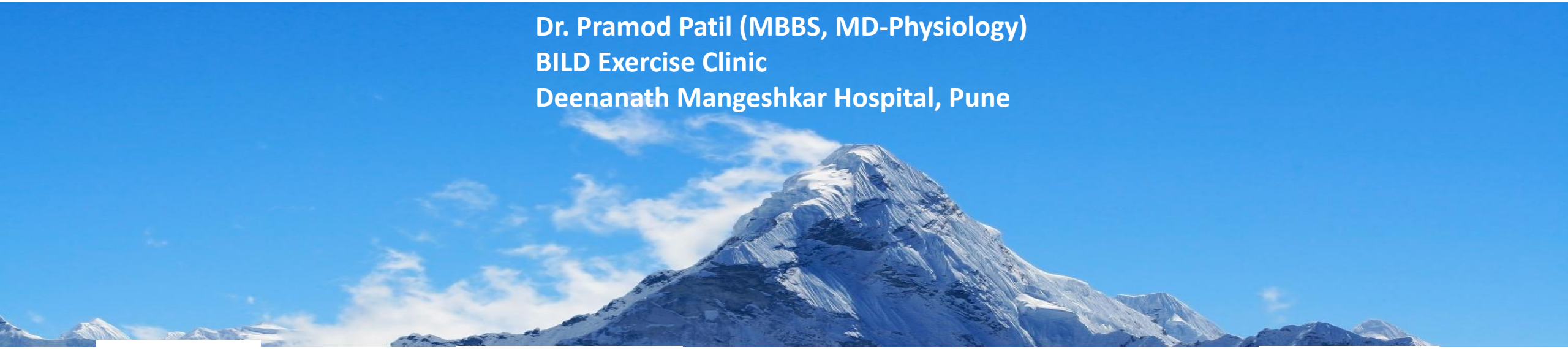
Acute Mountain Sickness (AMS)
High Altitude Pulmonary Edema (HAPE)
High Altitude Cerebral Edema (HACE)
Hypothermia
Cold injuries at High Altitude
Ophthalmic injuries at High Altitude (Snow blindness)



Dr. Pramod Patil (MBBS, MD-Physiology)
BILD Exercise Clinic
Deenanath Mangeshkar Hospital, Pune

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VBS MANI HYPOXIC TRAINING CENTER
Deenanath Mangeshkar Hospital, Pune

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Acute Mountain Sickness (AMS)

Dr. Pramod Patil (MBBS, MD-Physiology)
BILD Exercise Clinic
Deenanath Mangeshkar Hospital, Pune

Symptoms - Acute Mountain Sickness (AMS)

- Headache
- Dizziness
- Anorexia
- Nausea
- Vomiting
- Fatigue

Symptoms-
Acute Mountain Sickness (AMS)

Headache is a cardinal feature

- Bilateral
- Mild to moderate
- Throbbing or pulsatile
- Diffuse
- Aggravated by movement, bending forward, coughing, Valsalva maneuver (Silber et al. 2003)

Signs of AMS

- There are no physical examination findings specific to AMS.
- No consistent changes in BP.
- Singh et al. 1969 found bradycardia in two thirds of soldiers with AMS between 3350 m and 5490 m.
- Crackles on auscultation and peripheral edema found in both AMS and HAPE (Hackett and Rennie 1979).
- Increased body temperature by 0.5^0 C and 1.2^0 C (Maggiorini et al. 1997).
- Decreased body temperature by 1.7^0 C (Loeppky et al. 2003).
- Lower $S_p O_2$ (Basnyat et al. 1999) but seen in non-AMS too.

Factors affecting possibility of developing AMS

1) Rate of ascent (slower the better)
2) Genetic predisposition (can not be concluded)
3) Exercise capacity & fitness (not-related, but fitness is important)
4) Physical activity following arrival (exertion and complete rest are not good)
5) Age (no correlation)
6) Sex (no correlation)
7) Body habitus (obesity is bad)
8) Smoking (not good)
9) History of migraine headaches (not good)
10) Ventilatory response to hypoxia (better response, good it is)
11) Blood gas exchange (better blood gas exchange, better it is)

Understanding clinical features of AMS

1) Altitude of onset (more is worst)
2) Time course (few hours to start)
3) Predicting who will develop AMS
4) Pathophysiology of AMS
5) Prevention of AMS (non-pharmacological, pharmacological prophylaxis)
6) Treatment of AMS (pharmacological, subsequent action)
7) Future trips to high altitude

Which symptoms are not the cardinal features of AMS

- Disturbed sleep
- Diarrhea
- Pulmonary symptoms- Cough and dyspnea (HAPE)
- Altered mental status (HACE)
- Ataxia (HACE)
- Focal neurological deficit (HACE)

Assessment of Acute Mountain Sickness (AMS)

1) Lake Louise AMS Score (Roach et al. 1993; Roach et al 2018)
2) Environmental Symptoms Questionnaire (Sampson et al. 1983)
3) Chinese study scoring system (Ren et al. 2010)

Differential diagnosis for signs and symptoms compatible with AMS or HACE

- Acute psychosis
- Acute toxic encephalopathy due to substance ingestion
- Alcohol handover
- Carbon monoxide intoxication
- Cerebrovascular accident
- Dehydration
- Encephalitis

Differential diagnosis for signs and symptoms compatible with AMS or HACE

- Hypoglycemia
- Hyponatremia
- Hypothermia
- Meningitis
- Migraine headache
- Physical exhaustion
- Ruptured intracranial aneurysm or arteriovenous malformation

Predicting who will develop AMS

- Very challenging

- **Richalet et al. 2012 model (Severe AMS, HACE, or HAPE)**

1) Prior history of severe altitude illness
2) A history of migraine headaches
3) Decreased ventilatory responses during hypoxic exercise
4) Desaturation > 22 % during hypoxic exercise

AMS prevention

- Non-drug based
- Drug based

AMS management

- Non-drug based
- Drug based

Prevention of AMS- Non-drug measures

1) Rate of ascent
2) Staged ascent and pre-acclimatization
3) Hypoxic tents
4) Other measures that may be effective
5) Ineffective measures (Dietary intake, Preventing dehydration)

Prevention of AMS- Non-drug measures
Rate of ascent

- Rate at which one increases their sleeping elevation.
- Wilderness Medical Society (Luks et al. 2019): After 3000 m, they should not increase the sleeping elevation by more than 500 m per day.
- Only one RCT (Bloch et al. 2009)- slower ascent had lower symptom severity and greater chance of summit success.
- Limitations of guidelines are that on major climbing routes the sleeping locations are not necessarily laid in at 300-500 m intervals and logistical factors often mandate faster ascent.
- There is marked variability between protocols followed.

Prevention of AMS- Non-drug measures
Other measures that may be effective

- Avoid alcohol (lacks evidence)
- Avoid caffeine (lacks evidence)
- Abrupt stopping of caffeine produce withdrawal symptoms resembling AMS (Hackett 2010).
- Avoid opiate pain medications (lacks evidence)- respiratory depression
- NIPPV (non-invasive positive pressure device) during sleep improves nocturnal oxygen saturation and decreases AMS symptoms (Johnson et al. 2010).

Prevention of AMS- Non-drug measures
Measures with no clear evidence

Dietary intake

No effect of ingestion of CHO rich diet (Lawless et al. 1999; Swenson et al. 1997).

No effect of ingestion of beetroot juice (Cumpstey et al. 2017; Hennis et al. 2016; Masschelein et al. 2012; Rossetti et al. 2017b)

Preventing dehydration

Retrospective data collection study found protective role of hydration (Basnyat et al. 1999)

No difference (Aoki and Robinson 1971; Castellani et al. 2010)

AMS was more common in those with positive net water balance (Gatterer et al. 2013; Richardson et al. 2009)

Prevention of AMS-
Drug based (prophylaxis)

1) Who warrants prophylaxis?
2) Primary options for prophylaxis
3) Medications lacking clear benefits

Prevention of AMS- Drug based
Who warrants prophylaxis?

Based on

1) Patient's prior history of acute altitude illness
2) Planned sleeping elevation on first night at high altitude
3) Rate of ascent once above 2500 m
4) Prior history of HACE and HAPE
5) Number of planned rest days
6) Use of pre-acclimatization strategies

Luks et al. 2019 published guidelines for risk stratification
Low risk= no medications.
Moderate to high risk= should strongly consider medications

Prevention of AMS-

Drug based Primary options for prophylaxis

Medication	Age group	Dose for prevention
Acetazolamide	Adults	125 mg every 12 hours
	Pediatrics	2.5 mg kg^{-1} every 12 hours to max 125 mg per dose
Dexamethasone	Adults	2 mg every 6 hours or 4 mg every 12 hours
	Pediatrics	Not used for prevention in children

Acetazolamide (Diamox)

- Primary option
- Mechanism of action:
- Block carbonic anhydrase enzyme
- Respiratory stimulant by promoting excretion of bicarbonate in the kidneys causing metabolic acidosis that counteracts the respiratory alkalosis that arises due to hypoxic ventilatory response and slows the rise in minute ventilation.
- Benzolamide – selective inhibitor of renal carbonic anhydrase with no cerebral action, decreases the incidence of periodic breathing (Swenson et al. 1991) and prevents AMS (Collier et al. 2016).
- In the brain it blocks brain vascular endothelial carbnic anhydrase preventing conversion of carbon diaoxide to bicarbonate causing rise in tissue PCO2 near the central and peripheral chemoreceptors that stimulate the increase in minute ventilation (Swenson and Teppema 2007).
- Increases hydrogen ion concentration in the central chemoreceptors which counteracts the inhibitory effects of respiratory alkalosis (Leaf and Goldfarb 2007; Swenson 1998; Swenson and Teppema 2007).
- Use discovered by Cain and Dunn (1965)- increases ventilation and PaO2, decreases PaCO2.
- Many RCTs found useful (Forwand et al. 1968; Larson et al. 1982; van Patot et al. 2008)
- Appropriate dose is subject of debate (Dumont et al. 2000; Kayser et al. 2012)
- Recent studies report 125 mg every 12 hours is sufficient (Basnyat et al. 2006; van Patot et al. 2008)
- Recent studies 62.5 mg every 12 hours is sufficient (McIntosh et al. 2019)

Acetazolamide (Diamox)

- Medication is best started the day before ascent to high altitude, although it can also have a protective effect if started on the day of ascent (Lipman et al. 2019)
- Usually last dose is taken on the day of summit.
- Dose can be adjusted based on ascent rate.
- Side effects

1. Paraesthesias in hands and feet
2. Altered taste of carbonated beverages (due to blocking of carbonic anhydrase on the tongue which blocks conversion of CO_2 to carbonic acid preventing stimulation of acid sensing buds.
3. Mild diuresis (volume and frequency)
4. Sulfa moiety (sulfa allergy alert) (Kelly and Hackett 2010; Luks and Swenson 2008)
5. Caution raised over adverse effect on exercise in both normoxia (Gonzales and Scheuermann 2013) and hypoxia (Elisabeth et al. 2017) but no consistent data (Posch et al. 2018)
6. Caution has been raised on its psychomotor function (Collier et al. 2016; Wang et al. 2013)

Those who haven't tried medication before can try it for 48 hours at home before starting the journey.

Dexamethasone

- For individuals with allergy or intolerance to acetazolamide dexamethasone is better option.
- Several RCTs have been proven beneficial (Ellsworth et al. 1987; Ellsworth et al. 1991; Johnson et al. 1984).
- For highly susceptible individuals, the combination of acetazolamide and dexamethasone may be more effective (Bernhard et al. 1998).
- It should be avoided as prophylaxis in case of children.

Dexamethasone

- Exact mechanism is not clear.
- More useful in individuals rapidly accenting to altitudes higher than 3000 m for a rescue.
- Not to be used as a prophylaxis for more than 7 or 10 days.
- While stopping it has to be tapered off, rather than abrupt stoppage to avoid problems with adrenal suppression (Addisonian crisis can develop (Subedi et al. 2010)

Ibuprofen

- Ibuprofen can prevent AMS (Gertsch et al. 2012; Gertsch et al. 2010; Lipman et al. 2012)
- 600 mg dose every 8 hours starting six hours prior to ascent.
- It is not more effective than acetazolamide (Burns et al. 2018; Gertsch et al. 2010)
- It is not safe with respect to GI bleeding in the first few days at high altitude (Fruehauf et al. 2019)
- Has not been adopted as part of consensus guidelines for prevention of altitude illness (Luks et al. 2019)

Medications lacking clear preventive benefits

Budesonide

Effective (Zheng et al. 2014; Chen et al. 2015)

Not effective (Berger et al. 2017; Lipman et al. 2018)

Ginko biloba **(herbal extract)**

Effective (Moraga et al. 2007; Roncin et al. 1996)

Not effective (Chow et al. 2005; Gertsch et al. 2004)

No standardization of concentration and dose etc.

Spironolactone

Conflicting data (Basnyat et al. 2011; Kupper et al. 2008)

Medications lacking clear preventive benefits

Sumatriptan

May be effective (Jafarian et al. 2007)

Antioxidant

Not effective (Baillie et al 2009)

Coca

No evidence (Salazar et al. 2012)

Non-drug measures for AMS

Avoid further increases in their sleeping elevation.

Descent to lower elevation remains the single best treatment.

Rest at elevation is best (Bartsch et al. 1993a).

Rehydrate to eliminate elements of dehydration that can mimic AMS

Eliminate hyponatremia.

Supplemental oxygen may not be needed in majority of individuals.

Hyperventilation or pursed lip breathing is theoretical.

Hyperbaric chambers are effective (Bartsch et al. 1993a; Keller et al. 1995) should be sustained for many hours. Rarely needed for AMS.

Drug measures for AMS

- Acetaminophen (no RCTs)- effective (Broome et al. 1994; Harris et al. 2003).
- Antiemetics
- Individuals not responding to conservative treatment can be added with acetazolamide and/or dexamethasone.
- Both agents can be used to treat AMS in children (Pollard et al. 2001)
- Dexamethasone is a faster, more reliably effective treatment for any degrees of AMS (Luks et al. 2019)

Primary options for AMS Treatment

Medication	Age group	Dose for treatment
Acetazolamide	Adults	250 mg every 12 hours
	Pediatrics	2.5 mg kg^{-1} every 12 hours to max 125 mg per dose
Dexamethasone	Adults	4 mg every 6 hours
	Pediatrics	0.15 mg kg^{-1} every 6 hours to maximum of 4 mg per dose

Future trips to high altitude

- There is no exact association between previous AMS and future AMS.
- Learn your tolerance if you are a frequent travelers.
- Ego is the biggest hurdle in taking wise decision.
- Experienced individuals can decide rate of ascent on their experience.

High Altitude Pulmonary Edema (HAPE)

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HIGH ALTITUDE PULMONARY EDEMA(HAPE)

HAPE is a life threatening condition. The main cause is increase in Pulmonary Artery pressure and fluid collection in the lungs.

Risk Factors

- Rapid ascent above 3000m
- Physical exertion
- History of previous AMS or HAPE

HIGH ALTITUDE PULMONARY EDEMA(HAPE)

Symptoms

Breathlessness at rest

Productive cough with pink frothy expectoration

Palpitation

Chest tightness

Weakness and decrease exercise performance.

Usually within 3-5 days at high altitude.

Signs

Central cyanosis (bluish discoloration in lips & tongue).

Increase heart rate & respiratory rate.

Lung crackles

Wheezing.

HIGH ALTITUDE PULMONARY EDEMA(HAPE)

Treatment

Evacuation to lower altitude - a descent of at least 1000m.

Drugs

Tab Nifedipine 20mg given 8 hourly or 30mg given 12 hourly.
Oxygen is provided by a face mask at a rate sufficient to maintain SpO2 > 90%.

Hyperbaric Bag

Placed in Portable one man recompression bag.

Inflate the bag to 130 mmHg (this reduce altitude by 6000ft).

Bring patient out of bag 2 hourly for 15-20min and monitoring done.

High Altitude Cerebral Edema (HACE)

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HIGH ALTITUDE CEREBRAL EDEMA (HACE)

- HACE represent extreme stage of AMS.
- Usually occurs at elevations above 4000m but may seen above 2500m also and is more common in unacclimatised individuals.
- HACE once present progresses rapidly and can be fatal in matter of hours.
- Fluid leakage into the brain tissue leads to cerebral oedema.

HIGH ALTITUDE CEREBRAL EDEMA (HACE)

Symptoms

- Symptoms develop over 1-3 days.
- Usually in combination with HAPE or AMS, suspect if any patient develops ataxia or alteration in consciousness.
- Changes in mental state & behaviour, confusion, hallucination, blurring of vision.
- Characteristic loss of co-ordination of movements.

HIGH ALTITUDE CEREBRAL EDEMA (HACE)

Treatment

Descent

- Immediate and rapid descent, for at least 1000m and continue descent until symptoms improve.

Oxygen administered

A face mask at the rate sufficient to maintain SpO2 > 90%.

Dexamethasone

Intramuscular/Intravenous 8mg once followed by 4mg every 6 hours must be started.

Hypothermia

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HYPOTHERMIA

Hypothermia is defined as decrease in core body temperature below 35°C.

Risk Factors

Injury
Blood loss
Alcohol, low sugar level in blood
Old age
Malnutrition
Physical exhaustion
Wetness
Duration of exposure to low temperature/wind speed
Inadequate clothing
Submersion in cold water.

HYPOTHERMIA

Mild Hypothermia

Body Temperature 32-34°C.

Reversible.

Symptoms

Shivering due to tensed muscle

Fatigue

Weakness

Skin is pale

Patient is alert

Increase respiratory rate & heart rate.

HYPOTHERMIA

Moderate Hypothermia

Body Temperature 32-28°C

Symptoms

Marked muscular rigidity and stiff movements
Mental confusion
Speech becomes slow & slurred
Skin is cold
Breathing becomes shallow & slower
BP not detectable
Patient is very weak
Drowsy and gradual loss of consciousness.

HYPOTHERMIA

Severe Hypothermia

Body Temperature<28°C

Symptoms

Deep coma- no apparent breathing

Heart activity stops

Patient become unconscious and may appear dead.

HYPOTHERMIA

Treatment

Passive external rewarming (prevent heat loss) and supportive care.
Remove wet clothing
Warm blanket
Protection from wind
Use of hot water bottle around arms, neck, chest and groin area.
Maintenance of airway
Give Oxygen
CPR after rewarming.

Cold injuries at High Altitude

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Cold injuries at High Altitude

Freezing

Frost bite

Non-freezing

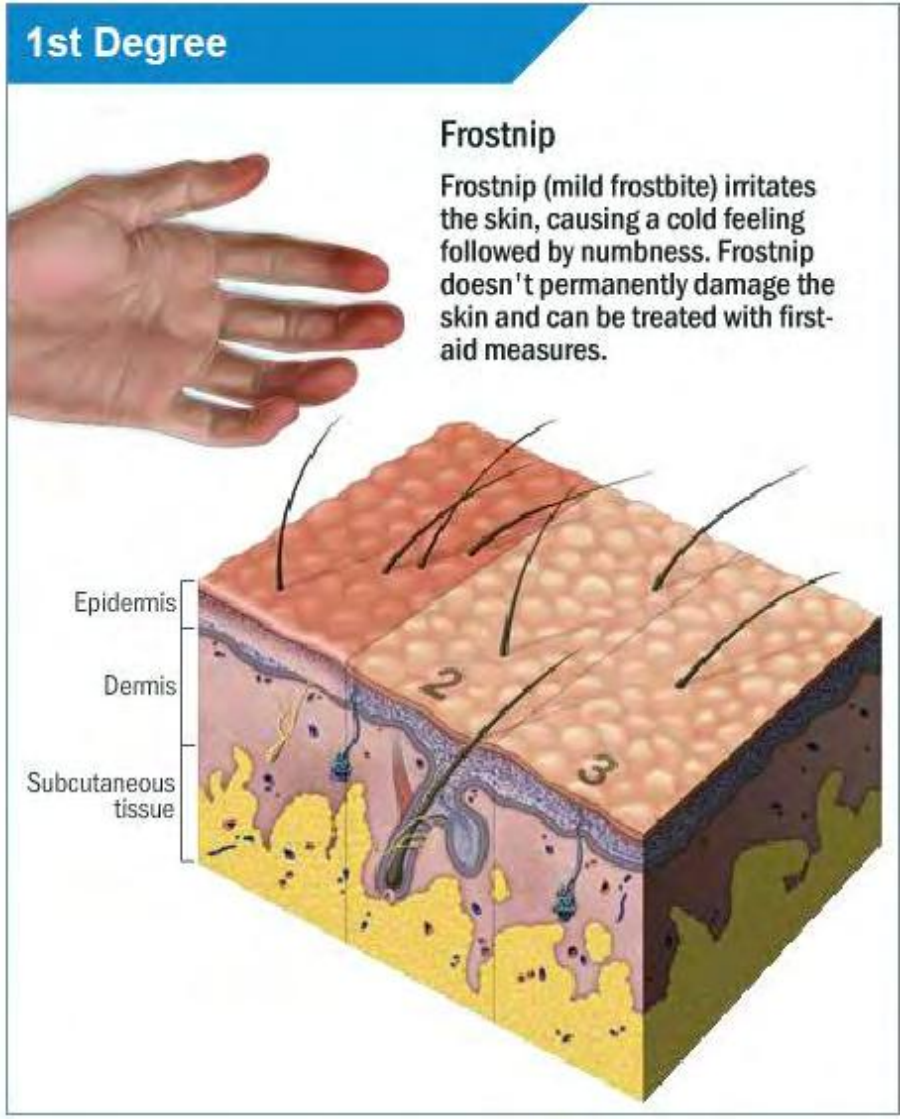
Chillblains

Trench foot

FROST BITE

- Actual freezing of tissues which are more exposed to cold temperature.
- Common are distal parts like nose, earlobes, hands and feet.
- This occurs as a result of prolonged freezing, causing ischemic injury by constriction of blood vessels and capillary stasis.

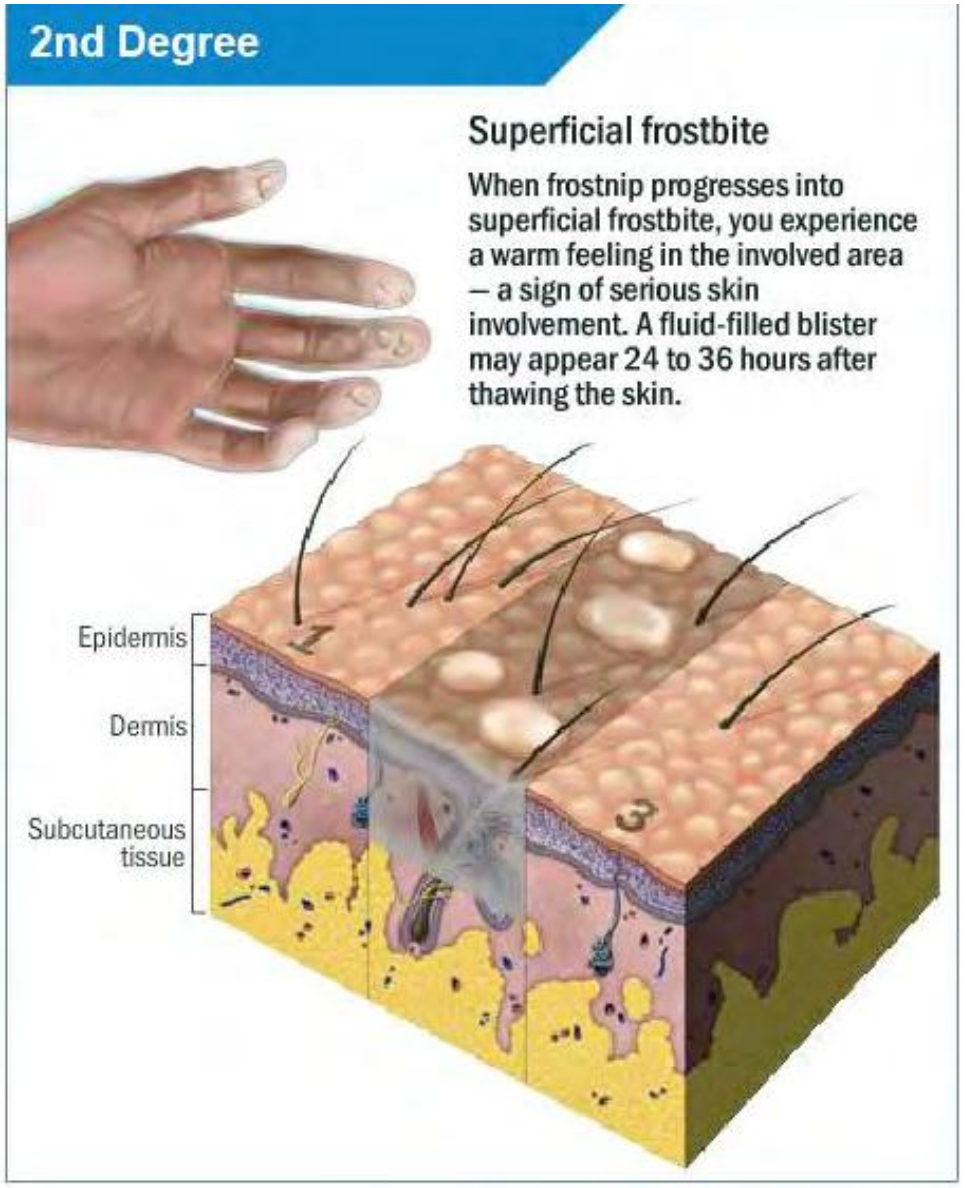
1st Degree



Superficial skin freezing.

Present with oedema and redness.

2 nd Degree



Full thickness skin freezing,

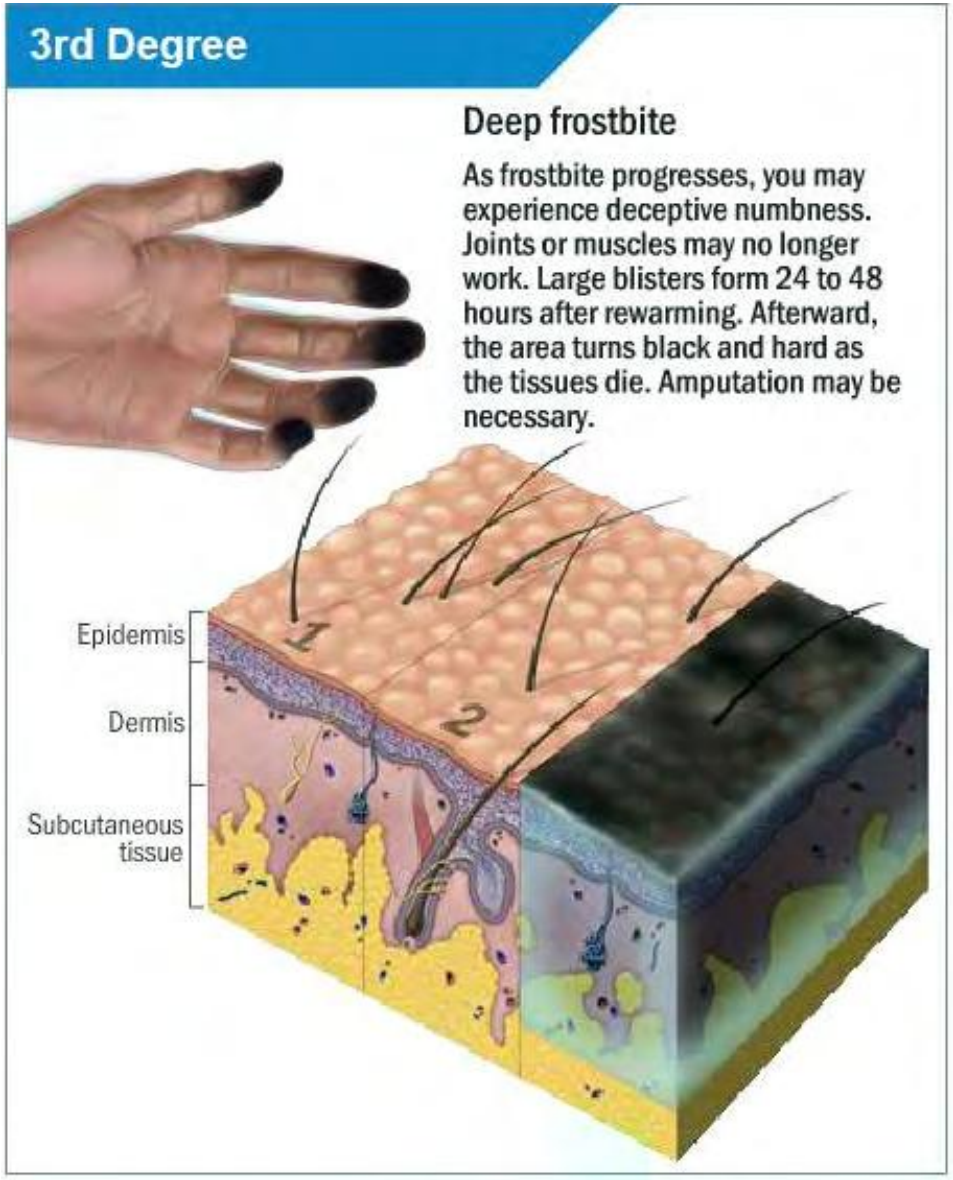
Pale skin,

Blister formation with clear fluid,

Numbness, tingling pain,

Eschar (piece of dead tissue) form in 2-4 weeks.

3 rd Degree



Complete skin necrosis and subcutaneous tissue freezing.

Blue-grey discoloration.

Loss of sensation

Gangrene (tissue death/decaying) formation. Some tissue loss seen.

FROST BITE Treatment

Treatment

- Initially rapid rewarming in a water bath at a temperature of 39-42°C with avoidance of refreezing.
- Protect the part from further injury by padding all affected areas, loosely wrap with gauze and elevation of affected part,
- Analgesic- IV opioids is administered,
- Smoking is prohibited,
- Medical management - Nifedipine, Pentoxifylline 400mg thrice daily and
- Ibuprofen is given.
- Surgical management-Amputation done only after full separation of gangrenous tissues

CHILLBLAINS

It is the mildest form of cold injury.

Occurs from exposure to moisture and temperatures of 0-15°C for 3-6 hours.

Symptoms

Presents with swelling, red- ness, burning and itching.

Signs

Edema and tenderness

Parts affected

Hands and Feet.

CHILLBLAINS

Treatment

Treated accordingly to the symptoms.

Rapid rewarming

Analgesics

Application of Vaseline.

Prevention

Avoid exposure.

TRENCH FOOT

- Prolonged immersion in cold water.
- Exposure to temperatures ranging 0-10°C for duration of 10-12 hours.
- Occurs as a result of wetness, stagnant blood circulation, alternate cooling and warming due to temperature fluctuations.

Symptoms

Itching

Irritation and pain

Swelling

Heavy feeling in the foot

TRENCH FOOT

Signs

Extensive oozing from tissues & Swelling

Blister formation

Nerve damage present

Treatment

Dry dressing

Remove wet clothes

Rewarming

Avoid exposure

Treat the infections if occurred.

Ophthalmic injuries at High Altitude (Snow blindness)

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SNOW BLINDNESS

High altitude permits an increased degree of direct solar radiation reflected from the snow.

Snow reflects up to 90% UV radiation.

Exposure of the eyes to UV radiation leads to direct corneal injury known as Snow Blindness.

An inflammation response occurs, which includes oedema and congestion of exposed part of the eye-conjunctiva and cornea.

SNOW BLINDNESS

Symptoms

Symptoms usually appear 6 to 12 hours after exposure.

Discomfort on exposure to light, foreign body sensation in eye.
Uneasiness, pain, excessive watering & blindness in severe exposure.

Signs

Conjunctiva- congestion seen and edema, cornea- ulceration occurs.

SNOW BLINDNESS

Protection

Wear dark goggles when outdoors, **especially in cloudy weather.**

Treatment

It comprises use of artificial tears and overnight patching of the eye in order for the cornea to heal.

Analgesics are given.

Healing usually occurs within 36 to 72 hours.

Thank you

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