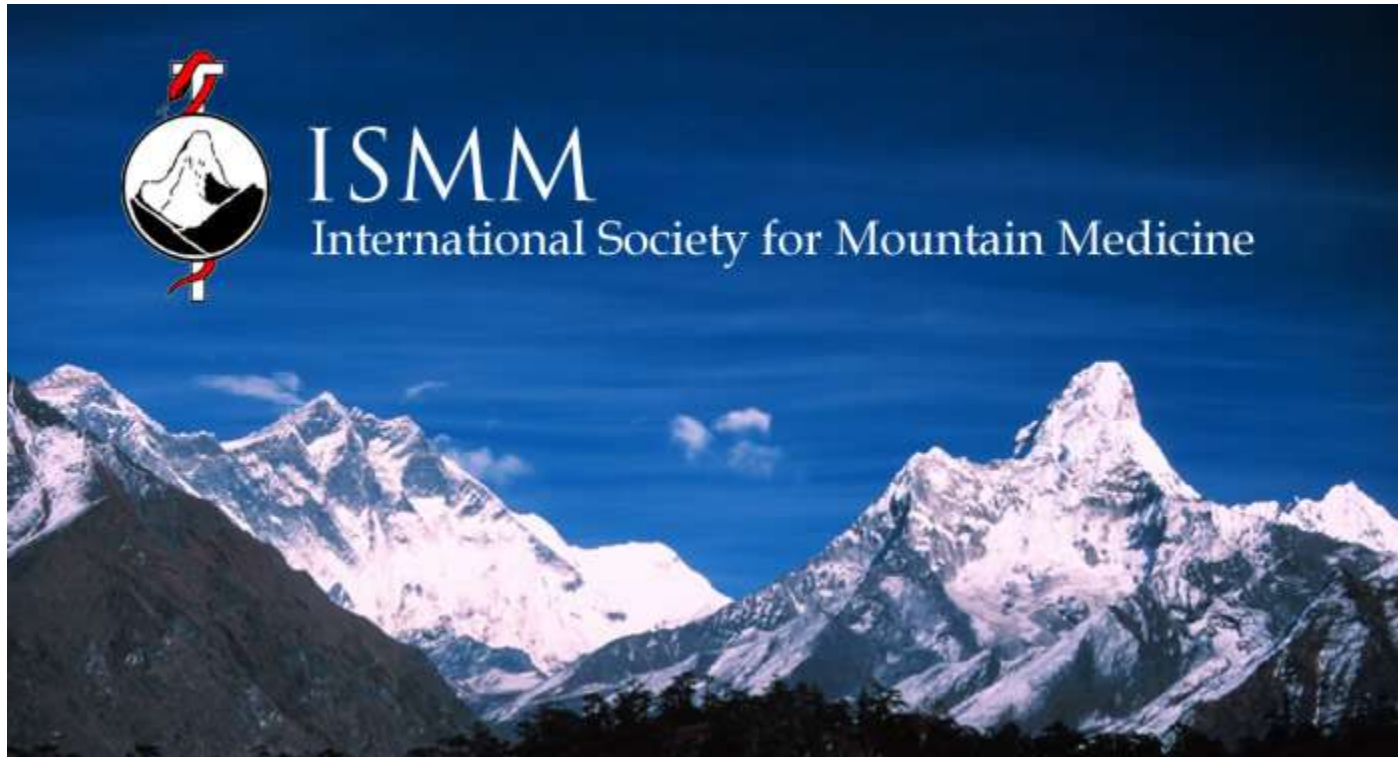


HAPE

introduction

High Altitude Pulmonary Edema

Lake Louise Consensus on the Definition of Altitude Illness



HAPE

introduction

In the setting of a recent gain in altitude, the presence of the following:

Symptoms: at least two of:- dyspnea at rest

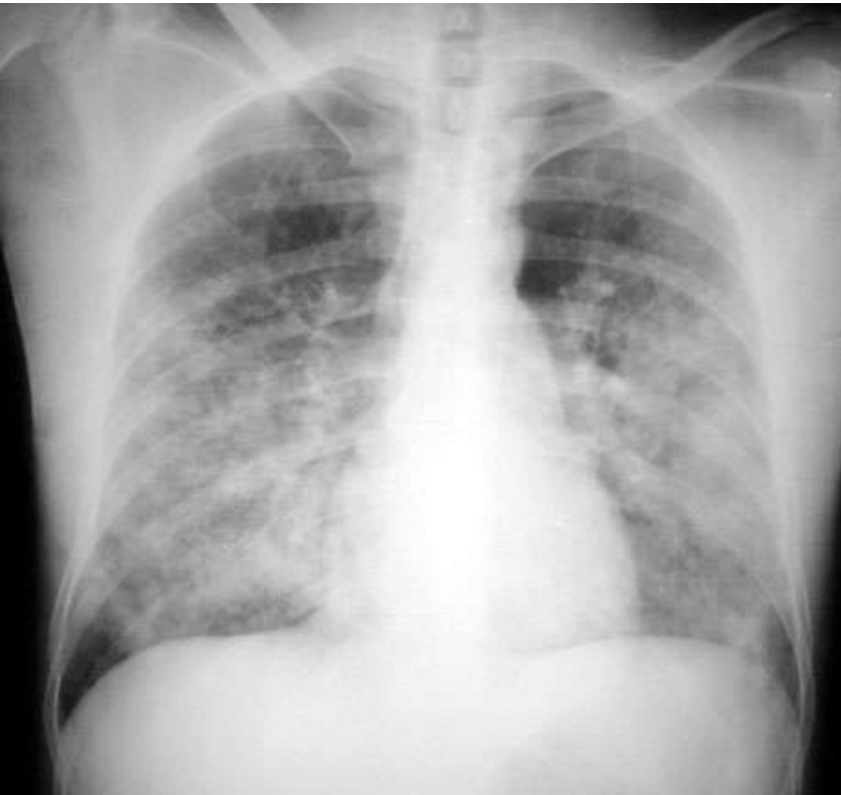
- cough
- weakness or decreased exercise performance
- chest tightness or congestion

Signs: at least two of:- crackles or wheezing in at least one lung field

- central cyanosis
- tachypnea
- tachycardia

HAPE

introduction



HAPE

introduction

Incidence of HAPE

Depends on several factors

-Altitude

-Ascent rate

-Individual susceptibility/ History of HAPE

HAPE

introduction

Incidence Data – HAPE				
Study Location	Altitude Reached	Rate of Ascent	Percent HAPE	Reference
Alps, Switzerland	4560m	1-2 days	11%	Bartsch et al 1990
Summit County, USA	3000m	1 day	42%	Dean, Yip, Hoffmann 1990
Mt. Rainier, USA	4420m	2 days	0.5%	Houston 1982
Pheriche, Nepal	4200m	5-8 days	2.5%	Hackett and Drummond 1976
Kashmir, India	5500m	1-2 days	2.3-15%	Singh et al 1969
Mt. McKinley (Denali). Alaska, USA	6200m	5-10 days	1%	Hackett 1980

Picture taken from syllabus DiMM Plas Y Brenin dec 2-8; 2006

HAPE

early discription

Fa-Hien or Faxian 400 ad

Bhoedist monk traveller

Companion died while
crossing mountain.

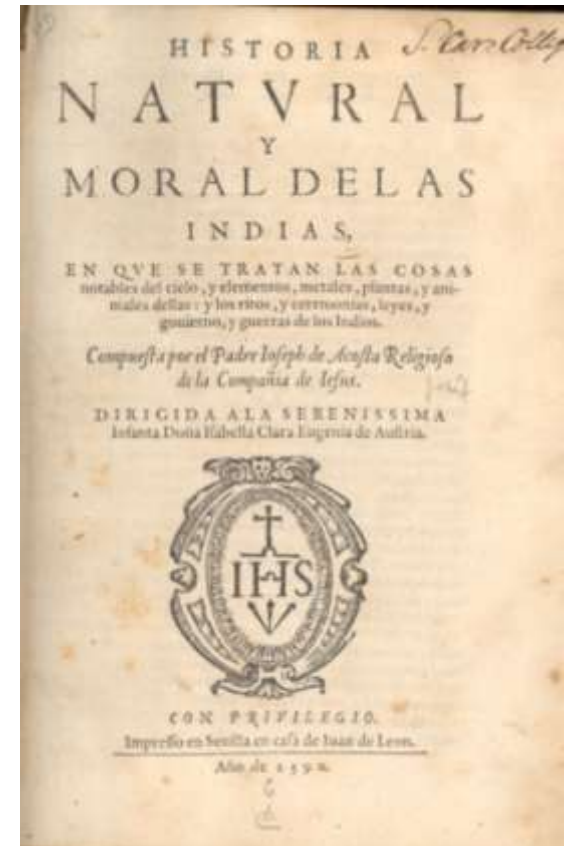


HAPE

early discription

Padre José de Acosta 1540-1600

travelled throughout Peru



HAPE

early discription

Montgolfier brothers invented hot air balloon 1783



Joseph Michel Montgolfier

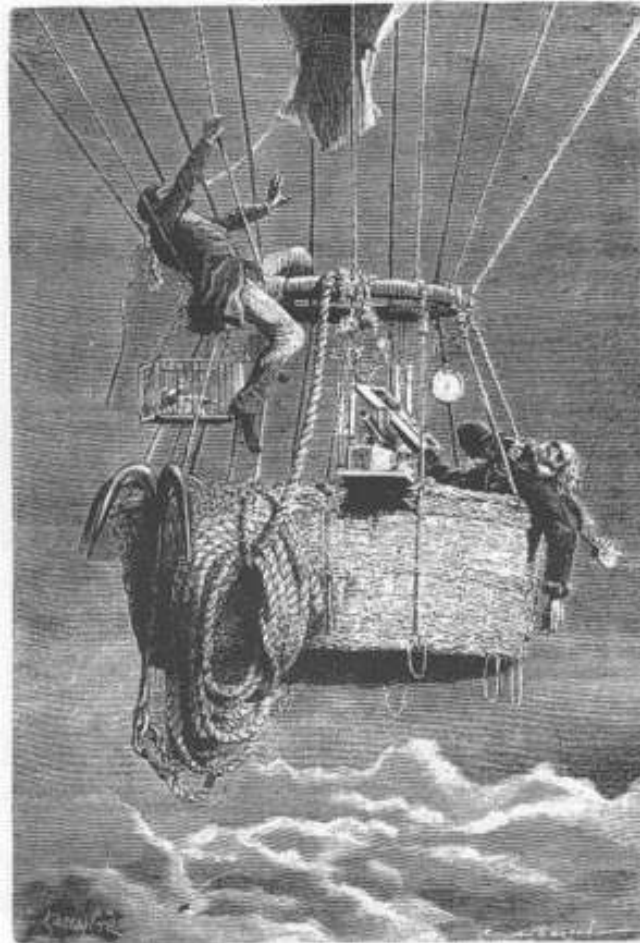


Jacques Etienne Montgolfier

HAPE

early discription

Early high altitude experiments?

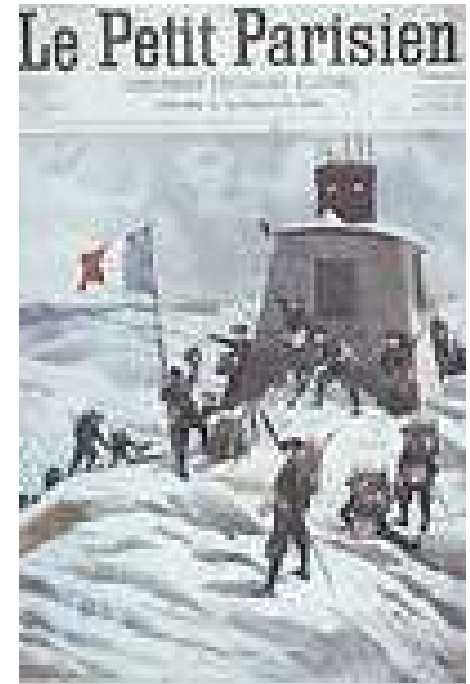


HAPE

early discription

Dr. Jacottet died spending two nights
In the Vallot hut (4300m)
on the Mont Blanc 1891

Post Mortem showed acute edema
of the lung



HAPE

aetiology

vascular response to hypoxia

Some 60 years ago experiments done on cats showed
vasconstrictive responses to hypoxia

An increase of about 12-25 mmHg in the a. pulmonalis was
found

Later this response was found in white men

Von Euler et al.; Observations on the pulmonary arterial blood pressure in cat ; Acta Physiol Scand.
Vol 12 pg301-320 (1946)

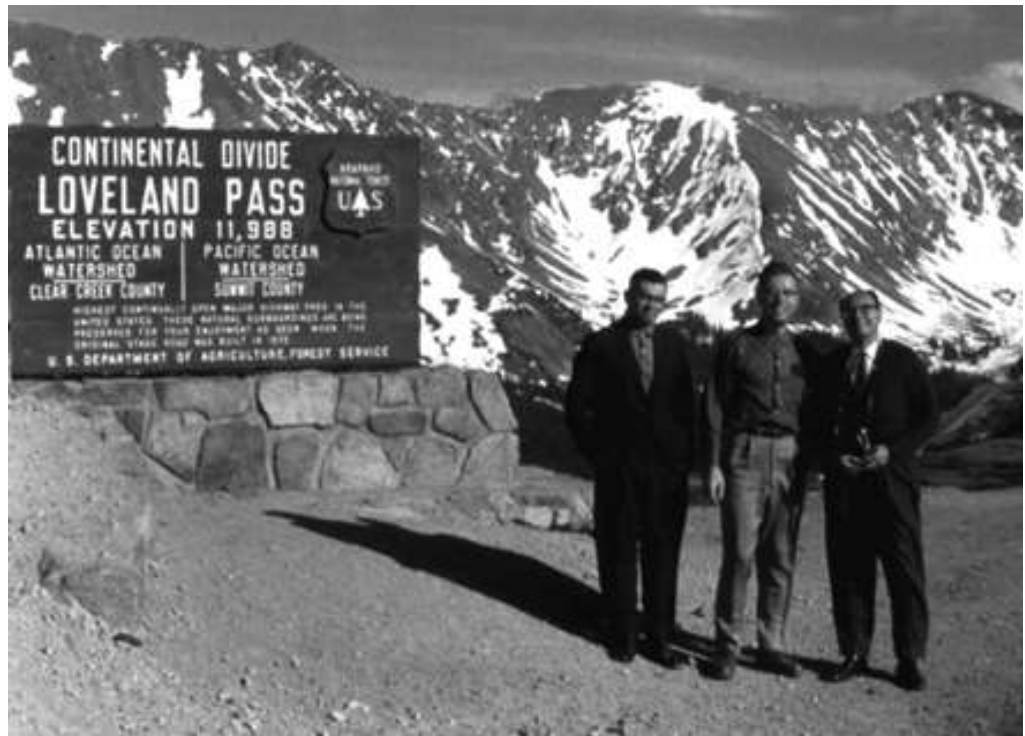
Motley et al.; influence of short periods of induced acute anoxia upon pulmonary artery pressure in
man; Am. J. Physiol.; 150: 390-403 (1947)

HAPE aetiology

ECG findings

ECG studies done on high-altitude natives Peruvian Andes

- Peaked P-waves
- Right axis deviation



Drs. Javier Arias-Stella, *left*, and Dante Penalzoza, *right*, visiting Colorado's high country on the occasion of the 1962 Aspen Conference, organized by Dr. Robert Grover, *center*. (Courtesy of Dr. Grover.)

HAPE

aetiology

post mortem studies

Post mortem studies in Japan 2001

Alveolar edema

Congestion of pulmonary vessels

Alveolar hyaline membranes

Alveolar hemorrhage

Multiple thrombi and fibrin clots

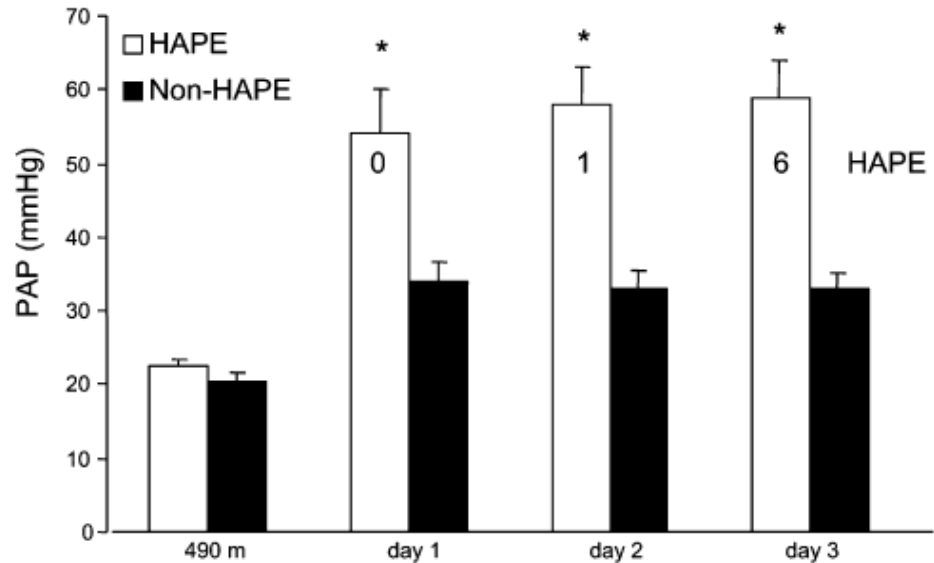
Increase of mast cells and pneumocytes type II intra alveolar

HAPE aetiology

pressure

Susceptible persons have increased HPV

Doppler echo cardiographic
Data at 4559m



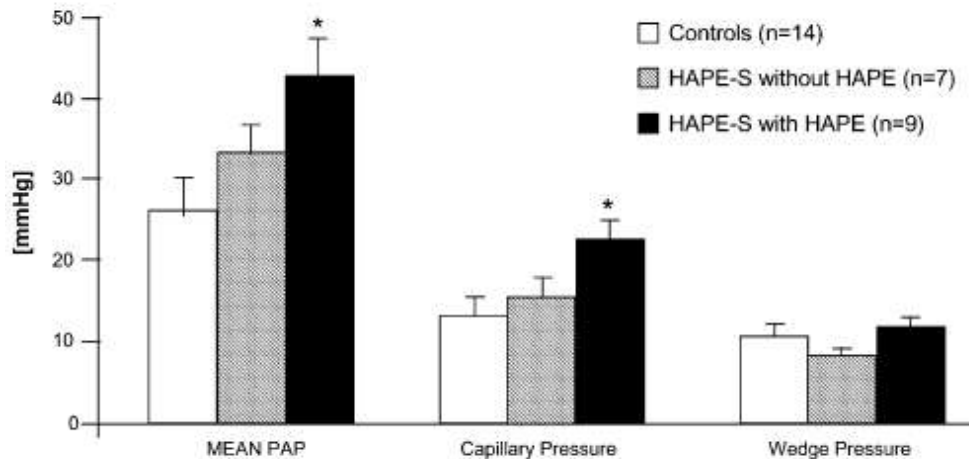
Bartch et al. ;Prevention of of high-altitude pulmonary edema by nifedipine; NEJM 325: 1284-1289
1991

HAPE aetiology

pressure

Wedge pressure remains normal in HAPE

Capillary pressure increases



Right Heart Cathetrization data at 4559m 2nd day

Maggiorini et al.; High-altitude Edem Is Initially Caused by an Increase in Capillary Pressure;
Circulation 103:2078-83 (2001)

HAPE aetiology

pressure

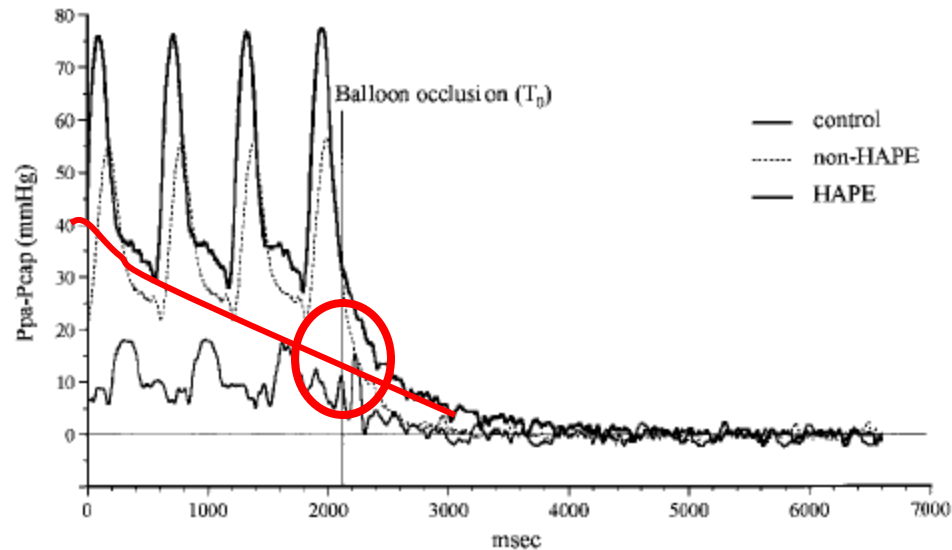


Figure 2. Pressure-decay curves for determination of P_c in 3 representative subjects at high altitude: a control subject, a HAPE-susceptible subject with no edema (non-HAPE), and a subject with HAPE. Calculated P_c s were 13, 15, and 26 mm Hg, respectively.

Maggiolini et al.; High-altitude Edema Is Initially Caused by an Increase in Capillary Pressure; Circulation 103:2078-83 (2001)

HAPE

aetiology

role of inflammation

Some studies suggest inflammation to be an etiological factor in developing HAPE

- Kaminsky et al. Chest 1996: elevated Leucotriene levels in Urine in HAPE
- Durmowisz et al.; Journ. Pediatr. 1997: high association of pre existing disease and developing HAPE
- Schoene et al.; BAL studies

HAPE aetiology

TABLE 3. Lavage protein and eicosanoid concentrations grouped by clinical severity of illness

Subj No.	Year	Group	Total Protein, mg/dl	Albumin, mg/dl	IgG, mg/dl	IgM, mg/dl	C5a, pg/ml	TxB ₂ , pg/ml	6-keto-PGF _{1α} , pg/ml	LTB ₄ , pg/ml	LTC ₄ , pg/ml
02	1983	Normal	8.0	4.7	0.4	ND		50	980	ND	ND
03	1983	Normal	16.0	7.6	0.7	ND		53	980	ND	ND
05	1983	Normal	11.0	6.8	0.4	ND		48	890	ND	ND
09	1985	Normal	13.0	7.8	1.9	ND	25.6	39	900	ND	ND
Mean ± SD			12.0±3.4	6.7±1.4	0.9±0.7		25.6	42.5±6.0	937.5±49.2		
10	1985	AMS	9.0	4.0	1.5	ND	24.0	40	790	ND	ND
12	1985	AMS	4.9	3.7	0.8	ND	20.8	37	740	ND	ND
13	1985	AMS	5.2	3.4		ND	30.4	39	1,030	ND	ND
14	1985	AMS	22.4	10.0	4.2	ND	24.0	36	1,130	ND	ND
Mean ± SD			10.4±8.3	5.3±2.7	2.2±1.5		24.8±4.0	38.0±1.8	922.5±187.5		
01	1983	HAPE	507	330	63	4.3		540	1,700	520	ND
04	1983	HAPE	1,136	660	152	7.0		500	850	1,350	ND
06	1983	HAPE	376	180	42	4.6		84	1,220	870	ND
07	1985	HAPE	840	630	153	13.8	52.0	440	840	1,050	ND
08	1985	HAPE	610	280	108	5.0	44.0	390	1,250	300	ND
11	1985	HAPE	227	140	55	8.8	36.0	100	600	770	ND
Mean ± SD			616.0±329.1†	370.0±223.8†	95.5±49.4†	7.3±3.6	44.0±8.0†	342.3±200.6*	1,076.7±393.4	810.0±373.8	

IgG, IgM, immunoglobins G and M; TxB₂, thromboxane B₂; LTB₄, LTC₄, leukotrienes B₄ and C₄. See legend of Table 1 for definitions of other abbreviations and details of groups. * $P < 0.02$, † $P < 0.01$ compared with AMS and with normal subjects (C5a is compared only with AMS). ND, not detectable.

HAPE aetiology

Table 1
Broncho-alveolar lavage at low and high altitude

	490 m		4559 m		
	CONT (n = 8)	HAPE-S (n = 9)	CONT	HAPE-S (well; n = 6)	HAPE-S (ill; n = 3)
Cell count ($\times 10^4 \text{ ml}^{-1}$)	8.1	6.3	9.5	8.1	9.8
Macrophages (%)	94	95	93	92	88
Neutrophils (%)	1	0	0	0	1
Red cells (%BAL cells)	1	4	6	51*	74*
Total protein (mg/dl)	1	2	14	34*	163*
Albumin ($\mu\text{g/ml}$)	34	29	42	127*	402*
PAP systolic	22	26	37	61*	81*
IL-1 (pg/ml)	ND	ND	ND	ND	ND
IL-6 (pg/ml)	ND	ND	ND	ND	176*
IL-8 (pg/ml)	0.1	0.1	0.2	0.2	0.2
TNF- α (pg/ml)	ND	ND	ND	ND	ND
LTB ₄ (pg/ml)	547	521	499	537	512
PGE-2 (pg/ml)	13	14	13	19	18
Thromboxane (pg/ml)	24	14	43	28	51

* $p < 0.05$ compared to control (CONT) and values at low altitude. "Well" indicate that subjects developed HAPE in the 24 h following the BAL, "ill" indicates that HAPE was present at the time of the lavage. Data from Swenson et al. (2002).

Swenson et al.; pathogenesis of High-Altitude pulmonary edema inflammation is not an etiologic factor; JAMA 2002; 287: (17)2228-2235

HAPE aetiology

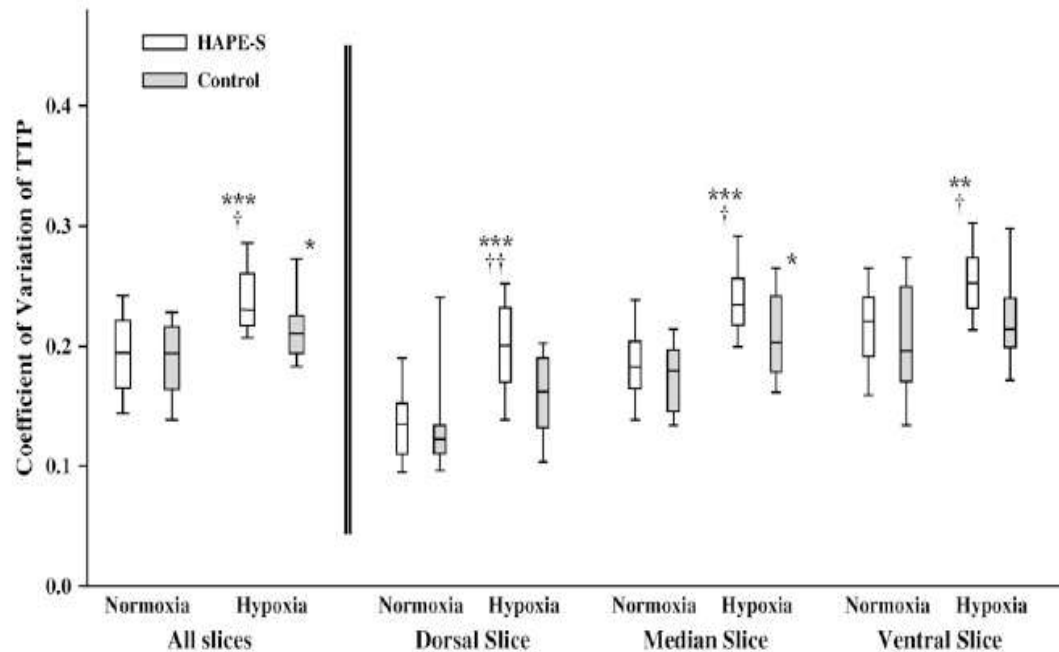


Figure 4. Coefficient of variation (CV) of TTP for HAPE-susceptible (HAPE-S) and control subjects. Values are presented as median, upper, and lower quartiles. The *left side* shows values for the whole lung; the *right side* shows values for the dorsal slice (dorsal edge of ascending aorta), the median slice (dorsal edge of left atrium), and the ventral slice (right pulmonary artery). Significant differences within one group from normoxia to hypoxia: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Significant differences between both groups in hypoxia: † $p < 0.05$, †† $p < 0.01$.

HAPE aetiology

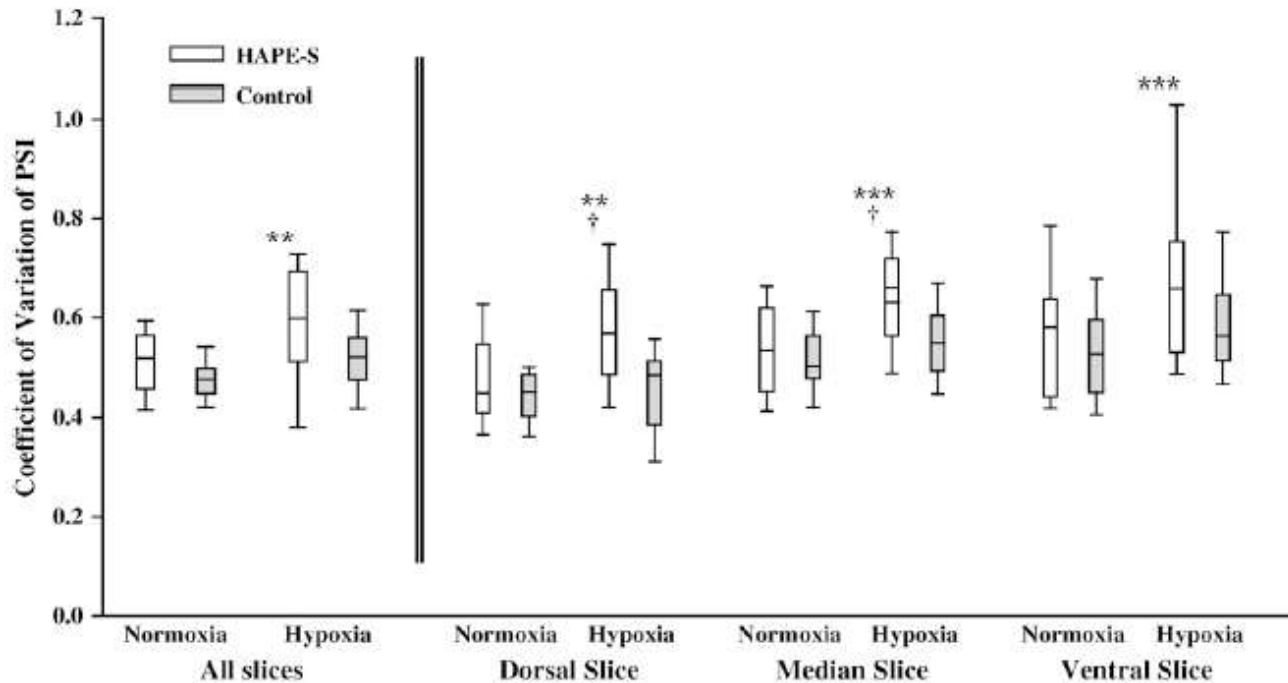


Figure 5. CV of peak signal intensity for HAPE-S and control subjects. Values are presented as median, upper, and lower quartiles. The *left side* shows values for the whole lung; the *right side* shows values for the dorsal slice (dorsal edge of ascending aorta), the median slice (dorsal edge of left atrium), and the ventral slice (right pulmonary artery). Significant differences within one group from normoxia to hypoxia: **p < 0.01, ***p < 0.001. Significant differences between both groups in hypoxia: †p < 0.05.

Dehnert et al. Am. J. resp. Crit. Care Med.; Pulmonary blood flow heterogeneity during hypoxia and high-altitude pulmonary edema; vol171: 83-87 2005

HAPE

conclusion

HAPE-S:

Increased PAP

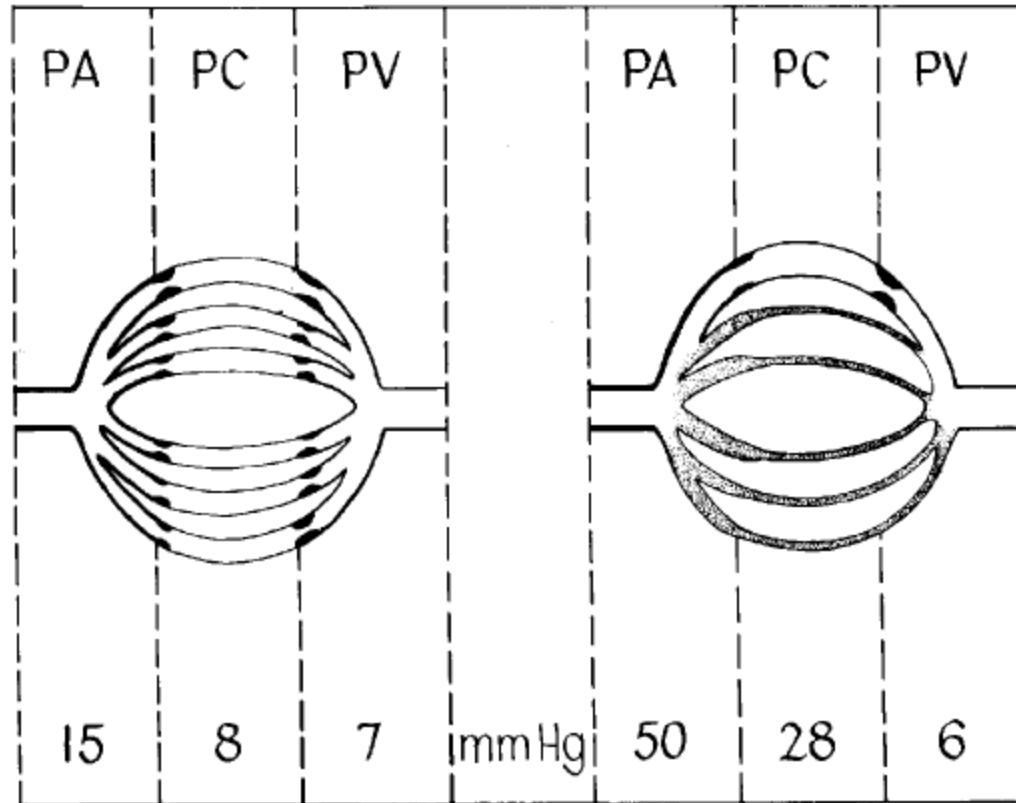
Normal Wedge

No primary inflammatory factor

Elevated capillary pressure

Uneven lung perfusion under hypoxic conditions

HAPE conclusion



Hultgren et al.; High-Altitude pulmonary edema: current concepts; ann. Rev. Med. 1996 47:267-284

HAPE

useful sites

- Werkgroep hoogtefysiologie Nederland
www.hoogtefysiologie.nl
- International Society for Mountain Medicine:
www.ismmed.org
- Himalayan Rescue Association Nepal:
www.himalayenrescue.com
- High Altitude Medicine Guide:
www.high-altitude-medicine.com
- Medical Expeditions:
www.medex.org.uk
- Everest basecamp clinic:
www.basecampmd.com
- Mountain Medicine Society of Nepal
www.mmsn.org

