Up, Up, and Away: Clinical Considerations for Altitude-Related Travel and Pulmonary Hypertension

Section Editor
Claire Parker, MS, CPNP-AC

Amanda Schnell Heringer, RN, MS, AGCNS-BC
Pulmonary Hypertension and Advanced Heart Failure Program
University of California San Francisco
San Francisco, CA

Elise Hazlewood, RN, MS, CCNS
Pulmonary Hypertension and Advanced Heart Failure Program
University of California San Francisco
San Francisco, CA

WHAT HAPPENS AT HIGH ALTITUDE?

High altitude is defined in the literature[1,2] as locations higher than 2500 m (8000 feet) above sea level. Increased altitude leads to lower barometric pressures, lower partial pressure, and lower inspired oxygen levels, leading to hypoxia. The body's attempt at homeostasis triggers increased ventilation, vasoconstriction of the pulmonary vasculature, systemic vasodilation, as well as increased heart rate, blood pressure, cardiac output, and hemoglobin. Importantly, pulmonary arterial pressures increase along with pulmonary vascular resistance at high altitudes. These effects are profound in patients with baseline pulmonary hypertension, as exposure to high altitudes can worsen hemodynamics, symptoms, and therefore result in short- and long-term negative sequelae.[1–4]

PULMONARY HYPERTENSION AND HIGH-ALTITUDE TRAVEL

Due to the aforementioned pathophysiologic changes at high altitude, patients with known pulmonary hypertension should exercise caution when traveling to higher altitudes. However, many patients with pulmonary hypertension may still desire travel for pleasure, quality of life, and family or work obligations. It is important for patients and clinicians to be aware of risks of high-altitude travel and determine strategies to mitigate these risks. Current recommendations for travel to high altitudes in patients with known pulmonary hypertension include use of supplemental oxygen at altitudes greater than 1500–2000 m (4900–6500 feet) in any patient with WHO Functional Class 3–4 pulmonary hypertension, and it has been recommended that WHO Functional Class 3–4 patients avoid altitudes greater than 2000 m completely.[1,3,4]

COMMERCIAL AIR TRAVEL

The effects of commercial air travel in pulmonary hypertension have been a growing area of interest, as many patients use commercial airlines for travel. Patients with pulmonary hypertension have varied tolerance during air travel and many can become hypoxemic in flight.[5,6] To minimize risk, supplemental oxygen while in flight is currently recommended for pulmonary hypertension patients with WHO Functional Class 3 and 4 and/or with those with arterial blood O_2 pressure <8 kPa (60 mm Hg).[3,4] Patients with known pulmonary hypertension should undergo high-altitude simulation testing (HAST) to determine their specific in-flight oxygen needs and plan accordingly to ensure adherence to airline policies and regulations to minimize travel interruptions.[7]

DETERMINATION OF MEDICAL STABILITY

Before high-altitude exposure, patients should be evaluated by their cardiologist or pulmonologist to ensure medical stability. Considerations for medical stability are important, and each patient has unique needs and recommendations regarding high-altitude exposure as related to WHO Functional Class.[1,3,4] Risks of airline travel and extended stay at high altitude should be reviewed clearly with patients to make an informed decision and prepare for emergency needs. Assessment of current hemodynamics and right ventricular function via right heart catheterization and transthoracic echocardiogram are valuable. Patients with baseline hypoxia and supplemental oxygen needs will likely have higher oxygen needs at higher altitudes. In addition to HAST, it is recommended to determine baseline needs for oxygen at rest and with exertion by performing 6-minute walk testing per American Thoracic Society standards.[8] Additionally, overnight oximetry testing can evaluate current nocturnal oxygen needs, and clinicians can determine if altitude-related adjustments are indicated. If a patient is reporting significant symptoms, severe medication side effects, or is in process of medication titration, this may affect his or her ability to tolerate the increased demands of high-altitude changes.

These test results in addition to laboratory testing, physical examination, and symptom assessment can provide information on determination of clinical stability and risk for decompensation at altitude. High-altitude simulation

Key Words—high altitude, travel, pulmonary hypertension, COVID-19
Correspondence: claire.parker@ucsf.edu
Disclosures: Amanda Schnell Heringer is an Advisory Board participant for Actelion. Elise Hazlewood is an Advisory Board participant for United Therapeutics.

 DOI:10.21693/1933-088X-19.3.80

testing can provide valuable information on individual oxygen needs.[1,4,7] Finally, when determining medical stability and recommendations for travel to high altitudes, clinicians should discuss goals of care and review education, including medication and supplemental oxygen adherence, and behavioral interventions, including diet, alcohol use, and effects of dehydration at high altitudes.

ALTITUDE SIMULATION TESTING

High-altitude simulation testing is typically performed in a pulmonary function laboratory; testing protocols vary between centers. Use of a hypobaric chamber is an option for HAST, but these are not widely available.[9] More commonly, HAST is administered with the patient wearing a tight-fitting mask and breathing air with 14%–15% oxygen (rather than 21%), to match the typical amount present in the pressurized cabin of an airplane at cruising altitude (equivalent to ~8000 feet).[10] A pulse oximeter continuously monitors the patient's oxygen saturation (SaO_2) as the supplemental oxygen level is adjusted to maintain the desired oxygen saturation (typical goal is $SaO_2 > 90\%$). Oxygen saturation can also be confirmed by obtaining an arterial blood gas sample. It is recommended that patients planning to travel to high altitudes and/or via airplane undergo HAST testing at least 1 month before departure to allow for ordering and obtaining of oxygen equipment.

OXYGEN EQUIPMENT AND DOCUMENTATION FOR AIRLINE TRAVEL

Once oxygen requirements have been confirmed by testing, allow adequate time for obtaining insurance authorization and delivery of oxygen-related equipment. Per Federal Aviation Administration (FAA) regulations, US commercial airlines do not allow patients to bring their own oxygen tanks onto a flight (not in checked baggage, nor with them into the cabin). However, compressed oxygen can be used if provided by the airline.[11] Some airlines can directly provide the patient with oxygen for the flight, either free of charge or for a cost; patients can check with their airline if these services are available.[12] Some airlines do permit portable oxygen concentrators (POCs). Before travel, patients should check whether their oxygen company can provide a POC that is FAA approved and inquire about airline-specific policies regarding oxygen and batteries, including the process for boarding and disembarking, and required paperwork.[12,13] Due to the limited battery life of POCs, the patient may need to bring multiple charged batteries to last the duration of the flight. The general recommendation from the Pulmonary Hypertension Association (PHA) is to bring enough batteries to last 150% of the predicted length of the flight.[13] Battery life for POCs can be widely variable from 2 to 16 hours, depending on the machine itself, battery size, the oxygen flow rate, and whether oxygen flow is pulsed or continuous. Portable oxygen concentrator batteries contain lithium and must be packed in carryon baggage and cannot be in checked baggage per FAA regulation.[11] Patients should ensure they have access to oxygen tubing appropriate for the delivery system they will use in travel. If supplemental oxygen for travel is not approved by insurance, patients can pay out of pocket to rent the equipment for the trip.

Required documentation for flights can vary between airlines. Typically, a physician statement detailing the patient's medical need for oxygen is sufficient; however, some airlines will require specific forms to be completed for bringing medical equipment such as oxygen onto the flight.[12] Most airlines require notification of need for oxygen in flight at least 48 hours in advance. Allow adequate time to confirm documentation needs and submit completed forms. The PHA has multiple resources for patients and clinicians, including a template letter that can be provided for travel with oxygen or other medical equipment such as infusion pumps.[13]

COVID-19 CONSIDERATIONS

During the novel COVID-19 pandemic, travel is not recommended for groups at high risk for decompensation with COVID-19 infection.[14] However, some patients may choose to continue with travel plans including airplane travel or to areas of high altitude. Due to current international travel restrictions, many patients are choosing to minimize air travel at this time, and travel by car has become more popular. While the need for in-flight oxygen is not an issue for these patients, considerations should be made if patients will drive through areas of high altitude or have a prolonged stay in locations above 1500 feet. Patients should continue to follow COVID-19 prevention precautions, including avoiding "hot spots" of high COVID-19 infection rates, adherence to hand hygiene, masking, social distancing, and minimizing contact with symptomatic individuals. Some locations require patients to quarantine for 14 days upon arrival, and this may affect access to oxygen equipment. Pulmonary function labs may require COVID-19 testing to be completed in a specific timeframe before having a HAST. Additionally, availability of some pulmonary function tests has decreased due to new COVID-19 protocols. As COVID-19-related guidelines are dynamic and change frequently, health care providers and patients should continue to review travel restrictions, precautions, and recommendations as provided by local health departments and the Centers for Disease Control and Prevention.[14]

RESOURCE AVAILABILITY DURING TRAVEL

The patient should be provided with contact information for a nearby pulmonary hypertension center or provider to contact if medical needs arise during travel. Depending on insurance, patients may need out-of-network care during travel, and a preauthorization may be beneficial to have in place before departure. If needed, the patient's oxygen supplier can work with insurance and arrange for oxygen equipment to be delivered to the patient's destination. This is especially important if the patient plans to travel in a high-altitude area.

CONCLUSIONS

Many patients with pulmonary hypertension identify travel as something that improves quality of life. Given the presence of the COVID-19 pandemic, additional considerations are needed re-

garding travel precautions in this patient population. Testing to determine oxygen needs for in-flight or prolonged high-altitude travel can inform decision making and treat high-altitude–induced complications. It is important for care teams to be aware of specific needs for patients with pulmonary hypertension who plan to travel to areas of high altitude to minimize risk and improve safety.

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