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Protocols for the use of a portable hyperbaric chamber for the treatment of high altitude disorders

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Descent remains the definitive treatment for high altitude illness. However, in alpine settings of over 8000 ft, immediate evacuation is often impossible. A portable, lightweight (7 kg) hyperbaric bag has been devised capable of withstanding a pressure of 2 psi. The author investigated the optimal period of treatment in the bag to achieve resolution of symptoms and to prevent recurrence. Observations were recorded in Pheriche, Nepal at 13920 ft. At this altitude, inflation of the bag to 2 psi effects a descent to 8400 ft. Dramatic improvements were seen in victims with symptoms of acute mountain sickness (AMS), high altitude pulmonary edema (HAPE) and cerebral edema (HACE). AMS, HAPE and HACE patients required time frames of 2, 4, and 6 h respectively to provide resolution of symptoms without complications or deterioration. The author advocates the hyperbaric bag as an effective adjunct and temporizing measure in the treatment of HAPE and HACE.

Key words: altitude illness, hyperbaric therapy, mountain rescue; Gamow Bag

Introduction

High altitude illness is a common and sometimes fatal problem affecting persons who ascend to elevations over 8200 ft [1]. The consequences of rapid ascent in unacclimatized individuals fall into a spectrum of disorders that can be grouped into three broad categories: acute mountain sickness (AMS), high altitude pulmonary edema (HAPE) and high altitude cerebral edema (HACE) [1–4]. AMS is manifested by headache, nausea, loss of appetite, dizziness and extreme fatigue [2]. It is the most common of the disorders and is self-limited and rarely serious. However, if symptoms of AMS are ignored and further rapid ascent occurs, a climber can develop serious and potentially fatal HAPE and HACE [5]. HAPE is characterized by shortness of breath at rest, tachypnea and a dry then productive cough, and increasing respiratory distress. HACE is characterized by increasing disorientation, loss of fine motor coordination, slurred speech, gross ataxia, lethargy and coma [6].

The past decade has seen extensive and sophisticated studies into the pathophysiology and pharmacology of prophylaxis and treatment. While oxygen and drugs are adjunctive, descent remains the recommended definitive treatment, especially for HACE and HAPE [1,2,6–9]. However, such care is often difficult to render. Evacuations from alpine settings during adverse weather, breakdown of transportation systems and patient instability contribute to the difficulty.

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A lightweight, portable hyperbaric chamber (the Gamow Bag) has been developed for the treatment of high altitude disorders in situations where immediate descent is not feasible. The use of hyperbaric therapy for a wide spectrum of pathology is well established [10]. The coated nylon chamber employed in this setting is a much lower pressure version (2 psi, 104 torr) of its reinforced steel counterpart found in medical centers. However, a small increment of hyperbaria utilized in settings above 8000 ft can result in the simulation of a rapid, dramatic drop in altitude. Thus, a patient within the bag can achieve a 'descent' of thousands of feet in minutes that otherwise might take several days of evacuation (Table 1).

Hyperbaric therapy has been used for high altitude disorders, but little information is available in the literature [5]. Japanese authors report anecdotal support of efficacy with

Table 1. Simulated altitudes within the Gamow bag.

Starting (true) elevation			*Simulated elevation inside the bag at 2 PSI (104 mmHg)*		
meters	*feet*	*mmHg absolute*	*meters*	*feet*	*mmHg absolute*
0	0	760	−1022	−3353	864
300	984	731	− 751	−2464	838
600	1969	705	− 495	−1624	837
900	2953	679	− 232	− 761	783
1200	3937	654	24	78	758
1500	4921	630	288	945	734
1800	5906	607	535	1755	711
2100	6890	584	798	2618	688
2400	7874	562	1054	3458	666
2700	8859	541	1310	4298	645
3000	9843	522	1555	5102	626
3300	10827	503	1805	5922	607
3600	11812	484	2053	6736	588
3900	12796	466	2299	7543	570
4200	13780	449	2544	8347	553
4500	14765	433	2787	9144	537
4800	15749	417	3028	9935	521
5100	16733	401	3268	10722	505
5400	17717	387	3505	11500	491
5700	18702	372	3741	12274	476
6000	19686	359	3975	13042	463
6300	20670	345	4206	13800	449
6600	21655	333	4436	14555	437
6900	22639	320	4664	15303	424
7200	23623	309	4890	16044	413
7500	24608	297	5113	16776	401
7800	25592	286	5335	17504	390
8100	26576	276	5554	18223	380
8400	27560	266	5771	18935	370
8700	28545	256	5986	19640	360
9000	29528	246	6198	20335	350

(Reproduced with permission from Hyperbaric Mountain Technologies, Inc., Boulder, Colorado).

a fixed, steel chamber in Pheriche, Nepal (elev. 13920 ft) used in the early 1980s. This one-man chamber could effect an increase in pressure that simulated a descent to 5200 ft [11]. Takei reported a regimen of 20 min to descend, 10 min at the pressure equivalent of 5200 ft, followed by immediate 'return' to 13920 ft. 'Resolution of symptoms' in four HACE, one HAPE/HACE and eight of ten AMS patients occurred. There was no mention whether any of the symptoms recurred after leaving the chamber. Anecdotal reports of bag use on Himalayan expeditions in the past few years describe favorable results with both HAPE and HACE within time frames of 30 min to 9.5 h. The bag was studied on Mount McKinley in the spring of 1988, and deemed to be as efficacious as oxygen in treatment of HAPE [12]. The purpose of this study is to establish the time required to treat, based on categorization into AMS, HAPE and HACE.

Study design

Field tests were performed at the Himalayan Rescue Association's medical clinic at Pheriche, Nepal in the fall of 1988. Working at 13920 ft in the Khumbu Valley, the clinic staff has treated Sherpas and trekkers to Mount Everest for more than a decade. Patients presented to the clinic in various stages of distress were assessed rapidly and given oxygen and dexamethasone where appropriate. Categorization of patients was based on signs and symptoms of headache, nausea/vomiting (in the absence of diarrhea) and loss of appetite for AMS; shortness of breath at rest, tachypnea and rales for HAPE; and papilledema with neurologic impairment (loss of fine coordination, slurred speech, disorientation and ataxia) for HACE. History included rate of ascent, elevation and time at which symptoms started, maximum elevation reached, distance of descent to reach the clinic and medications taken. During the study period, more than 125 cases of AMS, 23 of HAPE and 8 of HACE were seen. When possible, patients with HAPE and HACE were quickly evacuated. However, for 9 HAPE and 6 HACE patients, this was not feasible, either because of adverse weather or lack of transportation. These patients were administered oxygen (when available), dexamethasone (8 mg IV/po initially, then 4 mg every 6 h) where appropriate, and were treated with the Gamow Bag. The bag was utilized for the HAPE and HACE patients as an adjunct pending evacuation.

Data collected consist of observations of changes (improvements) of patients' symptoms at 10–15 min intervals and whether any deterioration was noted after emerging from the bag. There were no control patients with untreated HAPE or HACE. Early on, it was noted that patients reported marked resolution of headache after a short time in the bag. Therefore, the study was expanded to treat patients who had AMS. AMS is a self-limited disorder that doesn't require evacuation; patients generally have resolution of symptoms following rest at a constant elevation for one or two nights.

Results

During the fall of 1988, the clinic staff treated 10 AMS, 9 HAPE and 6 HACE patients with the Gamow Bag. Table 2 reflects pertinent information. Patients A–I designate those with HAPE, while patients C and J–N designate those with HACE (patient C had both HAPE and HACE). The remainder (O–X) designate those with AMS. For HAPE patients E–G and I, no supplemental oxygen was given because the clinic's supply had been exhausted.

Table 2.

Patient	*Onset of symptoms (ft)*	*Maximum altitude achieved*	*Descent in altitude to clinic (ft)*	*Time of descent* to clinic (h)*	*Prior medications*	*Medication at clinic+*
A	17300	18500	4500	48	None	O_2
B	15000	18500	4500	14	O_2	O_2
C	14500	16200	2200	10	None	O_2
D	14000	16000	2000	5	None	O_2
E	15500	20000	6000	48	None	None
F	14000	20000	6000	48	Aspirin	None
G	12500	14000	0	N/A	Furosemide	None
H	12000	14000	0	N/A	None	O_2 dexamethasone
I	12000	14300	300	1	None	None
J	14000	14300	300	2	O_2, dexamethasone	O_2
K	15000	18800	3800	8	O_2, dexamethasone	O_2
L	12500	16200	2200	6	None	O_2
M	14000	16200	2200	8	None	O_2
N	12500	18800	4800	12	Aspirin	O_2
O	13000	14000	0	N/A	None	None
P	12500	14000	0	N/A	None	None
Q	14000	18800	4800	8	None	None
R	13400	14000	0	N/A	Aspirin	None
S	12500	14000	0	N/A	Aspirin	None
T	14300	16000	1000	4	None	None
U	13000	15000	1000	3	Acetazolamide	None
V	14000	14000	0	N/A	None	None
W	12500	14000	0	N/A	None	None
X	14000	16200	2200	8	None	None

*Some patients had not gone higher than the clinic's altitude. N/A (not applicable) reflects this.
+These were given within 30 min of hyperbaric treatment. Oxygen was given at 5 l min^{-1} and the dexamethasone was given 8 mg IV/po initially, then 4 mg q 6 h.

Table 3. AMS victims: time (min) required for resolution of symptoms.

Patient	*Length of time (h) already at clinic elevation**	*Headache*	*Loss of appetite*	*Dizziness*	*Total time in bag*	*Rebound*[+]
O	4	60	70	30	90	no (18)
P	0	45	N/A	90	90	no (4)
Q	12	45	60	15	45	yes (2)[++]
R	0	10	45	45	120	no (24)
S	2	25	N/A	N/A	120	no (18)
T	96	45	60	60	120	no (18)
U	40	60	120	45	120	no (10)
V	4	15	60	15	90	yes (36)[§]
W	30	25	45	10	120	no (18)
X	20	50	60	30	60	yes (12)[¶]

*This heading is not in Tables 4 and 6 because it is significant in this categorization, in that the self-limiting resolution of AMS symptoms may already have started, depending on the length of time already at Pheriche.
[+]Number in parentheses reflects number of hours of observation at clinic after treatment.
[++]Headache returned in 2h; gone with rest in 12h.
[§]Headache returned in 4–5h; gone with rest in the next 8–12h.
[¶]Headache, dizziness returned in 6h; gone with rest in 18h.
N/A: Patient never had this symptom.

Table 3 details the resolution times for symptoms of AMS with different lengths of treatment in the Gamow Bag. Headache resolution ranged from 10–60 min with a mean of 38 min. Loss of appetite, when present, disappeared in 45–120 min with a mean of 65 min, while dizziness resolved in 10–90 min with a mean of 38 min. The 10 patients were kept in the bag for 45–120 min. While each individual reported total relief of symptoms within the time frame of treatment, several reported a return of symptoms (headache and/or dizziness) after leaving the bag. The symptoms recurred in patients Q, V & X within 2–6 h; all reported resolution after an additional 12–18 h of rest. No patient treated for 120 min in the Gamow Bag reported the reappearance of AMS symptoms. In addition, six patients had no problems during the remainder of their ascent (the other four patients were lost to follow-up).

Observations of the resolution of HAPE symptoms are delineated in Table 4. Nine patients were treated with the Gamow Bag. Patients E, F, G and I did not have the benefit of supplemental oxygen. Headache was reported to resolve in 10–60 min with a mean of 31 min. Dyspnea was alleviated in 10–60 min with a mean of 29 min. Tachypnea and cough abated in 15–45 min (mean 28 min) and 60–120 min (mean 84 min), respectively. Repeat exams revealed that no patient had total clearance of rales; only two patients (D & G) had a decrease in ausculted rales. The HAPE patients were treated in the Gamow Bag for 2–5 h. The period of observation after removal from the bag reflects the time in residence at the clinic (1–18 h) until evacuation to a lower altitude. Patients, A, C and D deteriorated during this period. Patients treated in the bag for at least 4 h remained asymptomatic for up to 15 h without supplemental oxygen. Patient F was treated for 2 h and remained asymptomatic, but his post-treatment observation period was only 1 h. The other two patients treated for 2 h reported a return of dyspnea in 4 and 10 h, respectively.

Table 4. HAPE victims: time (min) required for resolution of symptoms.

Patient	*Headache*	*Dyspnea*	*Tachypnea (>30)*	*Cough*	*Rales**	*Total time in bag (h)*	*Rebound+*
A	40	45	30	120	N/C (no change)	2	yes (4)++
B	20	30	30	60	N/C	4	no (4)
C	10	10	15	120	N/C	4.5	no (13)§
D	N/A	20	45	45	decreased	2	yes (18)¶
E	25	45	45	90	N/C	3	yes (6)‡
F	20	15	15	N/C	N/C	2	no (1)
G	40	60	30	60	decreased	4	no (12)
H	N/A	10	30	60	N/C	4	no (15)
I	60	30	15	120	N/C	5	no (3)

*These were assessed before and after treatment only.
+Number in parentheses reflects number of hours of observation at clinic after treatment.
++Reported return of dyspnea at rest in 4 h.
§Patient C had no observed rebound germane to HAPE symptoms, but he did have rebound of ataxia (see Table 5).
¶Reported return of dyspnea at rest in 10 h.
‡Reported return of cough (productive) in 3 h.
N/A: Patient never had this symptom.

Information concerning the treatment of six HACE victims with the Gamow Bag is presented in Table 5. Headache cleared up in 10–60 min (mean 26 min), while clarity of speech and mental orientation (to person/place/time) required 15–120 min (mean 54 min) and 15–50 min (mean 31 min), respectively. Fine coordination returned in 30–120 min (mean 70 min). Ataxia was re-evaluated within 2 min after treatment. It was felt to have not improved in patient J, while totally resolving in patients K and N. The other three patients had variable degrees of improvement. Treatment times ranged from 2.5–6 h. All patients showed dramatic improvement in sensorium over the first 60 min of treatment, with improvement of fine coordination noted within 2 h.

Dramatic resolution was apparent within 6 h of treatment for patients K and N, with no return of symptoms of headache, altered speech, disorientation or loss of fine coordination. Patient C, who was treated for 4.5 h, demonstrated marked, but not total, improvement in ataxia, yet suffered noticeable deterioration in symptoms 7 h after treatment. Two additional treatment hours in the bag completely resolved the symptoms. Persons with partial resolution of ataxia (patients L and M) did not deteriorate during the 10 and 12 h, respectively, of observation pending evacuation. It was felt that 6 h in the bag allowed total resolution of the symptoms of HACE.

Discussion

The results point to the following parameters for treatment with the Gamow Bag: 2 h for AMS, 4 h for HAPE and 6 h for HACE. These time frames worked well for the resolution of symptoms and in the prevention of rebound. The period of observation for HAPE and HACE patients who remained symptom free ranged up to 18 h. It may well be that this period could be longer, but we still chose to evacuate patients expeditiously in keeping with the bag's role as an adjunct to evacuation. The recommendations for treatment times are germane to an elevation of approximately 14000 ft. Many authorities report that a victim often need only descend 300–1000 m to effect clinical improvement. Table 1 demonstrates simulated drops of 4000 to over 7000 ft at elevations of 8000 to 20000 ft with the use of the Gamow Bag.

Although no control group was studied, it is the author's strong impression that the speed of resolution of AMS would compare favorably with that attained solely by rest. One individual who had waited 4 days at Pheriche for his headache to resolve reported total resolution after only 45 min in the bag. We found that the bag was helpful in differentiating headache due to AMS from that caused by a sinus problem. We treated four individuals with suspected sinusitis who reported that their headaches grew worse in the first 30 min of treatment. After aborting the treatment, these individuals continued to ascend without waiting for the headache to clear. None reported worsening of headache or onset of other symptoms, despite climbing approximately 1000 m higher. This serves only as an anecdotal finding which will require further corroboration prior to a clinical recommendation.

With regard to HAPE, 4 h of treatment seemed beneficial. No controls were observed, because either immediate evacuation was available or the patient was treated with the Gamow Bag. Administration of supplemental oxygen is standard therapy for HAPE victims. It is thought to lower pulmonary artery pressure, improve ventilation/perfusion mismatch and to increase PaO_2 [5]. However, except in very mild cases, it remains palliative, not curative, and victims still need to descend [6]. Because of a busy climbing season, the

Table 5. HACE victims: time (min) required for resolution of symptoms.

Patient	*Headache*	*Slurred speech*	*Disorientation*	*Loss of fine coordination*	*Ataxia*	*Papilledema**	*Total time in bag (h)*	*Rebound+*
C	10	50	50	120	Markedly decreased	no change	4.5	yes (13)++
J	60	120	30	60	No Change	no change	2.5	no (15)
K	20	N/A	30	30	Resolved	no change	6	no (2)
L	20	15	15	30	Mildly decreased	no change	4	no (10)§
M	30	N/A	30	60	Markedly decreased	no change	4	no (12)¶
N	15	30	30	120	Resolved	no change	6	no (4)

*Checked only before and after treatment.
+Number reflects number of hours of observation at clinic after treatment.
++Ataxia deterioration noted at 7 h. Victim was treated for additional 2 h with resolution. Evacuation 2 h later without recurrence.
§No deterioration noted, but prominent ataxia and decreased strength persisted.
¶No change in mild ataxia noted during observation period.
N/A: Patient never had this symptom.

supply of oxygen at the clinic was limited. Several HAPE victims [patients E,F,G and I) were treated in the bag without supplemental oxygen and reported good resolution of their dyspnea. In a comparison of the Gamow Bag versus supplemental oxygen on Mount McKinley, Hackett demonstrated similar arterial oxygen saturation levels and changes in the alveolar-arteriolar gradient. He concluded that the rise in PO_2 induced by treatment within the pressurized bag or by increasing inspired PO_2 was equally effective [12]. Use of the bag alone does increase the inspired partial pressure of oxygen. At Pheriche's elevation, the internal pressure of the inflated bag is 550 torr. Using the formula $PIO_2 = FIO_2 (P_B - 47)$, one computes a PO_2 of 106 torr within the bag. This is equivalent to breathing 27% FIO_2 at Pheriche's elevation (106 = FIO_2 [446 torr − 47 torr]). One cannot fail to be impressed by patients' sustained improvement of symptoms after leaving the bag without the benefit of supplemental oxygen.

One can contemplate the relative contributions of hypobaria and hypoxia to the pathogenesis of high altitude disorders. It is widely accepted that hypoxia is the dominant environmental stress at altitude and chiefly responsible for the development of altitude illness [13]. However, it is noted that descent (which mitigates both hypobaria and hypoxia) more rapidly improves symptoms than does supplemental oxygen alone [7]. Bland showed that alveolar hypoxia alone does not produce changes in the lung found in pulmonary fluid balance to a HAPE configuration [15]. These observations suggest a hypobaria and hypoxia did pulmonary lymph flow in sheep increase, reflecting an increase in intravascular lung volume. Neither hypobaria nor hypoxia alone changed pulmonary fluid balance to a HAPE configuration [15]. These observations suggest a significant role for hypobaria in the pathophysiology of altitude illness.

Since no controls were evaluated in HAPE patients, no firm conclusions can be reached about the contribution of dexamethasone in the resolution process. Cerebrospinal fluid pressure increases in a hypobaric/hypoxic environment [16]. Hyperbaric therapy decreases cerebral-cortical blood flow and has reputed benefit in the treatment of vasogenic cerebral edema [17]. It remains to be seen whether the small incremental increase in pressure afforded by the Gamow Bag plays a role in the reduction of cerebral edema.

The hyperbaric Gamow Bag (named after its inventor) was developed by Hyperbaric Mountain Technologies of Boulder, Colorado. It is a nonpermeable, nylon cordura cylinder with an internal polyurethane coating. An air-tight access zipper is vertically aligned. A pressure inlet valve is attached to a foot pump for inflation. A 2 psi gauge pop-off valve vents the bag's atmospheric contents continuously while maintaining internal pressure. This accommodates a flow of 30 l min^{-1}. The deflated bag folds easily to fit into a medium-size ruck sack and weighs 7 kg. Fully inflated, it has dimensions of 2.5 m in length and 6 m in diameter, which is able to fit most rescue sleds and litters. The bag has a face portal to allow visual contact with the victim. Verbal communication is quite easy and can be facilitated by placing a stethoscope head on the external surface. Adaptation is possible to install other portals for physiologic monitoring, cables and intravenous lines. Patient comfort is attained with pillows and pads. There is room for a small (E size) oxygen cylinder. Patients with an IV are best served by switching to a heparin lock, if safety isn't compromised.

The bag can be fully inflated to 2 psi in approximately 3 min. The amount of 'drop' in elevation depends on the starting elevation (see Table 1). The amount of 'descent' at any altitude can also be calculated by the pressure-altitude graph in Fig. 1. By

adding 104 mmHg to the pressure existing at the starting elevation, one can find the simulated altitude that exists within the inflated bag. At the Pheriche clinic at 13920 ft, a drop to the equivalent of around 8400 ft would be expected. This was confirmed by altimeter.

Studies at the University of Colorado have shown that the 2 psi internal environment is constantly maintained by 10–15 foot-pumps min^{-1} [18]. At this rate, the steady state concentration of oxygen within the bag fell to 20.23% ± .11 and of CO_2 increased slightly to .73% ± .11. These concentrations are well within safety limits.

In our study, the bag was deflated over 30–60 sec. In a simulated emergency, we were able to get a subject out in less than 10 sec.

The FDA has approved the use of the bag for treatment of high altitude illness in humans, provided that the treatment is intended to be hyperbaric, not hyperoxic.

In over 30 uses there has been no morbidity. While there are no reported complications, a review of safety considerations is merited:

(1) Otic barotrauma: The sensation that one feels in the ears during inflation is roughly equivalent to that felt by divers 4.5 ft under water. For many persons, the discomfort is considerable. It is recommended that, when possible, the patient chew gum and be coached to perform a Valsalva or Frenzel maneuver. Tympanic membrane rupture has been reported to occur with a pressure gradient differential as low as 100 torr (the bag can generate a 104 torr gradient across the eardrum if the ears are not cleared) [19]. If the above attempts fail, one can slow the rate of inflation or utilize short-acting nasal decongestants. The bag's manufacturer recommends not using the bag if a victim

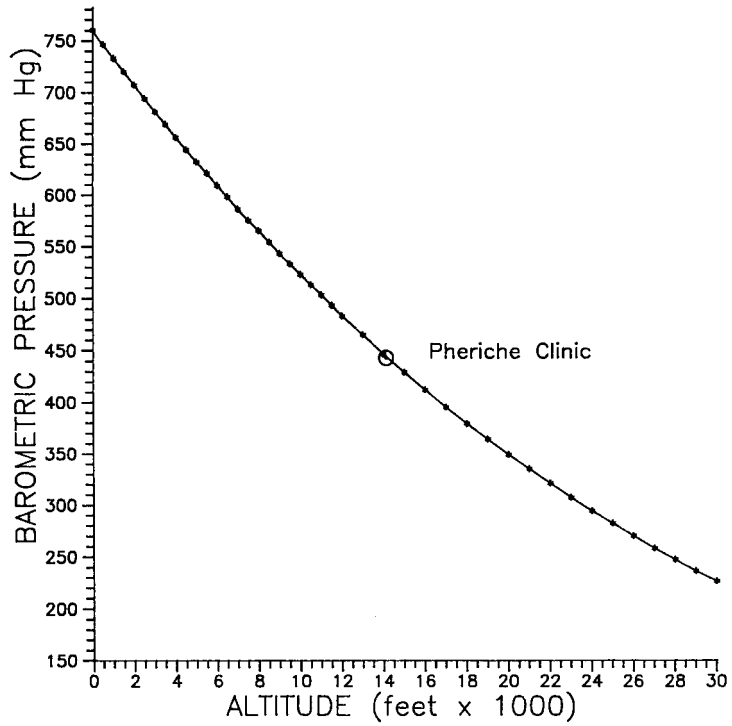

Fig.1. Relationship of barometric pressure to altitude.

has 'blocked ear canals' or an upper respiratory infection. Despite a high preponderance of both conditions in those trekking in the Khumbu, we encountered only one patient who could not clear his ears to the point of comfort.

(2) Decompression sickness ('bends'): This occurs in divers who ascend too rapidly. The potential for an analogy exists with utilization of the Gamow Bag in that at the end of treatment, the subject rapidly (i.e., 30–60 sec) 'ascends' thousands of feet. However, the pressure change is equivalent to an ascent from only 4–5 ft under the surface; decompression sickness generally involves pressure differences found at depths of over 30 ft of water, regardless of the rate of ascent [20]. Deflation of the bag at any rate does not cause decompression sickness. It is interesting to note that many people reported transient mild dizziness immediately upon release of pressure from the bag. This can be minimized by releasing the pressure via the pop-off valve over 1–2 min.

(3) Pulmonary overinflation: There is a theoretical potential of excessive lung expansion with subsequent alveolar rupture if the ambient pressure within the bag is rapidly released while the lungs remain fully inflated. In divers, this can occur in someone who holds his breath while ascending the last 6 ft to the surface [19]. The manufacturer recommends exhaling while deflating the bag.

(4) Claustrophobia: It is important that the attendant regularly communicate with the patient. The patient should be warned about 'ear squeeze'. If the patient panics and cannot be calmed, he can easily be removed from the bag.

(5) CO_2 exposure: Carbon dioxide steady state levels of less than 1% can easily be maintained. The pop-off valve and foot pump create a continuously vented environment. Exposure to 1% CO_2 is tolerable without ill effects for up to 24 h [21]. There is some question whether the slight increase in ambient CO_2 concentration noted by researchers at the University of Colorado might act as a respiratory stimulant, thereby ameliorating symptoms. One study reported that supplemental CO_2 worsened, not relieved, symptoms of AMS [22]. One drawback to the bag is that to prevent unacceptable CO_2 buildup, it is necessary to utilize the foot pumps 10–15 times per min. This exertion, especially at altitudes over 20000 ft, can quickly become fatiguing to the rescuer. Studies are currently underway to develop a CO_2 scrubber for the Gamow bag.

At the time of this writing, the bag used in this study has been inflated over 50 times and remains durable, despite use in harsh, winter environments.

Summary

Alpine terrain often makes immediate evacuation of the HAPE or HACE victim difficult, if not impossible. The Gamow Bag can improve the symptoms found in AMS, HAPE and HACE victims. By virtue of such clinical improvement, evacuation is rendered potentially safer and easier. It is far easier to assist a patient who can walk down a steep trail than someone who is lethargic, grossly ataxic and requires a litter carry. The Gamow Bag seems ideally suited for alpine expeditions and search and rescue teams. It is recommended as an adjunct to evacuation to a lower altitude and not as a curative modality in which no further action is required for the patient's benefit.

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