High-Altitude Medicine

Current trends and prevention

FMF - 2014
Eric Mercier, MD, MSc

3

Objectives

CIWEC clinic

Nepal

Acclimatization process

Altitude-related diseases

Prevention | Treatment

Plan

Acclimatization process

Altitude-related diseases

Prevention | Treatment

No conflicts of interest

Plan

Acclimatization

Series of integrated adaptations that take place at high altitude, which tend to restore the oxygene pressure toward normal sea levels despite the lowered PO2

Acclimatization

	Barometric pressure	FiO2	Inspired oxygen pressure (PiO2)

Sea level :

760 mmHg x 0.21 =

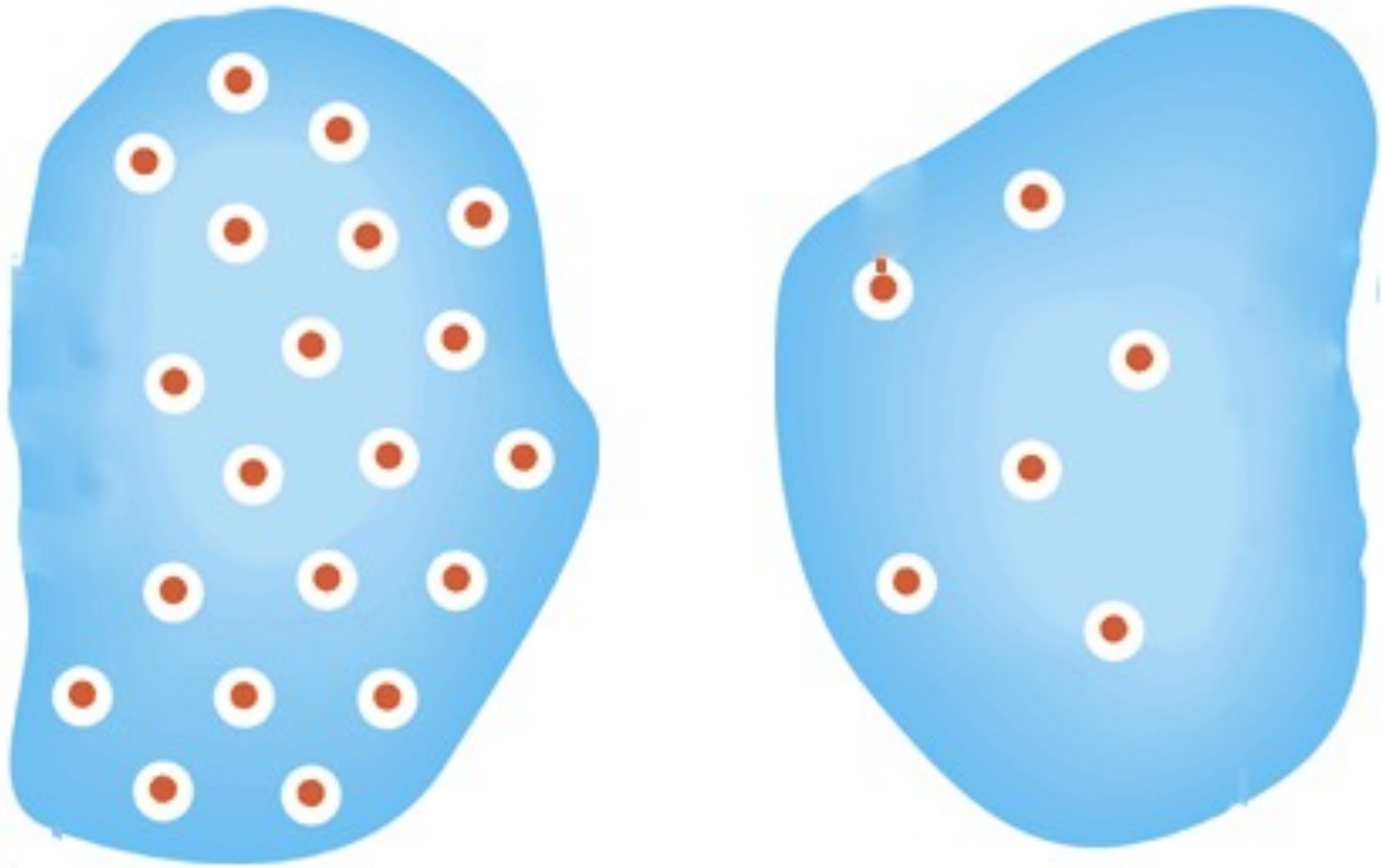
Barometric pressure	FiO2	Inspired oxygen pressure (PiO2)

Sea level :

760 mmHg x 0.21 = 160 mmHg

	Barometric pressure		FiO2		Inspired oxygen pressure (PiO2)
Sea level :	760 mmHg	x	0.21	=	160 mmHg
Everest summit (8848 m) :	253 mmHg	x	0.21	=	

	Barometric pressure		FiO2		Inspired oxygen pressure (PiO2)
Sea level :	760 mmHg	x	0.21	=	160 mmHg
Everest summit (8848 m) :	253 mmHg	x	0.21	=	53 mmHg



# of Oxygen in air at sea level

# of Oxygen in air at altitude

WMS, 2011

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Arterial Blood Gases and Oxygen Content in Climbers on Mount Everest

Michael P.W. Grocott, M.B., B.S., Daniel S. Martin, M.B., Ch.B.,
Denny Z.H. Levett, B.M., B.Ch., Roger McMorrow, M.B., B.Ch.,
Jeremy Windsor, M.B., Ch.B., and Hugh E. Montgomery, M.B., B.S., M.D.,
for the Caudwell Xtreme Everest Research Group*

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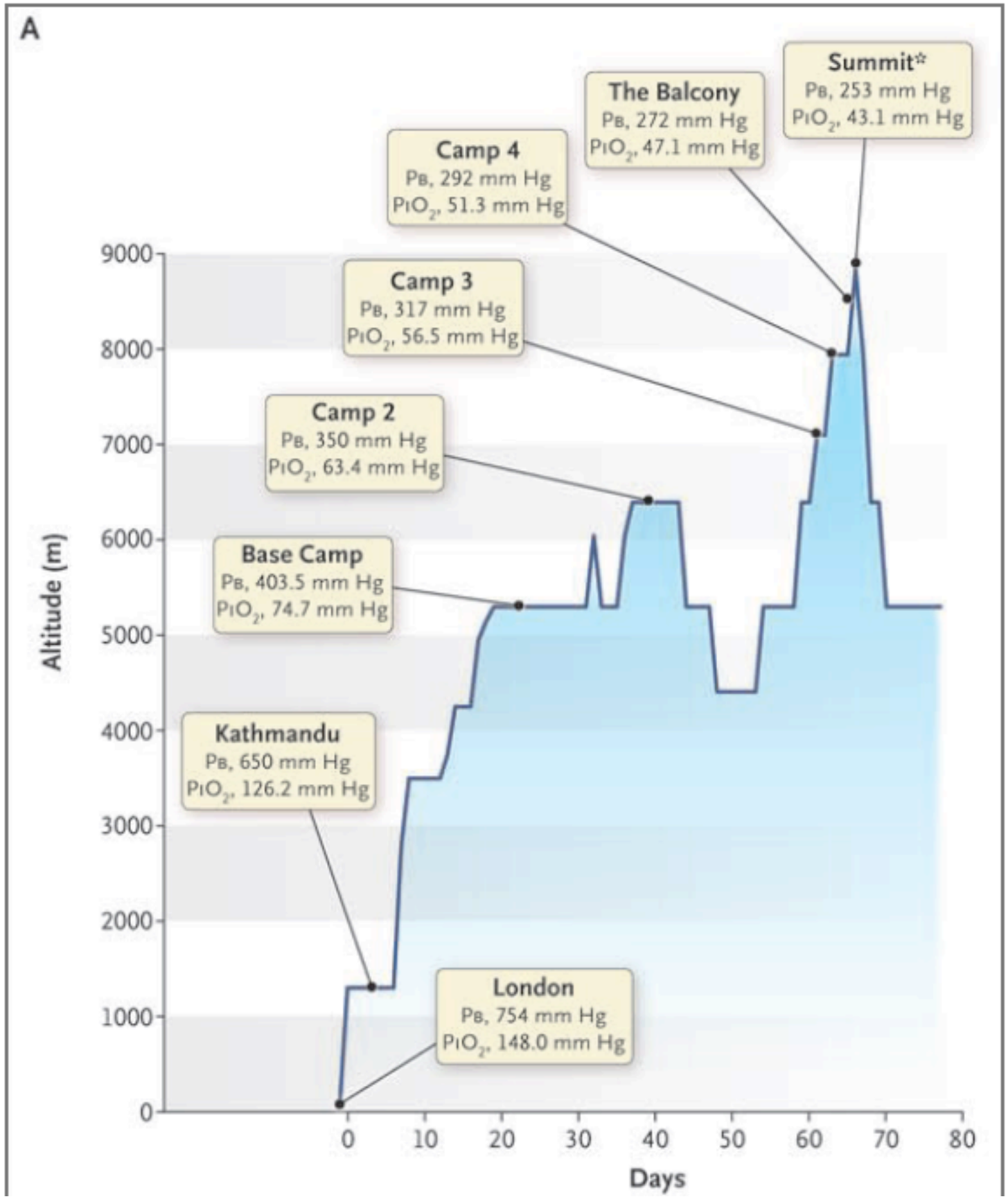

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Table 2. Arterial Blood Gas Measurements and Calculated Values for Pulmonary Gas Exchange from Four Subjects at an Altitude of 8400 m, during Descent from the Summit of Mount Everest.*

Variable	Subject No.				Group Mean
	1	2	3	4	
pH	7.55	7.45	7.52	7.60	7.53
PaO_2 (mm Hg)†	29.5	19.1	21.0	28.7	24.6
$PaCO_2$ (mm Hg)†	12.3	15.7	15.0	10.3	13.3
Bicarbonate (mmol/liter)‡	10.5	10.67	11.97	9.87	10.8
Base excess of blood‡	–6.3	–9.16	–6.39	–5.71	–6.9
Lactate concentration (mmol/liter)	2.0	2.0	2.9	1.8	2.2
SaO_2 (%)‡	68.1	34.4	43.7	69.7	54.0
Hemoglobin (g/dl)§	20.2	18.7	18.8	19.4	19.3
Respiratory exchange ratio¶	0.81	0.74‖	0.72	0.70	0.74
P_AO_2 — mm Hg†**	32.4	26.9	27.4	33.2	30.0
Alveolar–arterial oxygen difference — mm Hg†	2.89	7.81	6.44	4.51	5.41

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Hypoxic ventilatory response

Altitude-related diseases

AMS

HACE

HAPE

Acute mountain sickness (AMS)

Table 2: Lake Louise Consensus Definition For The Diagnosis Of AMS

- An individual is at or above 2500 m above sea level *and*
- A headache is present *and*
- An individual has any one of the following:
  - GI Symptoms (nausea, vomiting, anorexia)
  - Sleep symptoms (insomnia, difficulty sleeping)
  - Fatigue/weakness
  - Dizziness/lightheadedness

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  - Fatigue/weakness
  - Dizziness/lightheadedness

Table 7: The Lake Louise Consensus Criteria For HACE
The presence of a change in mental status or ataxia in a person with AMS
OR
The presence of both a change in mental status and ataxia in a person without AMS

High-altitude cerebral edema (HACE)

Table 4: The Lake Louise Consensus Definition Of HAPE Includes[31]

At least two of the following symptoms:

- Dyspnea at rest
- Cough
- Weakness or decreased exercise performance
- Chest tightness or congestion

And two of the following signs:

- Crackles or wheezing in at least one lung field
- Central cyanosis
- Tachypnea
- Tachycardia

High-altitude pulmonary edema (HAPE)

Table 4: The Lake Louise Consensus Definition Of HAPE Includes[31]

At least two of the following symptoms:

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- Weakness or decreased exercise performance
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And two of the following signs:

- Crackles or wheezing in at least one lung field
- Central cyanosis
- Tachypnea
- Tachycardia

High-altitude pulmonary edema (HAPE)

Most of the **deaths**

are caused

by a **trauma**

Prevention | Treatment

Planification

Medication

Technologies

Planification

Planification

Single

MOST

important

factor

Planification

Before

The time allowed to complete your trip
MUST be longer than the expected one

It is IMPOSSIBLE to save a significant amount of money without compromising your safety

Case report

Case report

Day 1 (3440 m) : Did not feel good

Case report

Day 1 (3440 m) : Did not feel good

Day 2 (3860 m) : Continued to climb, was feeling worst

Case report

Day 1 (3440 m) : Did not feel good

Day 2 (3860 m) : Continued to climb, was feeling worst

Day 3 (4410 m) : Used a horse to continue her ascension

Case report

Day 1 (3440 m) : Did not feel good

Day 2 (3860 m) : Continued to climb, was feeling worst

Day 3 (4410 m) : Used a horse to continue her ascension

Day 4 : Was not able to walk
Fell off the horse
Broke her wrist
Rescuers were called

Planification

During

Planification

During

Respect your body and
pay close attention to your symptoms

Planification

During

Respect your body and
pay close attention to your symptoms

Your position within the group should be the
same during the whole trip

During

Planification

Climb high, sleep low

Respect your body and
pay close attention to your symptoms

Your position within the group should be the same during the whole trip

Planification

WILDERNESS & ENVIRONMENTAL MEDICINE, 21, 146–155 (2010)

REVIEW ARTICLE

Wilderness Medical Society Consensus Guidelines for the Prevention and Treatment of Acute Altitude Illness

Andrew M. Luks, MD; Scott E. McIntosh, MD, MPH; Colin K. Grissom, MD; Paul S. Auerbach, MD, MS; George W. Rodway, PhD, APRN; Robert B. Schoene, MD; Ken Zafren, MD; Peter H. Hackett, MD

From the Division of Pulmonary and Critical Care Medicine, University of Washington, Seattle, WA (Drs Luks and Schoene); Division of Emergency Medicine, University of Utah, Salt Lake City, UT (Dr McIntosh); Division of Pulmonary and Critical Care Medicine, Intermountain Medical Center and the University of Utah, Salt Lake City, UT (Dr Grissom); Department of Surgery, Division of Emergency Medicine, Stanford University School of Medicine, Palo Alto, CA (Drs Auerbach and Zafren); College of Nursing and School of Medicine, University of Utah, Salt Lake City, UT (Dr Rodway); Bozeman Deaconess Hospital, Bozeman, MT (Dr Schoene); Himalayan Rescue Association, Kathmandu, Nepal (Dr Zafren); Division of Emergency Medicine, Altitude Research Center, University of Colorado Denver School of Medicine, Denver, CO (Dr Hackett); and Institute for Altitude Medicine, Telluride, CO (Dr Hackett).

1. Sleep the first night ⩽ 2750 meters

2. Climb a maximum of 500 meters per day

3. Sleep an extra night at the same altitude every 1000 meters

AMS → stay

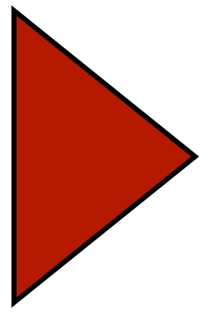
HACE → go down

HAPE → go down*

Medication

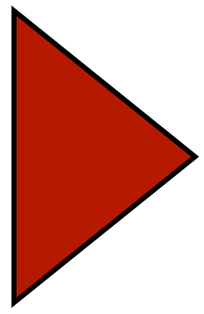
Medication

Acetazolamide
NSAID
Dexamethasone

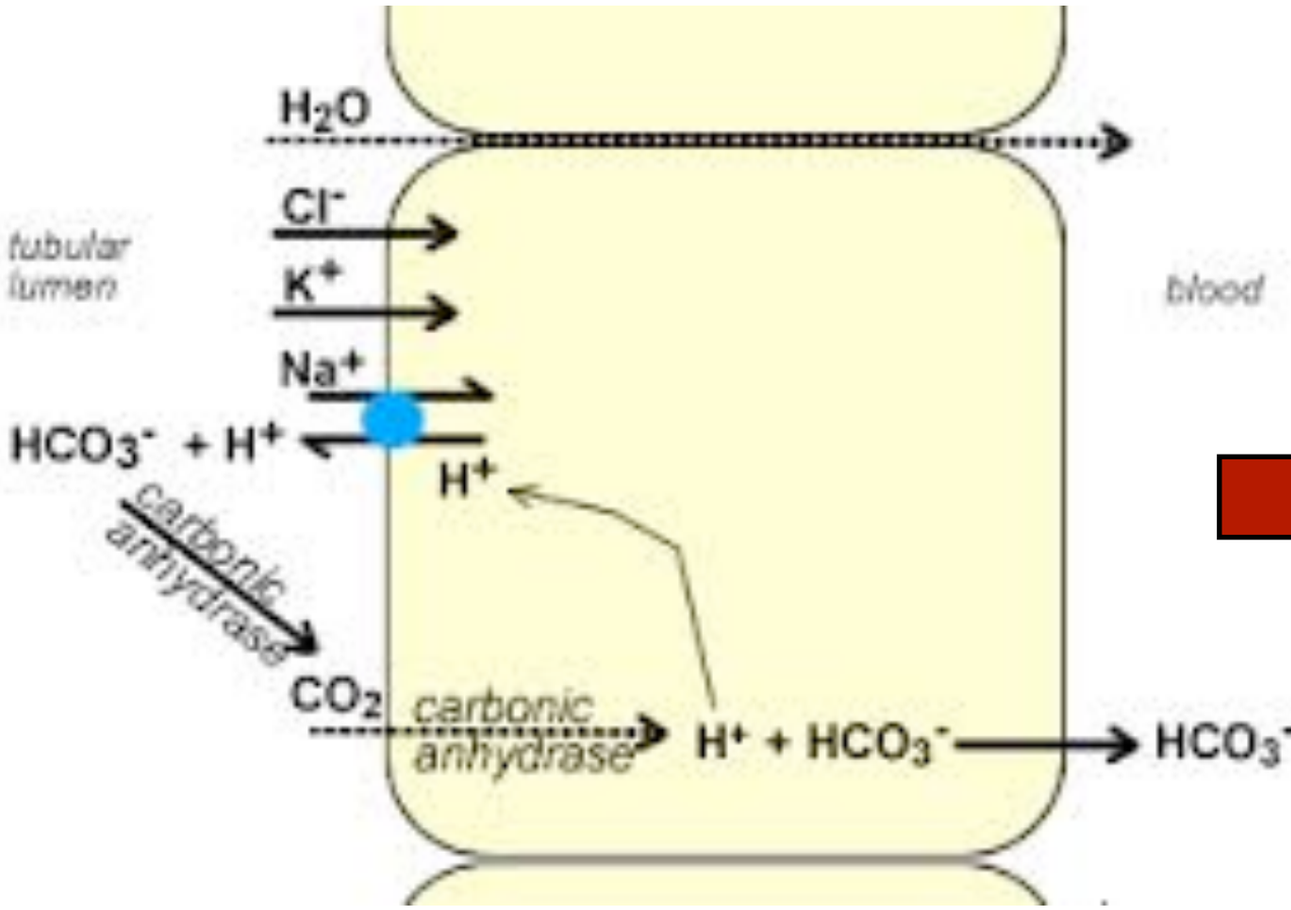


AMS/HACE

Nifedipine
5-phosphodiesterase inhibitors
Azithromycin



HAPE



Respiratory stimulant

Acetazolamide

AMS/HACE

BMJ

BMJ 2012;345:e6779 doi: 10.1136/bmj.e6779 (Published 18 October 2012) Page 1 of 14

RESEARCH

Identifying the lowest effective dose of acetazolamide for the prophylaxis of acute mountain sickness: systematic review and meta-analysis

OPEN ACCESS

Prophylaxis : 125 mg PO BID NNT = 8

Treatment : 500 mg PO BID

Acetazolamide

WILDERNESS & ENVIRONMENTAL MEDICINE, 23, 307–315 (2012)

ORIGINAL RESEARCH

Altitude Sickness in Climbers and Efficacy of NSAIDs Trial (ASCENT): Randomized, Controlled Trial of Ibuprofen Versus Placebo for Prevention of Altitude Illness

Jeffrey H. Gertsch, MD; Bryan Corbett, MD; Peter S. Holck, PhD; Allison Mulcahy, MD; Melanie Watts, MD; Nathan Thomas Stillwagon, MD; Amanda Morgan Casto, MD; Charles Hessel Abramson, MD; Charles Peter Aloysius Vaughan, MD; Christopher Macguire, MD; Neda Nicole Farzan, MD; Baotran Nguyen Vo, MD; Rebecca Jean Norvelle, MD; Kerstin May, MD; Jessica Elizabeth Holly, MD; Hillary Irons, MD; Aaron Michael Stutz, MD; Pradip Chapagain, MD; Siddhartha Yadav, MD; Matiram Pun, MD; Jeremy Farrar, BSc, MBBS, FRCP, DPhil, OBE; Buddha Basnyat, MD, MSc, FRCP(E)

AMS/HACE

Ibuprofen most studied

Efficacy ?
Prevention - Maybe
Treatment - Yes

NSAID

Only a few studies

Dexamethasone

AMS/HACE

Only a few studies

Efficacity proven for
prevention and treatment of AMS

Standard of care for HACE

Dexamethasone

AMS/HACE

Only a few studies

Efficacity proven for
prevention and treatment of AMS

Standard of care for HACE

Prevention of HAPE

Dexamethasone

AMS/HACE

HAPE

Nifedipine

WILDERNESS & ENVIRONMENTAL MEDICINE, 23, 7–10 (2012)

ORIGINAL RESEARCH

Nifedipine for the Treatment of High Altitude Pulmonary Edema

Rajesh Deshwal, MD, FHM; Mohd Iqbal, MD; Sidhant Basnet, MBBS

From the Department of Medicine, Military Hospital, Gangtok, Sikkim, India (Drs Deshwal, Iqbal, and Basnet).

HAPE

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Nifedipine

Controversial

HAPE

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Nifedipine

Controversial

No role in prevention
Maybe for treatment

HAPE

5-phosphodiesterase inhbitors

HAPE

Only one small RCT

5-phosphodiesterase inhbitors

HAPE

Only one small RCT

Maybe for prevention
Maybe for treatment

5-phosphodiesterase inhbitors

HAPE

Azithromycin

Absolutely no studies
but...

HAPE

Azithromycin

Absolutely no studies
but...

many clinicians think it works

Other medications

Furosemide
Prednisone
Salbutamol
Magnesium
Ginko bilboa

Avoid all substances that may interfere with the hypoxic ventilatory response

Technologies

Hypobaric chamber

Hypobaric chamber

NO scientific evidence

Dangerous !

Pulse oximetry

HIGH ALTITUDE MEDICINE & BIOLOGY
Volume 12, Number 2, 2011
© Mary Ann Liebert, Inc.
DOI: 10.1089/ham.2011.0013

Pulse Oximetry at High Altitude

Andrew M. Luks and Erik R. Swenson

Pulse oximetry

HIGH ALTITUDE MEDICINE & BIOLOGY
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DOI: 10.1089.ham.2011.0013

Pulse Oximetry at High Altitude

Andrew M. Luks and Erik R. Swenson

NO scientific evidence

Inaccurate
No correlation SpO2 - HAPE

WILDERNESS & ENVIRONMENTAL MEDICINE, **24**, 159–164 (2013)

REVIEW ARTICLE

Using Ultrasound Lung Comets in the Diagnosis of High Altitude Pulmonary Edema: Fact or Fiction?

Yashvi Wimalasena, BM, FCEM, DiMM; Jeremy Windsor, MBChB, DCH, FCARCS;
Mark Edsell, MBChB, FRCA, FFICM

From the Emergency Department. University Hospitals Coventry and Warwickshire (Dr Wimalasena) and the Birmingham Medical Research Expeditionary Society (Drs Wimalasena and Edsell), Birmingham; and University College London (Dr Windsor) and St George's Hospital London (Dr Edsell), UK.

Ultrasound

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Ultrasound

Maybe

Sensitive for HAPE
Specific ?

Eric-based medicine

Eric-based medicine

Planification is the key

Eric-based medicine

Planification is the key

Respect the ascension rate

Eric-based medicine

Planification is the key

Respect the ascension rate

Avoid sedatives

What to bring with you

What to bring with you

Acetazolamide

Dexamethasone

Nifedipine ?

Cipro/azithro

Immobilisation kit

Questions ?

Thank you