15. Travelling, altitude and diving

Authors: Estelle Yersin, Alain Sauty

1. INTRODUCTION

- No specific recommendations related to travelling are available for adult CF patients. The following recommendations are based on guidelines for other pulmonary diseases and expert opinions.
- Compared to healthy people, travelling may confer additional risks in adult CF patients. It is best to prepare a trip well ahead in collaboration with the CF team in order to anticipate some potential health issues.

2. TRAVELLING

2.1 Prior to travelling

- Patients should inform beforehand their CF center for risk and medical assessment, particularly if flights, high altitude stay, journey in hot countries or diving are planned.
- Airlines should be contacted in advance if assistance at the airport and/or in-flight supplemental oxygen are needed.

2.2 Risk assessment and pre-travel check (Table 1)

- Assess if the patient is well enough for the planned trip and activities:
  - Medical history: recent infectious exacerbation? Pneumothorax? Allergic asthma? Pulmonary hypertension? Recent surgery? Acute sinus disease? Diabetes?
  - Problems during previous trips?
  - Mode of transportation/accommodation (car, plane, train, boat etc.) and travel duration.
- Vaccination **(see also Chapter *"Vaccination"*)**
  - Check and, if necessary, complete routine vaccinations such as tetanus, pertussis, hepatitis B, poliomyelitis, influenza.
  - Are immunizations requested for the visited countries? Travel Medicine consultation or electronic resources (for example: www.safetravel.ch) may be consulted. CF patients with chronic liver disease should be immunized against hepatitis A and B.
- Patients should inform themselves of the local expected weather conditions (such as temperature, humidity, and pollution) in order to discuss special considerations with the CF team.
- CF patients should have **cancellation and repatriation insurances** and be aware of insurance conditions.
- Accompanying persons should know how to react and who to contact in case of medical problems related to CF.

Table 1: Pre-travel check list

Check	Comments
Medical history	Is the patient able to perform the journey?
Problems during previous trips?	
Expected weather conditions?	Protection against dehydration, cold, excessive dust
Routine vaccinations?	Complete if necessary
Specific immunizations?	Complete if necessary
Cancellation/repatriation insurances	Conditions?
Airport assistance/in-flight O2 need	Contact the airline in advance

2.3 Documents

- Depending on the journey, the patient should be provided with a short report including the diagnosis, treatment, microbiology results and PFT's.
- If the patient is flying, he/she should be in possession of a certificate in English with all medications that will be carried in his cabin hand luggage, including material such as needles, syringes, liquids as well as aerosol equipment, CPAP, etc. A similar certificate is also useful for customs.
- The patient should be able to contact his/her CF center in case of problems or be aware of local CF centers in the visited countries.

3. ALTITUDE AND AIRPLANE JOURNEY

3.1 Precautions

- **CF patients with a recent pneumothorax should not fly.** For patients with an underlying lung disease, recurrence of pneumothorax may occur during the 12 months following the initial episode, despite thoracotomy, surgical or talc pleurodesis.
- **Recent major hemoptysis is a contraindication to airplane travel.**
- In-flight hypoxemia is common in patients with **pulmonary hypertension**, mainly due to the occurring hypoxic pulmonary vasoconstriction. This can result in additional elevation of the pulmonary artery pressure and possibly to hemodynamic compromise. Patients with severe pulmonary hypertension should avoid flying.
- CF patients may be at a higher risk of dehydration and decreased mobility during long-haul flights which are risk factors for deep venous thrombosis and, consequently, pulmonary embolism. CF patients should, therefore, be encouraged to drink sufficiently during flights, especially if they return from hot countries.

3.2 Altitude-related hypoxemia

- Hypoxemia may occur during a flight or at relatively high altitude. This is due to a combination of different factors including low inspired O_2 concentration (15% during a common

flight), severity of lung disease, severity of bronchial congestion and dehydration with more viscous secretions because of low cabin air humidity. There is no consensus about which is the best predictor of oxygen need at high altitude for severely impaired CF patients.

- Although many severely ill CF patients may be adapted to tolerate PaO_2 < 50 mmHg (6.6 kPa), **symptoms of acute hypoxemia** such as headache, dizziness, euphoria and/or visual defects may occur during flights.
- For patients with PaO_2 < 70mmHg (9.3 kPa) or with FEV_1 < 60% predicted, a "Hypoxia Altitude Simulation Test" (HAST) or "Hypoxic Challenge Test" (HCT) may be considered if available.
  - During this test, the patient is breathing for 20 minutes a gas mixture containing 15% O_2 representative of the FiO_2 at 2438m which corresponds to the maximal cabin altitude pressure in commercial planes.
  - For patients with obstructive lung diseases, the current guidelines recommend in-flight O_2 supplementation (2-4 l/min) if $PaO_2 \leq 50$ mmHg (6.6 kPa) or SaO_2 < 85% during hypoxic challenge test.

3.3 Need for oxygen supply during flights

- In order to simplify the assessment for oxygen need during commercial flights, we propose the following algorithm using, SpO_2, 6 minutes walk test and FEV_1 **(Figure 1).** Although not yet validated, this algorithm is based on recent studies developed for COPD and CF patients.
- It has been shown that one third of COPD patients with SpO_2 > 95% have PaO_2 < 50 mmHg (6.6 kPa) during flights. SpO_2 alone is therefore not a good predictor of PaO_2 at high altitude.
- Airline companies usually accept passengers with portable oxygen concentrators. However, this needs to be discussed in advance. The airline company may request a certificate and arterial blood gas results before the flight.

4. SPECIAL CONSIDERATIONS

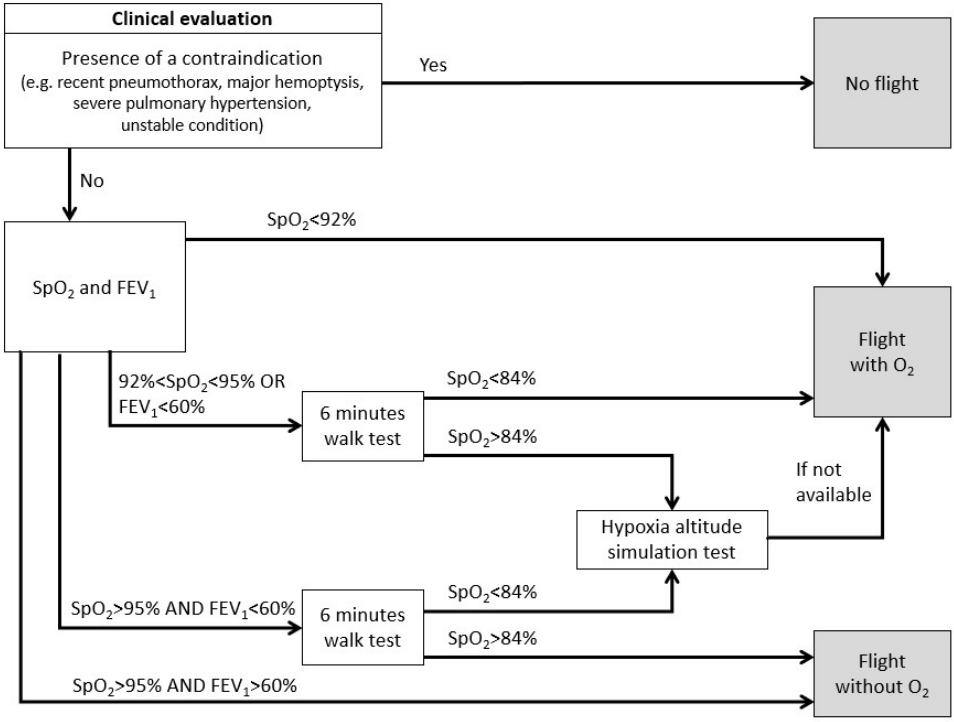
4.1 Medications

- Some medications such as inhaled tobramycin and dornase alpha need special storage conditions **(Table 2)**. If this requirement cannot be respected for dornase alpha, replacement by hypertonic saline should be considered.
- Patients should be advised to protect themselves from the sun when taking medications that may cause **photosensitivity** such as ciprofloxacin, doxycycline, fluconazole, itraconazole, voriconazole, tetracycline, TMP/SMX, and NSAID.
- Electric equipment (nebulizer, CPAP etc.) may require a power adaptor compatible to the travel location.

4.2 Risk of specific infections

- Some regions, such as Thailand, Malaysia, Vietnam and Northern Australia, can have a high prevalence of *Burkholderia pseudomallei* which may expose patients to a risk for severe pneumonia.

Figure 1: Assessment of O_2 need during flights for adult CF patients (adapted from [1-3])



Note: this algorithm is not validated yet but it was developed using information from recent studies assessing COPD and CF patients. It proposes a rather conservative approach putting patient safety first, especially when it is not possible to perform a hypoxia altitude simulation test.

Table 2: Medications in liquid form and their storage conditions

	Drug	Storage	Comments
Inhaled antibiotics	Aztreonam lysine	2-8°C	Stable for ≤ 28 days at ≤ 25°C
	Colistin	15-25°C	
	Tobramycin TOBI® Bramitob®	2-8°C	 Stable for ≤ 28 days at ≤ 25°C Stable for ≤ 3 months at ≤ 25°C
Inhaled mucolytic	Dornase alpha	2-8°C	Stable for ≤ 24 hours at ≤ 30°C. Protect from light.
	Hypertonic saline	15-25°C	Protect from light
	Acetylcysteine	15-25°C	Protect from light

- *P. aeruginosa*, non-tuberculous mycobacteria: CF patients should comply with basic hygiene rules, especially regarding sanitary installations and swimming pools.

4.3 Dehydration and salt depletion

- CF patients may lose 3 times more NaCl in their sweat than non-CF individuals.
- If they travel to hot countries and/or practice intense exercise, they are at risk of blood hypoosmolality particularly if they drink pure water. In addition, hypoosmolality may reduce the feeling of thirst which increases further the risk of dehydration.
- Patients at risk of dehydration should be advised to drink before, during and after exercising or regularly if exposed to hot conditions. Addition of carbohydrates, potassium, bicarbonates and NaCl 50 mmol/l is also recommended in such conditions.
- Commercially available electrolyte preparations such as Normolytoral® or Elotrans® contain 30 and 60 mmol/l of NaCl respectively, when correctly reconstituted. When enough NaCl cannot be provided in a liquid form, addition of salt, or of salty snacks can be considered. Some authors recommend NaCl slow release pills 2 x 1200 mg/day for adults travelling to hot destinations (up to 12g/day, if very high temperature and strenuous exercise).

4.4 Sports and special activities

- In cases of a previous pneumothorax, high intensity sports or having rapid upper body movements have to be avoided.
- Patients at a high risk for bone fracture should not perform high impact sports.

4.5 Summer camps

- Summer camps are an occasion for CF patients to socialize and also to improve exercise tolerance, nutrition and well-being. Unfortunately, it was shown that cross-infection with *B. cepacia* complex and *P. aeruginosa* significantly increased during these camps.
- Therefore, summer camps are no longer recommended.

5. DIVING

- Pulmonary barotrauma can lead to pneumothorax, pneumomediastinum and/or gas emboli.
- In patients with advanced lung disease, diving-associated pulmonary barotrauma may appear even without high-pressure changes. In the worst cases, gas emboli may spread to the patient's brain or heart, leading to loss of consciousness or heart failure. Therefore, **patients with CF should not dive, even if they are asymptomatic**.
- In contrast, there is no contraindication to snorkeling.

6. REFERENCES

1. Ahmedzai S, Balfour-Lynn IM, Bewick T, et al. Managing passengers with stable respiratory disease planning air travel: British Thoracic Society recommendations. Thorax 2011;66 Suppl 1:i1-30.
2. Akero A, Christensen CC, Edvardsen A, Ryg M, Skjonsberg OH. Pulse oximetry in the preflight evaluation of patients with chronic obstructive pulmonary disease. Aviat Space Environ Med 2008;79:518-24.
3. Edvardsen A, Akero A, Christensen CC, Ryg M, Skjonsberg OH. Air travel and chronic obstructive pulmonary disease: a new algorithm for pre-flight evaluation. Thorax 2012;67:964-9.
4. Hirche TO, Bradley J, d'Alquen D, et al. Travelling with cystic fibrosis: recommendations for patients and care team members. Journal of cystic fibrosis : official journal of the European Cystic Fibrosis Society 2010;9:385-99.
5. British Thoracic Society guidelines on respiratory aspects of fitness for diving. Thorax 2003;58:3-13.
6. Pegues DA, Carson LA, Tablan OC, et al. Acquisition of Pseudomonas cepacia at summer camps for patients with cystic fibrosis. Summer Camp Study Group. J Pediatr 1994;124:694-702.
7. Pseudomonas cepacia at summer camps for persons with cystic fibrosis. https://www.cdc.gov/mmwr/preview/mmwrhtml/00020832.htm. MMWR weekly 1993;42:456-9.
8. Brimicombe RW, Dijkshoorn L, van der Reijden TJ, et al. Transmission of Pseudomonas aeruginosa in children with cystic fibrosis attending summer camps in The Netherlands. Journal of cystic fibrosis : official journal of the European Cystic Fibrosis Society 2008;7:30-6.
9. Blau H, Mussaffi-Georgy H, Fink G, et al. Effects of an intensive 4-week summer camp on cystic fibrosis: pulmonary function, exercise tolerance, and nutrition. Chest 2002;121:1117-22.
10. Schlichting C, Branger C, Fournier JM, et al. Typing of Staphylococcus aureus by pulsed-field gel electrophoresis, zymotyping, capsular typing, and phage typing: resolution of clonal relationships. J Clin Microbiol 1993;31:227-32.