Rescue at Very High Altitude Project

ICAR Congress -Greece - October 2024

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International Commission for Alpine Rescue

CMH HELI SKIING

ACMG
Association of Canadian Mountain Guides
Association canadienne des guides de montagne

Avalanche Canada

CANADIAN SOCIETY OF MOUNTAIN MEDICINE

UNIVERSITY OF CALGARY
CUMMING SCHOOL OF MEDICINE

Parks Canada Parcs Canada

Mount Logan

5959m


Project Timeline
CAR MedCom
lontreux,
witzerland (OCT
022)
Brainstorming topics for discussion Development (Nov- Dec 2022)
Rough Draft (Jan -Sept. 2023)
Presented update ICAR Toblach (Oct 2023)
Divide Project into 4 papers & research protocols developed (Oct-Dec 2023)
Helicopter Rescue paper and O2 + Pharm prophylaxis (Jan -Sept 2024)
Rough Drafts (Sept 2024)

THANK YOU TO ALL OF OUR CONTRIBUTORS

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TER COM

MOUNTAINEERS

PILOTS

GUIDES

10 Countries

SUPPLEMENTAL OXYGEN AND PHARMACOLOGIC PROPHYLAXIS FOR RAPID ASCENT TO VERY HIGH AND EXTREME ALTITUDES

McLaughlin, Paal, Falla, Strapazzon, Luks, Zafren Brugger, Musi, Tomazin, Roy

Target Journal: High Altitude Medicine & Biology

Questions:

1. O2 for rapid ascent > 3500 m?

2. Pharmacologic prophylaxis (Acetazolamide, Dexamethasone, Nifedipine, Tadalaphil) for rapid ascent > 3500m?

3. Application in Terrestrial Rescue?

4. Application in Helicopter Rescue?

Supplemental Oxygen and Pharmacological Prophylaxis for Rapid Ascent Rescue to Very High and Extreme Altitudes - a scoping review

Kyle McLaughlin[1,2], Peter Paal[2,3], Marika Falla[2,4], Giacomo Strapazzon[2,4], Andrew M. Luks[5], Ken Zafren[2,6], Hermann Brugger[2,4], Martin Musi[2,7], Iztok Tomazin[2,8], Steve Roy[2,10]

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TERMS OF REFERENCE:

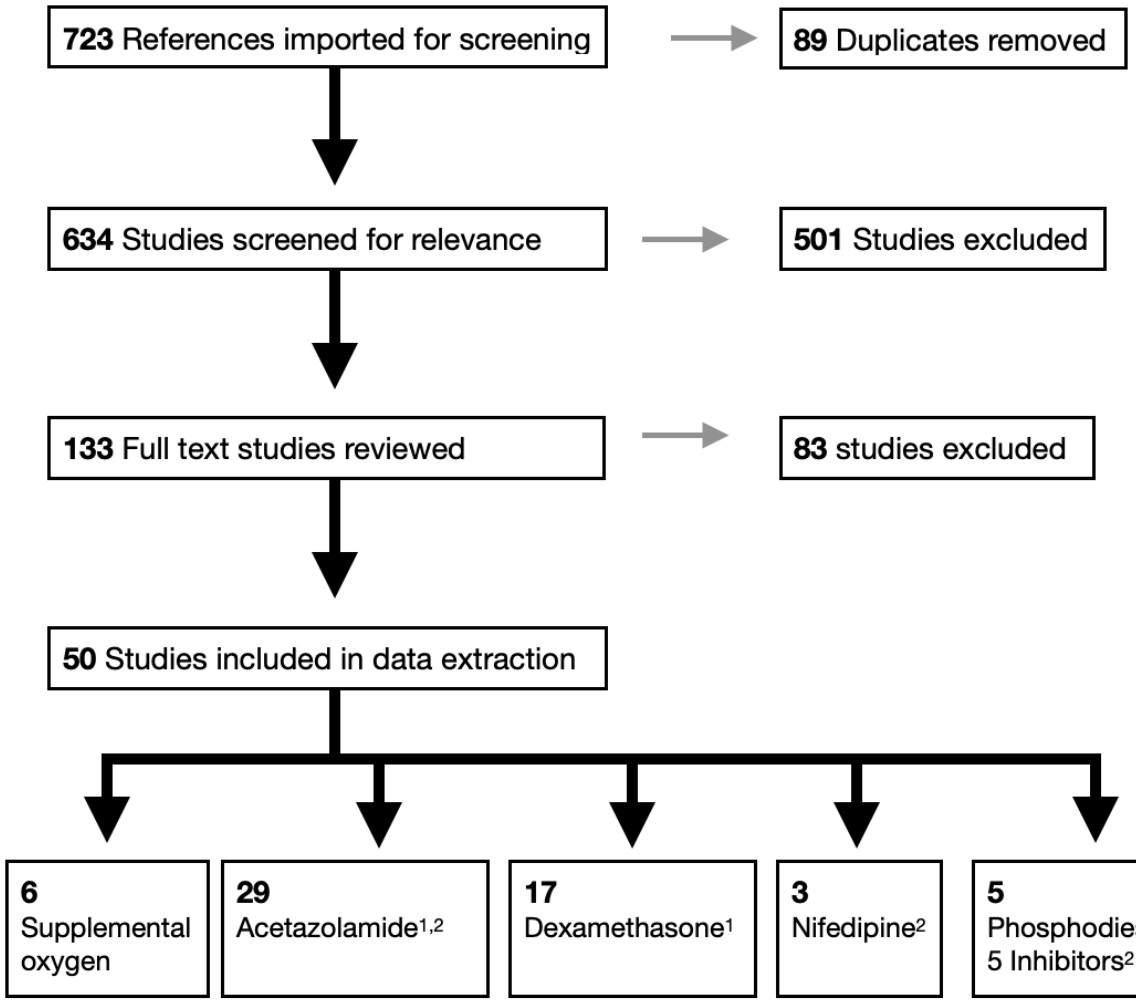
RAPID ASCENT: >300 M/DAY

VERY HIGH ALTITUDE: 3500 m - 5500 m (5000 m)

EXTREME ALTITUDE: >5500 m (5000 m)

METHODS

- RCT or Observational studies
- Elevation >3500 m
- Ascent rate >300 m/day



1. 8 studies were included in both Acetazolamide and Dexamethasone data tables.
2. 1 study was included in acetazolamide, Nifedipine and Phosphodiesterase-5 Inhibitor data tables

SUPPLEMENTAL OXYGEN

Canadian Transport Agency[a]:

- Oxygen required for:
  - Aircraft operators (pilots) and all occupants flying to altitudes of 10000 ft (3048 m) to 13000 ft (3962 m) for flights longer than 30 min
  - Aircraft operators (pilots) and all occupants flying above 13000 ft (3962 m) for any duration

Federal Aviation Agency (USA)[b]:

- Oxygen required for:
  - Aircraft operators (pilots) flying to altitudes of 12500 ft (3810 m) to 14000 ft (4267 m) for flights longer then 30 min.
  - Aircraft operators (pilots) flying to altitudes above 14000 ft (4267 m) for any duration
  - Aircraft operators (pilots) and all occupants above 15000 ft (4572 m) for any duration

European Union Aviation Safety Agency (EASA)[c]:

- No Oxygen is necessary between 13000-16000 ft (3962 - 4877m) if:
  - Duration <30 min,
  - Pilot is experienced conducting operations at high altitude without supplemental oxygen,
  - Pilots and crew are acclimatized, and
  - Pilot and crew have received training in hypoxia.
- Oxygen is required for:
  - Aircraft operators (pilots) and all occupants flying to altitudes of 13000 ft (3962 m) to 16000 ft (4877 m) for flights longer then 30 min.
  - Aircraft operators (pilots) and all occupants flying above 16000 ft (4877 m) for any duration

SUPPLEMENTAL OXYGEN

Recommendations

1. **During Flight:** Follow aviation regulations. If a regulation is not available, O2 for: (strong recommendation, moderate-quality evidence)
    1. Optional for short duration <30 min flights above 4000 m.
    2. Recommended for longer duration >30 min flights between 3500-4000 m.
    3. Mandatory for any duration above 4000 m

2. **Rescuers on the ground after helicopter rapid ascent:** Same as above for rescuers on the ground or on long-line for HEC missions. (strong recommendation, moderate-quality evidence)

3. **Terrestrial Rescuers approaching patients by ground:** Consider oxygen when rapidly ascending >3500 m, if resources allow. (weak recommendation, moderate-quality evidence)

4. If supplemental oxygen is being used, pharmacologic prophylaxis is not needed. (strong recommendation, low-quality evidence)

ACETAZOLAMIDE FOR AMS/HACE PROPHYLAXIS

Recommendations

1. AZ 250 mg every 12 h for rapid ascent rescue to 3500-5000 m if the duration expected to exceed 3 h and immediate deployment is not required. (Strong recommendation, high quality evidence)

2. Start AZ as soon as notified, ideally the day before ascent. (Strong recommendation, moderate-quality evidence)

3. Continue AZ during the rescue for 2-4 d or until descent, whichever comes first. (Strong recommendation, low-quality evidence)

4. Avoid AZ in rescuers with prior anaphylaxis or Stevens-Johnson syndrome caused by sulfonamides. (Strong recommendation, low-quality evidence)

DEXAMETHASONE FOR AMS/HACE PROPHYLAXIS

Recommendations

1. DEX 4 mg every 6 h above 3500 m for > 3 h and immediate deployment is required. (Strong recommendation, moderate-quality evidence)

2. Az + DEX when >5000 m for >3 hours. (Strong recommendation, high quality evidence)

3. If prolonged time at altitude is unavoidable, continue DEX for 2-4 d or until descent, whichever comes first. (Strong recommendation, low-quality evidence)

4. DEX should be tapered slowly rather than stopped abruptly when used for more than 7 d (Strong recommendation, high-quality evidence)

NIFEDIPINE FOR HAPE PROPHYLAXIS

Recommendations

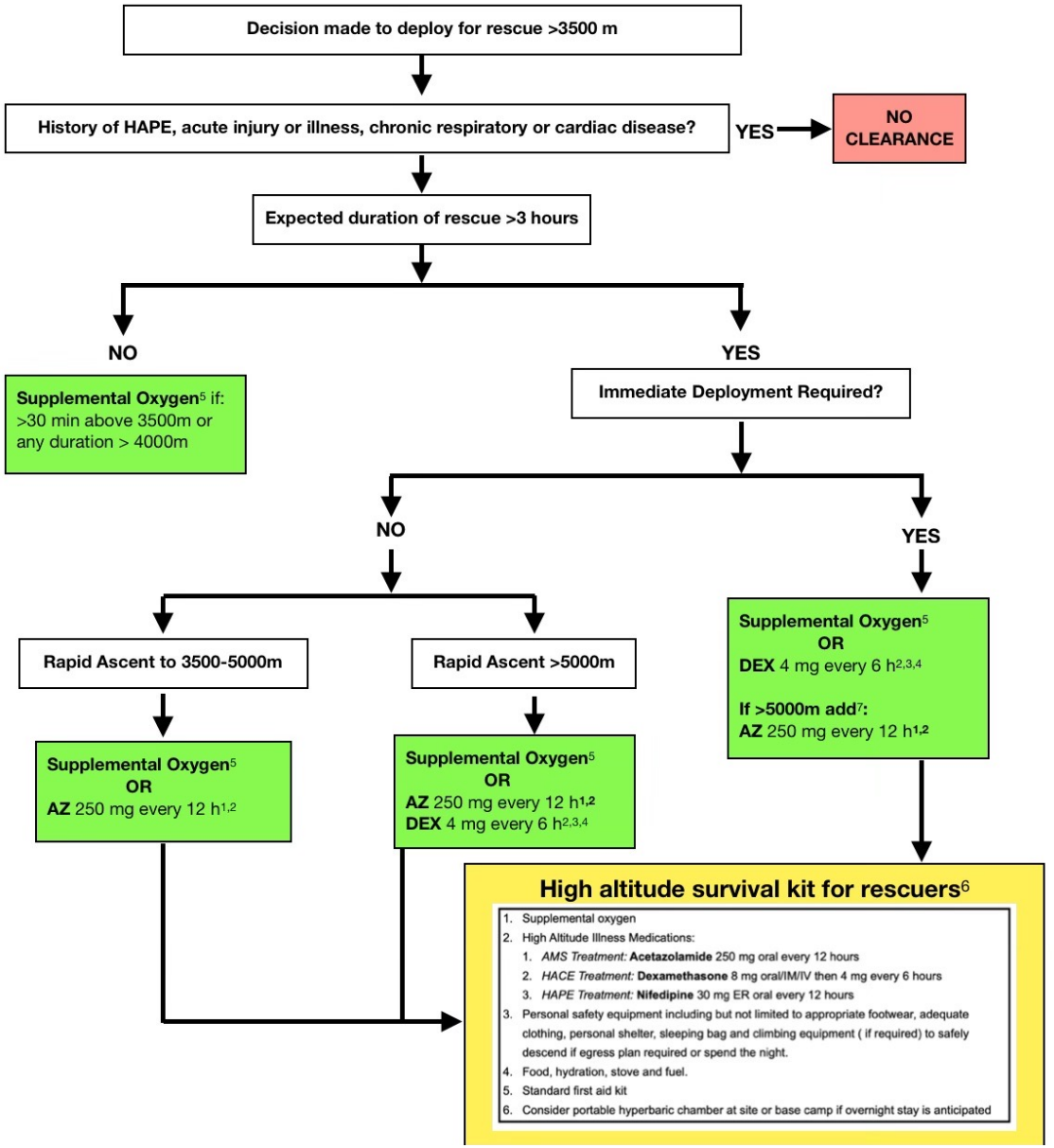
1. Rescuers with a history of HAPE should avoid rescue missions with rapid ascent above 3500 m. (Strong recommendation, low-quality evidence)
2. Rescuers with a history of HAPE who must rapidly deploy above 3500 m for rescue should use NIF 30 mg SR every 12 h or 20 mg SR every 8 h. (Strong recommendation, high-quality evidence)
3. Rescuers with a history of HAPE who are unable to take NIF and must rapidly deploy to above 3500 m should use Tadalafil 10 mg every 12 hours (weak recommendation, low quality evidence)
4. Avoid concurrent use of NIF and PDE-5I (Strong recommendation, high quality evidence)

ALGORITHM: RAPID ASCENT RESCUE > 3500M

CONCEPTS THAT INFLUENCED ALGORITHM:

1. Acetazolamide, Dexamethasone reduces AMS incidence and severity
2. Acetazolamide has slower onset of action then Dexamethasone
3. Nifedipine has strong evidence for HAPE prevention in subjects with previous HAPE
4. Tadalaphil is not superior then Nifidepine but can be used as an alternative
5. AMS typical onset is 6-12 hours - arbitrary time of 3 hours chosen for duration to initiate pharmacologic prophylaxis
6. HACE incidence is elevated > 5000m, therefore combine Acetazolamide and Dexamethasone
7. Pharmacologic prophylaxis is not required if supplemental oxygen is being used

ALGORITHM: RAPID ASCENT RESCUE > 3500M



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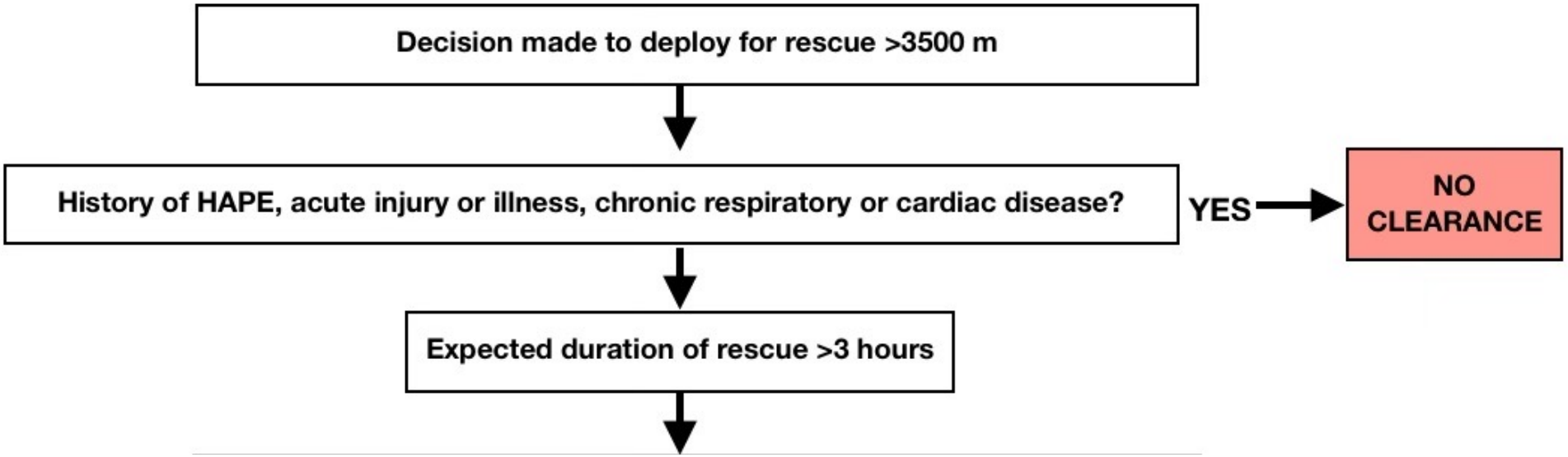

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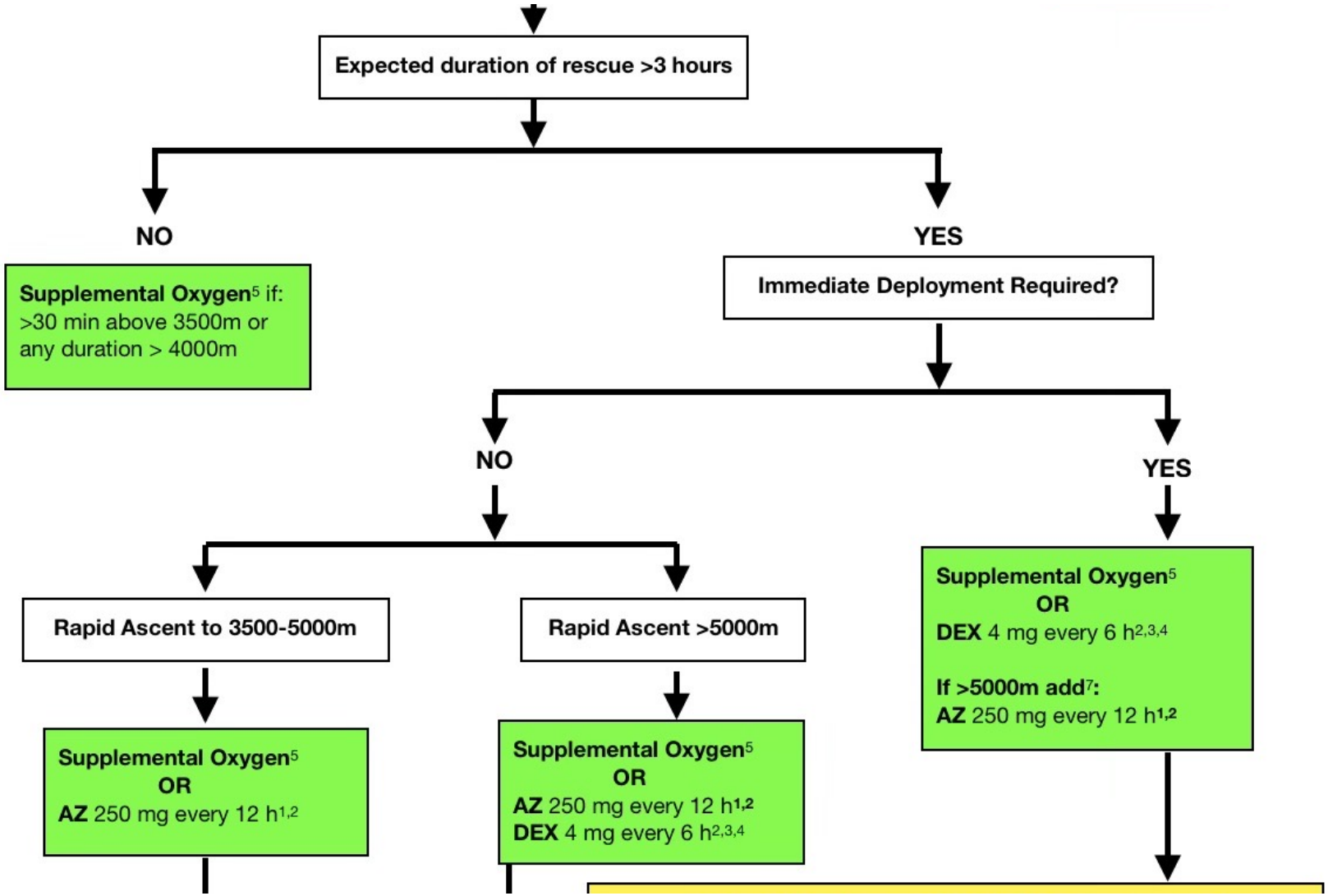
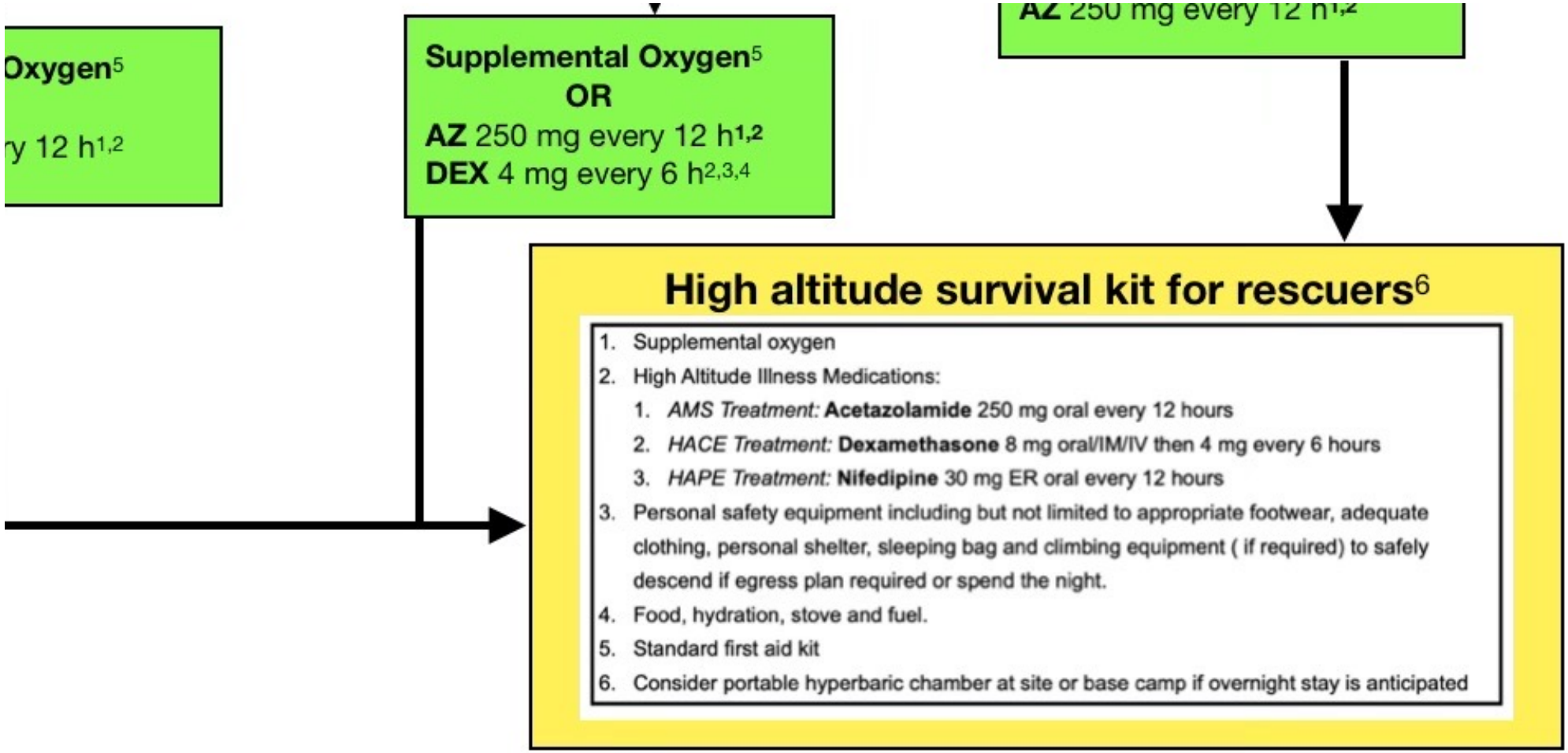


ALGORITHM RAPID ASCENT RESCUE > 3500M



HELICOPTER RESCUE AT VERY HIGH & EXTREME ALTITUDE

McLaughlin, Shimanski, Jackson, Biner, Folini, Hermansky, Ridington, Hicks, Zafren, Strapazzon, Falla, Brugger

Video: Maurizio Folini
Location: Everest Camp 3 @ 7300 m

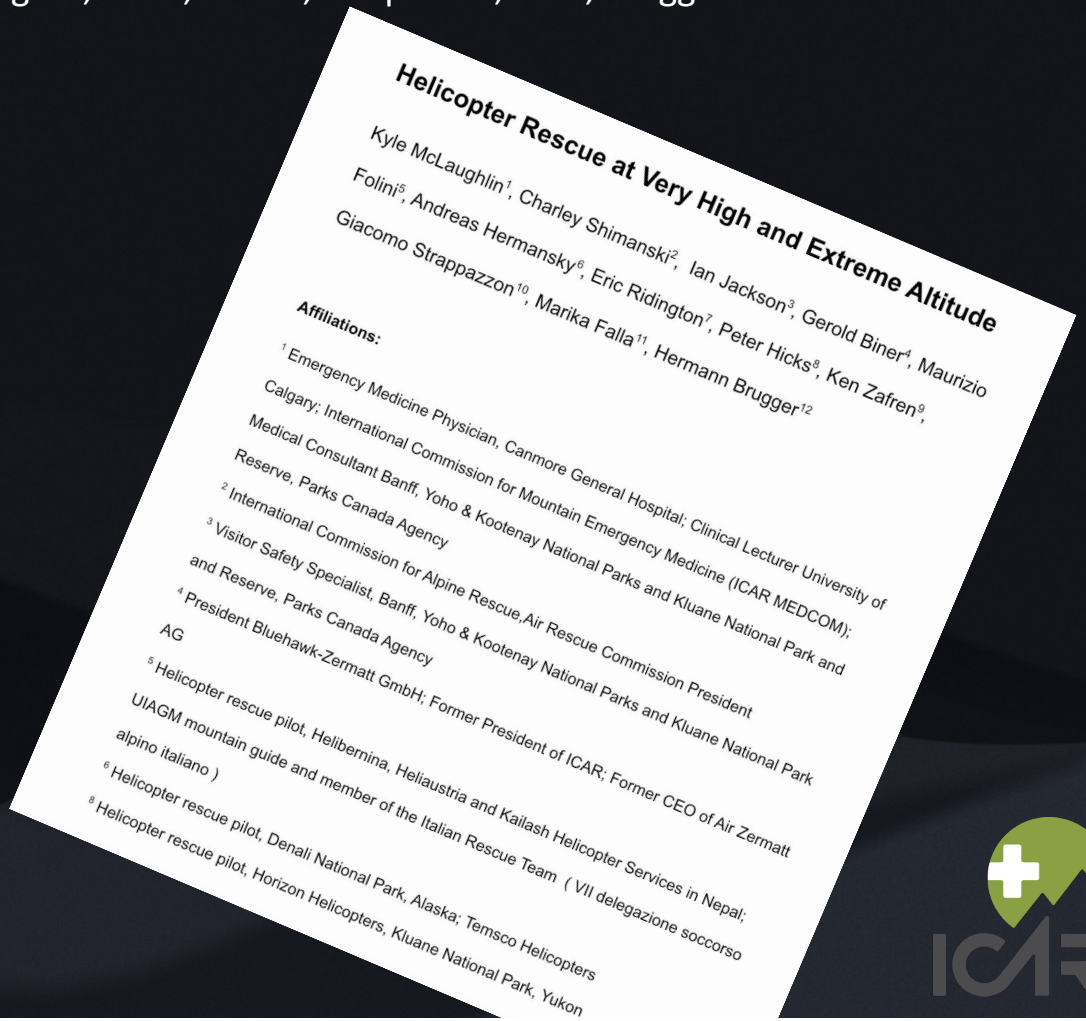
HELICOPTER RESCUE AT VERY HIGH & EXTREME ALTITUDE

McLaughlin, Shimanski, Jackson, Biner, Folini, Hermansky, Ridington, Hicks, Zafren, Strapazzon, Falla, Brugger

Target Journal: High Altitude Medicine & Biology

Discussion Points:

1. Operational Considerations
2. Ground Site Considerations
3. Pilot & Rescue Personnel Safety
4. Post Mission Considerations



Helicopter Rescue at Very High and Extreme Altitude

Kyle McLaughlin[1], Charley Shimanski[2], Ian Jackson[3], Gerold Biner[4], Maurizio Folini[5], Andreas Hermansky[6], Eric Ridington[7], Peter Hicks[8], Ken Zafren[9], Giacomo Strappazzon[10], Marika Falla[11], Hermann Brugger[12]

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HELICOPTER RESCUE AT VERY HIGH & EXTREME ALTITUDE

OPERATIONAL CONSIDERATIONS

1. Aircraft performance
2. Reducing exposure time
3. Pre-flight risk assessment
4. Meteorological concerns
5. Human external cargo (HEC)
6. “Plan B” ground rescue plan
7. “Contingency Plan” for aircraft grounding

OPERATIONAL CONSIDERATIONS

1. AIRCRAFT PERFORMANCE

- Impact of air density on helicopter performance
- Weight reduction for VHA efficiency
- Fuel management and optimization
- Power reserves for high-altitude flying
- Ideal helicopter attributes for rescue missions

OPERATIONAL CONSIDERATIONS

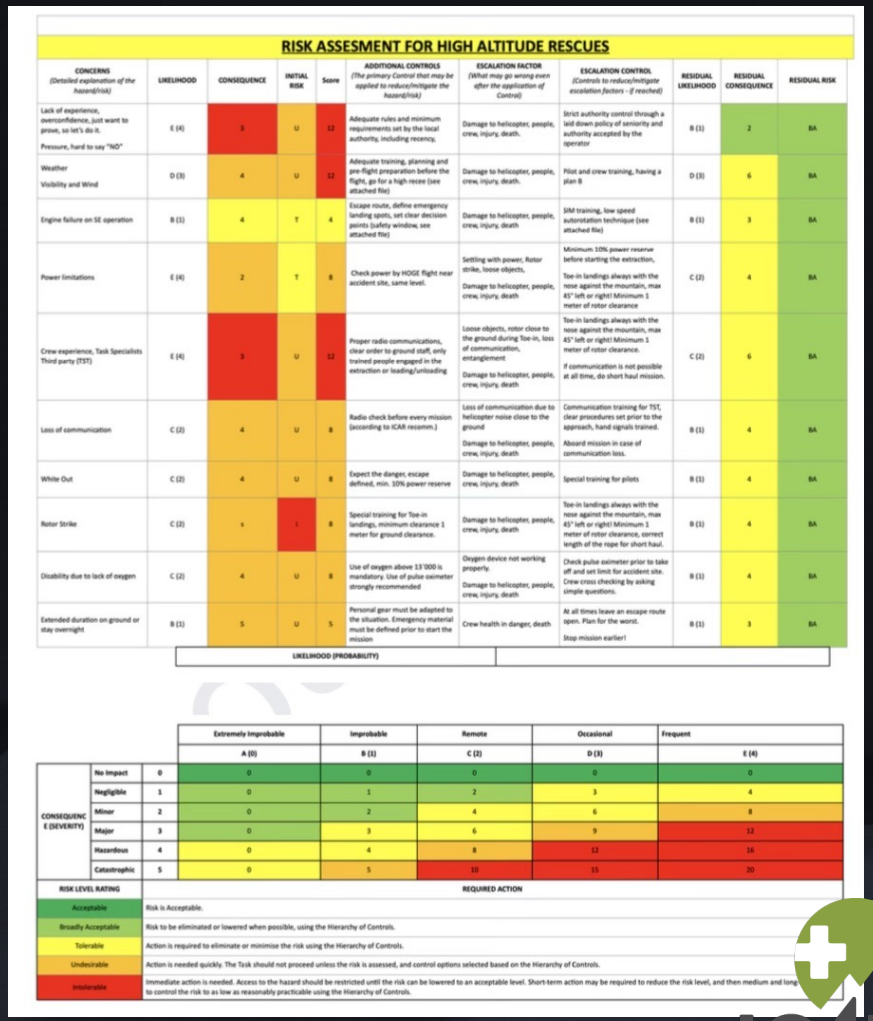
2. REDUCING EXPOSURE TIME

- Minimizing flight and exposure time
- Key Operation Decision: solo vs. accompanied pilot
- Human External Cargo (HEC) vs. landing options
- Flight planning: number of flights and personnel per flight
- Managing flight duration

OPERATIONAL CONSIDERATIONS

3. PRE-FLIGHT RISK ASSESSMENT

- Pre-flight risk checklist should be performed for ALL helicopter rescue operations
- Extra risks of VHA missions must be included.
- Safety of the pilot and rescue team is the first priority
- Risk analysis matrix specific for rescue at VHA



RISK ASSESMENT FOR HIGH ALTITUDE RESCUES

CONCERNS (Detailed explanation of the hazard/risk)	LIKELIHOOD	CONSEQUENCE	INITIAL RISK	Score	ADDITIONAL CONTROLS (The primary Control that may be applied to reduce/mitigate the hazard/risk)	ESCALATION FACTOR (What may go wrong even after the application of Control)	ESCALATION CONTROL (Controls to reduce/mitigate escalation factors - if reached)	RESIDUAL LIKELIHOOD	RESIDUAL CONSEQUENCE	RESIDUAL RISK
Lack of experience, overconfidence, just want to prove, so let's do it. Pressure, hard to say "NO"	E (4)	3	U	12	Adequate rules and minimum requirements set by the local authority, including recency,	Damage to helicopter, people, crew, injury, death.	Strict authority control through a laid down policy of seniority and authority accepted by the operator	B (1)	2	BA
Weather Visibility and Wind	D (3)	4	U	12	Adequate training, planning and pre-flight preparation before the flight, go for a high recee (see attached file)	Damage to helicopter, people, crew, injury, death.	Pilot and crew training, having a plan B	D (3)	6	BA
Engine failure on SE operation	B (1)	4	T	4	Escape route, define emergency landing spots, set clear decision points (safety window, see attached file)	Damage to helicopter, people, crew, injury, death	SIM training, low speed autorotation technique (see attached file)	B (1)	3	BA
Power limitations	E (4)	2	T	8	Check power by HOGE flight near accident site, same level.	Settling with power, Rotor strike, loose objects, Damage to helicopter, people, crew, injury, death	Minimum 10% power reserve before starting the extraction, Toe-in landings always with the nose against the mountain, max 45° left or right! Minimum 1 meter of rotor clearance	C (2)	4	BA
Crew experience, Task Specialists Third party (TST)	E (4)	3	U	12	Proper radio communications, clear order to ground staff, only trained people engaged in the extraction or loading/unloading	Loose objects, rotor close to the ground during Toe-in, loss of communication, entanglement Damage to helicopter, people, crew, injury, death	Toe-in landings always with the nose against the mountain, max 45° left or right! Minimum 1 meter of rotor clearance. If communication is not possible at all time, do short haul mission.	C (2)	6	BA
Loss of communication	C (2)	4	U	8	Radio check before every mission (according to ICAR recomm.)	Loss of communication due to helicopter noise close to the ground Damage to helicopter, people, crew, injury, death	Communication training for TST, clear procedures set prior to the approach, hand signals trained. Aboard mission in case of communication loss.	B (1)	4	BA
White Out	C (2)	4	U	8	Expect the danger, escape defined, min. 10% power reserve	Damage to helicopter, people, crew, injury, death	Special training for pilots	B (1)	4	BA
Rotor Strike	C (2)	4	I	8	Special training for Toe-in landings, minimum clearance 1 meter for ground clearance.	Damage to helicopter, people, crew, injury, death	Toe-in landings always with the nose against the mountain, max 45° left or right! Minimum 1 meter of rotor clearance, correct length of the rope for short haul.	B (1)	4	BA
Disability due to lack of oxygen	C (2)	4	U	8	Use of oxygen above 13'000 is mandatory. Use of pulse oximeter strongly recommended	Oxygen device not working properly. Damage to helicopter, people, crew, injury, death	Check pulse oximeter prior to take off and set limit for accident site. Crew cross checking by asking simple questions.	B (1)	4	BA
Extended duration on ground or stay overnight	B (1)	5	U	5	Personal gear must be adapted to the situation. Emergency material must be defined prior to start the mission	Crew health in danger, death	At all times leave an escape route open. Plan for the worst. Stop mission earlier!	B (1)	3	BA

			LIKELIHOOD (PROBABILITY)				
			Extremely Improbable	Improbable	Remote	Occasional	Frequent
			A (0)	B (1)	C (2)	D (3)	E (4)
CONSEQUENCE (SEVERITY)	No Impact	0	0	0	0	0	0
	Negligible	1	0	1	2	3	4
	Minor	2	0	2	4	6	8
	Major	3	0	3	6	9	12
	Hazardous	4	0	4	8	12	16
	Catastrophic	5	0	5	10	15	20

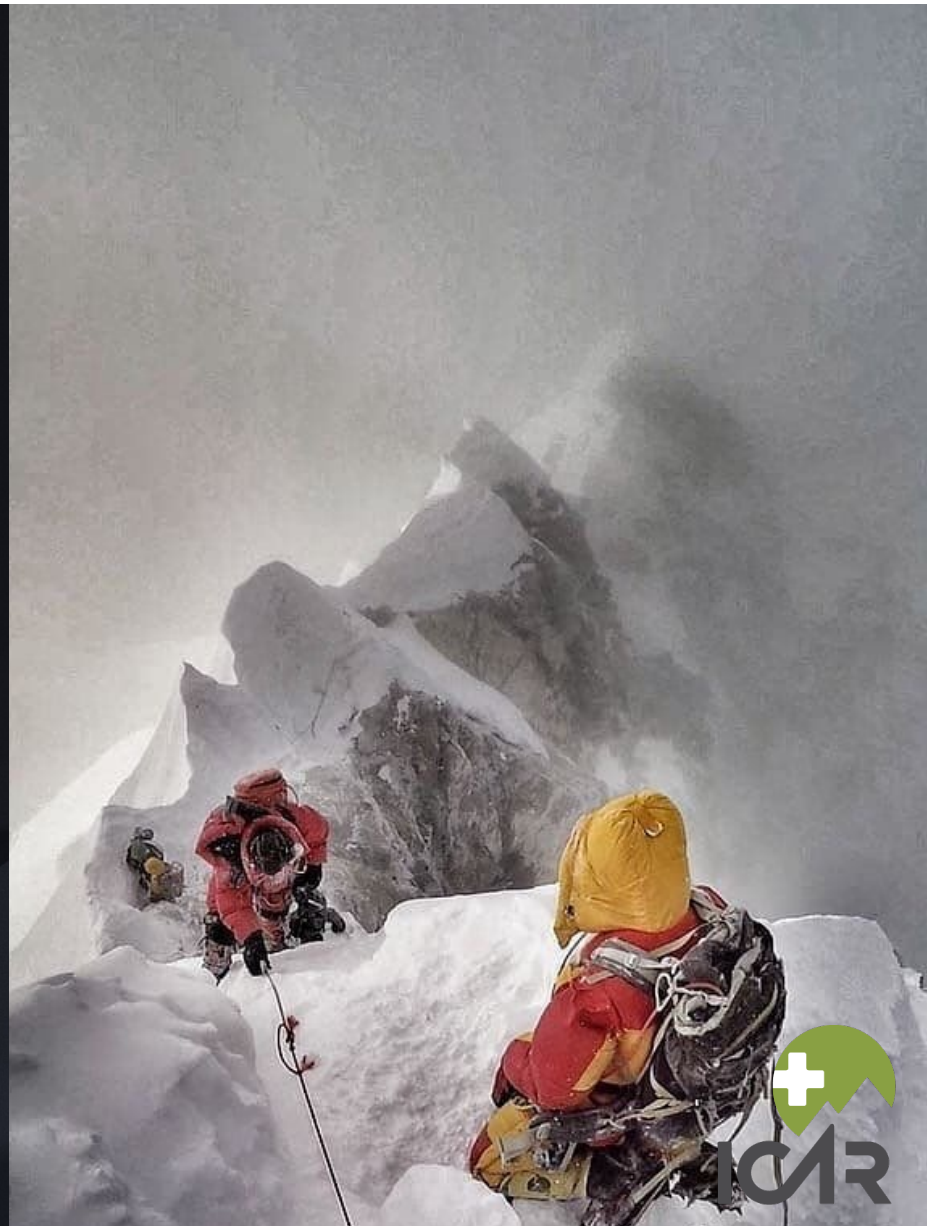
RISK LEVEL RATING	REQUIRED ACTION
Acceptable	Risk is Acceptable.
Broadly Acceptable	Risk to be eliminated or lowered when possible, using the Hierarchy of Controls.
Tolerable	Action is required to eliminate or minimise the risk using the Hierarchy of Controls.
Undesirable	Action is needed quickly. The Task should not proceed unless the risk is assessed, and control options selected based on the Hierarchy of Controls.
Intolerable	Immediate action is needed. Access to the hazard should be restricted until the risk can be lowered to an acceptable level. Short-term action may be required to reduce the risk level, and then medium and long to control the risk to as low as reasonably practicable using the Hierarchy of Controls.

Source: Gerold Biner Air Zermatt

OPERATIONAL CONSIDERATIONS

4. METEOROLOGICAL CONCERNS

- Challenges of severe weather at VHA
- Increased icing risk in cold and moist conditions
- Cabin humidity and windshield freezing issues
- Aircraft heating and de-misting limitations at altitude
- Fuel management in extreme cold temperatures



OPERATIONAL CONSIDERATIONS

5. HUMAN EXTERNAL CARGO (HEC)

- Challenges of terrain and weather at VHA for helicopter rescues
- Human External Cargo (HEC) methods: short-haul vs. hoist
- Optimal tactics for short-haul operations at VHA
- Long-Line techniques and balancing safety with performance
- Rescuer selection and medical care strategy at VHA

OPERATIONAL CONSIDERATIONS

6. “PLAN B” GROUND RESCUE PLAN

- Importance of alternate rescue options in VHA missions
- Factors leading to aborted air rescues
- Redundancy: Second helicopter and ground rescue teams
- Ground rescue as a viable backup in air rescue failures
- Effective communication for combined ground and air operations

OPERATIONAL CONSIDERATIONS

7. CONTINGENCY PLAN FOR AIRCRAFT GROUNDING

- Predetermined ground egress route to descend safely
- Personal high altitude survival kit (Table 2)
- Second helicopter evacuation option
- Concurrent ground rescue team
- Preparation for an overnight stay with adequate equipment

HELICOPTER RESCUE AT VERY HIGH & EXTREME ALTITUDE

GROUND SITE CONSIDERATIONS

1. Staging Area preparation
2. Rescue Site preparation
3. Destination determination

HELICOPTER RESCUE AT VERY HIGH & EXTREME ALTITUDE

PILOT & RESCUER SAFETY

1. Acclimatization
2. Training
3. Personal safety and survival
4. Supplemental oxygen
5. Pharmacologic prophylaxis

HIGH ALTITUDE SURVIVAL KIT FOR AIRCRAFT PERSONNEL

1. Supplemental oxygen
2. High Altitude Illness Medications:
    1. *AMS Treatment:* **Acetazolamide** 250 mg oral every 12 hours
    2. *HACE Treatment:* **Dexamethasone** 8 mg oral/IM/IV then 4 mg every 6 hours
    3. *HAPE Treatment:* **Nifedipine** 30 mg ER oral every 12 hours
3. Personal safety equipment including but not limited to appropriate footwear, adequate clothing, personal shelter, sleeping bag and climbing equipment (if required) to safely descend if egress plan required or spend the night.
4. Food, hydration, stove and fuel.
5. Standard first aid kit
6. Consider portable hyperbaric chamber at site or base camp if overnight stay is anticipated

HELICOPTER RESCUE AT VERY HIGH & EXTREME ALTITUDE

PILOT & RESCUER SAFETY

1. Acclimatization
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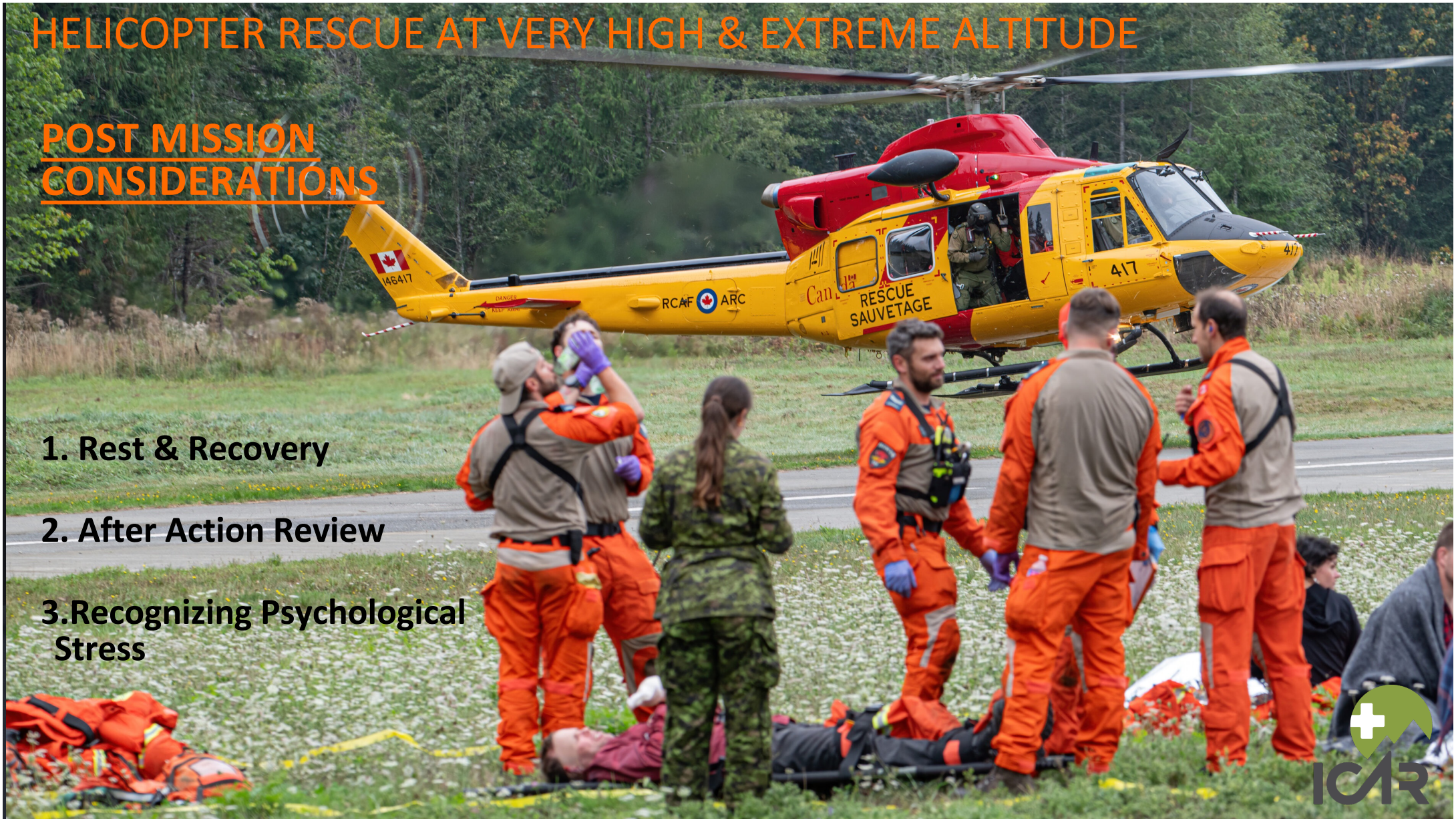
HELICOPTER RESCUE AT VERY HIGH & EXTREME ALTITUDE



POST MISSION CONSIDERATIONS

1. Rest & Recovery
2. After Action Review
3. Recognizing Psychological Stress

HELICOPTER RESCUE AT VERY HIGH & EXTREME ALTITUDE - RECOMMENDATIONS

Considerations	Element	Strategy
Operational	**Aircraft Performance**	• Optimize helicopter cabin weight and fuel for the mission
	Reducing Exposure Time	• Contemplate best possible landing strategy and minimize ground time
	Pre-Flight Risk	• Apply risk assessment for helicopter high altitude rescue analysis matrix (table 1)
	Meteorological Concerns	• Review weather forecast and wind
	Human External Cargo (HEC)	• Determine optimal HEC strategy, line length, need for attendant supplemental oxygen
	"Plan B" Ground Rescue Plan	• Establish a ground rescue option at a set staging area if unable to complete helicopter mission
	"Contingency Plan" for Aircraft Grounding	• Confirm egress plan for pilot and crew to descend safely by ground & ensure all have survival kit including prophylactic medications for high altitude illness (Table 2). Consider 2nd helicopter (if indicated)
Ground Site	**Staging Area**	• Acceptable mountain hazards at safe elevation for rescuer acclimatization and helicopter performance. Consider 2nd helicopter and/or ground rescue team at staging (if indicated)
	Rescue Site	• Prepare a safe landing zone & establish communication plan with ground team
	Destination Considerations	• Determine optimal destination for patient condition
Pilot and Rescue Personnel	**Acclimatization**	• Acclimatized pilots and rescuers with high altitude flying experience are preferable. Avoid using rescuers with a history of HAPE
	Training Considerations	• Familiarity with high altitude gear, techniques and high altitude illness and cold injury. Annual retraining with adequate proximity flying and HEC experience above 3500m
	Personal Survival equipment	• All pilots and rescuers should have a personal survival kit that includes clothing protection against the elements, suitable footwear, first aid kit and medications to prevent and/or treat high altitude illness (acetazolamide, dexamethasone, nifidepine). Climbing equipment may also be considered to allow for a safe descent if needed. (Table 2)
	Supplemental Oxygen	• Determine need for supplemental oxygen for pilot and crew during flight using Table 3.
		• Recommended for all rescuers exiting helicopter after rapidly ascending to >3500 m and performing physical activity.
	Pharmacologic Prophylaxis	• **On supplemental oxygen:** No need to take pharmacologic prophylaxis
		• **No supplemental oxygen:** Recommended for rescuers rapidly ascending to >3500m for duration >3 hours
Post Mission	**Rest and recovery**	• Allow adequate time for rescuer and pilot rest and recovery
	After Action Review	• Perform a post action review with operational and medical debrief
	Recognize Psychological Stress	• Train to recognize, prevent and manage occupational stress conditions.


Next Steps

MEDICAL CARE AT VERY HIGH ALTITUDE

Roy, Smith, McLaughlin, Zafren, Brugger, Holthof, Lechner

Discussion Points:

1. Barometric and non- barometric effects of high altitude on medical equipment and medications

2. Medical care, equipment and skills unique to the very high altitude environment

3. What are the expected medical conditions at very high altitude

ETHICAL CONSIDERATIONS OF VERY HIGH ALTITUDE MOUNTAIN RESCUE - ICAR POSITION PAPER

Ellerton, Paal, Tomazin

Discussion Points:

1. What are the important ethical decisions and philosophical considerations that may affect rescuer safety and patient outcome in rescue at very high altitude?

HISTORY OF HELICOPTER RESCUE AT VERY HIGH ALTITUDE

Agazzi, McLaughlin

Help Needed!

We need more contributions for historical Helicopter Rescues >3500 m

1. First use of helicopter in mountain rescue

2. Notable cases

Please contact: **gege@orobianet.it**

Kluane
National Park
and Reserve

Parc national et réserve
de parc national
Kluane

Parks Canada Parcs Canada

Canada

Thank you

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