Air travel in women with lymphangioleiomyomatosis

Stacey Pollock-BarZiv PhD 1, Marsha M Cohen, MD1,2
Gregory P. Downey MD 3,4, Simon R. Johnson MD5
Eugene Sullivan, MD 6, Francis X. McCormack, MD7

1. Women’s College Research Institute, Women’s College Hospital, Toronto, Ontario
2. The University of Toronto, Department of Health Policy, Management and Evaluation.
3. The University of Toronto, Department of Medicine, Division of Respirology and McLaughlin Center for Molecular Medicine
4. The University Health Network; Department of Medicine, Division of Respirology and Toronto General Hospital Research Institute
5. The University of Nottingham, UK, Division of Therapeutics and Molecular Medicine
6. US Food and Drug Administration; Center for Drug Evaluation and Research; Division of Pulmonary & Allergy Drug Products*
7. University of Cincinnati Medical Center; Division of Pulmonary & Critical Care Medicine.

*Disclaimer
The views presented in this article do not necessarily reflect those of the Food and Drug Administration.

Running head: Air travel in LAM
Manuscript keywords: Air travel, Lymphangioleiomyomatosis

Address for correspondence:
Stacey Pollock-BarZiv, PhD
Division of Cardiology
Cardiac Transplant, Room 6429
The Hospital for Sick Children
555 University Avenue
Toronto, Ontario M5G 1X8 Canada
Ph: 416.813-7654, ext 3604
Fax: 416.813-5541
Email: s.pollock.barziv@utoronto.ca

Acknowledgements:
Funding was provided by the US LAM Foundation, and the Social Sciences and Humanities Research Council of Canada doctoral fellowship to Stacey Pollock-BarZiv.
Dr. Downey currently holds the R. Fraser Elliott Chair in transplantation research from the Toronto General Hospital and is a tier 1 Canada Research Chair.

The Corresponding Author has the right to grant on behalf of all authors and does grant on behalf of all authors, an exclusive licence (or non exclusive for government employees) on a worldwide basis to the BMJ Publishing Group Ltd and its Licensees to permit this article (if accepted) to be published in [THORAX] editions and any other BMJPG Ltd products to exploit all subsidiary rights, as set out in our licence: http://thorax.bmjournals.com/ifora/licence.pdf
Abstract

Background: There has been little study of the safety of air travel in patients with pneumothorax-prone pulmonary diseases such as lymphangioleiomyomatosis (LAM). A questionnaire based evaluation of air travel in LAM patients was conducted to determine experiences aboard commercial aircraft.

Methods: A survey was sent to women listed in the US LAM Foundation registry (n=389) and the United Kingdom LAM Action registry (n = 59) to assess air travel, including problems occurring during flight. Women reporting a pneumothorax in flight were followed up to ascertain further details about the incident.

Results: A total of 327 women completed the survey (73%). 308 women answered the travel section, of whom 276 (90%) had ‘ever’ traveled by airplane for 454 flights. Ninety-five women (35%) had been advised by their doctor to avoid air travel. Adverse events reported include shortness of breath (14%), pneumothorax (2% - 8/10 confirmed by chest x-ray), nausea or dizziness (8%), chest pain (12%), unusual fatigue (11%), oxygen desaturation (8%), headache (9%), blue hands (2%), hemoptysis (0.4%), and anxiety (22%). Five of ten patients with pneumothoraces had symptoms that began prior to the flight; 2 occurred during cruising altitude, 2 soon after landing, 1 not known. The main symptoms were severe chest pain and shortness of breath.

Discussion: Adverse effects occurred during air travel with LAM, particularly dyspnea and chest pain. Hypoxemia and pneumothorax were reported. The decision to travel should be individualized; patients with unexplained shortness of breath or chest pain prior to scheduled flights should not board. Patients with borderline oxygen saturations on the ground should be evaluated for supplemental oxygen therapy during flight. While many women had been advised not to use air travel, most traveled without the occurrence of serious adverse effects.
Pulmonary lymphangioleiomyomatosis (LAM) is a progressive lung disease that affects young women characterized by diffuse proliferation of abnormal smooth muscle cells and cystic destruction of the lung parenchyma.[1-5] LAM occurs in approximately 30% of women with the neurocutaneous syndrome, tuberous sclerosis (TSC), and also in women without heritable disease (sporadic LAM). Clinically, LAM is characterized by progressive dyspnea with exertion, fatigue, pneumothorax (in up to 70% of patients), chronic cough, wheezing and chest pain, chylothorax, and an obstructive or mixed restrictive and obstructive pattern on pulmonary function tests.[1-5] There is considerable variability in the rate of advancement, however, as the disease progresses patients often require supplemental oxygen. No definitive treatment for LAM currently exists, and lung transplantation remains the only therapeutic option for advanced disease.

The exact prevalence of LAM is not known. In the UK, a minimum prevalence of 1/373 000 women ages 16-65 years was reported [3] and the minimal prevalence rate worldwide has been estimated at 2.6 cases per one million.[6, 7] The incidence of TSC LAM is currently estimated at about 30-40% of TSC women [8]; TSC occurs in 1/6000 births, suggesting there may be as many as 8-10,000 TSC women with LAM in North America, and almost 250,000 world-wide.[8]

Rajjoub (1995) reported on a 21 year old female who experienced acute, severe dyspnea during air travel requiring immediate transport to hospital where chest x-ray revealed pneumothorax.[9] and further anecdotal reports suggest air travel may predispose LAM patients to pneumothorax. [1, 9][Personal communications, US LAM Foundation] Therefore, physicians are often asked about the risk to patients when flying. Despite this there has been little study of the safety of commercial air travel in patients with LAM. During flight, the cabin pressure is generally adjusted to be equivalent to an altitude of 1524-2438 meters (5000-8000 feet) above sea level, which typically results in a 40% decrease in arterial oxygen pressure (PaO₂) from 95 mmHg (12.7 KPa) to approximately 56 mmHg (7.5 KPa) in healthy individuals.[10] Clinically significant hypoxia may occur in some patients with reduced baseline partial pressure of arterial oxygen at sea level.[10,11] Furthermore, given the sinusoidal shape of the oxy-hemoglobin saturation curve, these individuals may suffer precipitous declines in their oxygen levels during flight.[10] The falling partial pressure of oxygen with increasing altitude may in turn result in a number of physiologic adaptations including hyperventilation, pulmonary vasoconstriction, altered ventilation/perfusion matching, and increased sympathetic tone.[11,12]

The British Thoracic Society has published recommendations for passengers with respiratory disease planning air travel.[13] They note that physiological compensations for acute hypoxemia at rest include mild to moderate hyperventilation and a moderate tachycardia. In those with pulmonary disease, these compensatory mechanisms may be insufficient to offset the risk of hypoxemia and concurrent adverse effects especially during air travel. Similarly, the Canadian and American Thoracic Societies have published guidelines for air travel for patients with chronic obstructive pulmonary disease (COPD).[14,15] Both warn of the risks of altitude related hypoxemia and provide recommendations for pre travel assessment. Nonetheless, COPD patients with arterial oxygen tensions above the recommended ‘safe’ level of 7.3 KPa (55 mmHg) may still develop severe
hypoxemia in flight.[16] A study by Christensen et al reported that of fifteen stable patients with COPD (resting $\text{PaO}_2 > 9.3$ KPa; $\text{FEV}_1 < 50\%$ predicted), 3 developed marked hypoxemia during simulated air travel at 2438 meters (8000 feet), and that light exercise (such as walking along the aisle) led to severe hypoxemia in 13 of 15 subjects.[16]

The availability of in-flight oxygen may help to alleviate problems with hypoxemia in flight. Many commercial airlines offer in-flight oxygen to passengers, but some smaller airlines do not provide oxygen services. There is usually a substantial fee for oxygen for each in-flight segment and there are often restrictions on the type of aircraft that will accommodate the oxygen cylinders. New FAA regulations allow certain portable oxygen concentrators; but these are very expensive and not yet practical for most travelers. These factors may limit the accessibility of patients with lung disease to air travel.

In addition to the risk of hypoxemia, patients with cystic lung diseases such as LAM may be particularly vulnerable to other flight-related complications such as pneumothorax. During ascent, there is a decrease in cabin pressure and a consequent increase in the volume of gases contained in closed body cavities such as within non-communicating airspaces in the lungs of patients with LAM.[10,11] Pressure fluxes during ascent and descent pose the greatest risk for expansion of an existing pneumothorax and, in theory, for the occurrence of a new pneumothorax. The British Thoracic Society air travel [13] guidelines for those with history of pneumothorax have recently been updated in 2004 [http://www.brit-thoracic.org.uk/page246.html] and include the following recommendations:

- Minimum 1 week after full radiographic resolution on chest x-ray prior to air travel;
- Minimum of 2 weeks prior to air travel for traumatic pneumothorax or thoracic surgery;
- Patients with current closed pneumothorax should not travel by commercial air;
- Risk of recurrence is higher in those with co-existing lung disease up to a year, particularly in those not undergoing surgical treatment of the initial pneumothorax.

Patients with LAM may be at increased risk for pneumothorax in general. A recent study by Almoosa et al reported that 66% of patients had at least one spontaneous pneumothorax, and 77% of those had at least one subsequent pneumothorax.[17] While anecdotal reports of in-flight pneumothorax have led many physicians to advise patients not to fly, no published guidelines exist for air travel in women with LAM.[9][Personal communications, US LAM Foundation] Moreover, excess costs and limited access to medical assistance and supplemental oxygen are potential barriers to air travel in these women. To better understand the experiences of air travel and the occurrence of in flight adverse events, we surveyed a large population of women with LAM.

**Methods:**
After institutional research ethics board approval was obtained from the University of Toronto and the Trent Multicentre Research Ethics Committee, a survey was mailed to all women registered with the US LAM Foundation (n=389) and women in the UK LAM Action registry (n=59) in 2002/2003. The US LAM Foundation promotes support, research, and awareness of this disease, as well as the procurement of LAM tissue for research. Like the LAM Foundation, the UK LAM database holds all patients with LAM who complete registration. Patients with all severities of disease are included. Women who were wait-listed for transplant or transplant recipients were excluded as they were surveyed separately. To increase response rate, non-
respondents were sent a second survey within 6 weeks, followed one month later by a postcard reminder and a third mailing.

The survey included a letter summarizing the study, and women were told that by returning the survey, they were providing informed consent to participate. Potential identifying information on the surveys were removed and completed anonymized surveys were sent to the researchers for analyses. Respondents were asked to provide demographic data, time since LAM diagnosis, medical history, and medications including progesterone, and the use of supplemental oxygen. Participants were provided with a list and asked to check any medical conditions that have been diagnosed and treated with drug therapy. As well, women were asked to rate their degree of shortness of breath on a 1-7 scale where 1=never short of breath and 7 was short of breath all the time (dyspnea score).[18]

Respondents were also asked to provide detailed information about air travel experiences between 2000 and the fall of 2003, and flights prior to 2000. Women who did not travel by air were asked to provide detailed information about reasons for not flying (e.g., no reason to fly, health professional advice, fear of flying).

Women who had at least one trip via air were asked to indicate the year of flight, whether flight was greater or less than 4 hours duration, and whether or not they used supplemental oxygen in-flight. They were further asked if they experienced symptoms in flight including shortness of breath, unusual fatigue, chest pain, pneumothorax, headache, anxiety, drop in oxygen saturation, difficulty using the in flight restroom, no symptoms, and whether each of these symptoms existed prior to getting on the flight. Finally, women who flew were asked to indicate how they felt about flying again in the future, and under what circumstances they would fly again (e.g., with the use of supplemental oxygen, with the provision of medical assistance, on flights of a certain time duration).

Women who reported the occurrence of a pneumothorax in flight were sent a follow-up survey by mail to obtain detailed information regarding the event including the following questions:

1. Were there any symptoms to suggest that the pneumothorax actually occurred prior to boarding the flight (e.g., carrying luggage, etc)?
2. What were the symptoms of the pneumothorax?
3. If you can tell, did the pneumothorax occur during ascent, descent, or at cruising altitude?
4. Did you have a chest X-ray or other examination to verify the presence of the pneumothorax?
5. Were you hospitalized?
6. How was the pneumothorax treated?
7. How many pneumothoraces had you experienced prior to the in-flight event?
8. Do you have reactive airway disease/asthma?

Data Analysis:
Respondent characteristics and background data were reported descriptively using frequencies, central tendency, standard error and percentages. The frequency and percentage of adverse events occurring on flights were also calculated. The risk of pneumothorax during flight was estimated by using the number of women reporting at least one pneumothorax in flight and the
estimated number of flights as denominators. All data analyses were conducted using the SPSS software program (version 10.0) for statistical analyses. P value for significance was set at 0.05.

Results
There were 327 completed surveys (response rate 73%), of which 308 (94%) had complete information on air travel. The mean age of respondents was 46.6 years (Table 1). Of the 327 women who completed the survey, 209 (63%) reported at least one pneumothorax in their lifetime. Among respondents, 276 (90%) women indicated that they had flown by commercial air for a total of 454 flights. There was a wide range in dyspnea scores for both women who flew (mean dyspnea score = 4.2) and those who did not fly (mean dyspnea score = 4.8); however, women who did not fly had slightly worse scores overall (p=0.02) (Table 1).

Of the 32 women who indicated that they never flew, 8 had no reason to fly, 1 followed advice of health professional not to fly, 1 was afraid of flying, 1 did not fly due to fear of LAM complications, and 18 women provided no reason. Nineteen (59%) of the women who never flew had a history of pneumothorax although it is not known if this factor contributed to their avoidance of air travel. A total of 97 (35%) respondents in the total group had been advised by their health professional to avoid air travel, of whom 77 (79%) had had a prior pneumothorax.

Table 1: Respondent characteristics

<table>
<thead>
<tr>
<th>Factor</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuberous sclerosis</td>
<td>51 (16)</td>
</tr>
<tr>
<td>Sporadic LAM</td>
<td>276 (84)</td>
</tr>
<tr>
<td>Age (yrs): (Mean 46.6 yrs)</td>
<td></td>
</tr>
<tr>
<td>&lt;40</td>
<td>88 (27)</td>
</tr>
<tr>
<td>40-49</td>
<td>112 (34)</td>
</tr>
<tr>
<td>50-59</td>
<td>91 (28)</td>
</tr>
<tr>
<td>&gt;60</td>
<td>36 (11)</td>
</tr>
<tr>
<td>Mean time since LAM diagnosis to survey</td>
<td>7.5 yrs (range &lt;1 yr - 38 yrs)</td>
</tr>
<tr>
<td>Currently use supplemental O2</td>
<td>102 (32)</td>
</tr>
<tr>
<td>History of ever having a pneumothorax</td>
<td>209 (63)</td>
</tr>
<tr>
<td>Mean (SD) Dyspnea Score</td>
<td></td>
</tr>
<tr>
<td>Flew</td>
<td>4.2 (1.4) (range 1-7)</td>
</tr>
<tr>
<td>Never flew</td>
<td>4.8 (1.8) (range 1-7)</td>
</tr>
</tbody>
</table>

When asked about flying again in the future, 168 (61%) said yes, without hesitation, 43 (16%) noted yes, with supplemental oxygen, 11 (4%) said yes with oxygen and medical support, 29 (11%) said not unless it was an emergency, and 17 (6%) said absolutely not.
Use of supplemental oxygen:
The use of supplemental oxygen increased over time, with 4% using oxygen of respondents on flights prior to 1997, and 27% using oxygen on flights between 2000-2003. The lack of availability of supplemental oxygen was a deterrent to flying in 22 (9%) of women; an additional 23 (10%) indicated that the cost of supplemental oxygen restricted them from flying as much as they would like (fees for supplemental oxygen on domestic American flights range from $75 to $150 per flight segment).

Adverse events during flight:
While 68.5% of the flights were uneventful with no adverse events, many women did experience some adverse effect of LAM while flying (Table 2). The most commonly reported respiratory event occurring during air travel was shortness of breath, affecting women in 14% of flights overall. Events that could be attributed to hypoxemia also occurred during flights, with variable frequency. For example, on all flights, 8% of women reported a drop in oxygen saturation assessed by personal oximeters. Other adverse events reported included chest pain in 12%, fatigue or lethargy in 11%, and headache in 9%. Interestingly, anxiety was the most common adverse effect of flying, reported by women during 22% of flights. Women reporting no adverse effects were significantly less likely to have been evaluated for a lung transplant ($\chi^2=5.5$, df=1, $p=0.025$) but there were no differences in chronological age or age at diagnosis.

Table 2: Adverse Events on Flights Between 2001-2003, and Prior to 2001.

<table>
<thead>
<tr>
<th>Adverse Effect</th>
<th>2001-2003 (190 flights) n (%)</th>
<th>&lt;2001 (264 flights) n (%)</th>
<th>Total (454 flights) n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumothorax</td>
<td>5 (3)</td>
<td>5 (2)</td>
<td>10 (2.2)</td>
</tr>
<tr>
<td>Anxiety</td>
<td>57 (30)</td>
<td>43 (16)</td>
<td>100 (22)</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>33 (17)</td>
<td>32 (12)</td>
<td>65 (14)</td>
</tr>
<tr>
<td>Chest pain</td>
<td>29 (15)</td>
<td>25 (9)</td>
<td>54 (12)</td>
</tr>
<tr>
<td>Drop in O₂ saturations</td>
<td>27 (14)</td>
<td>11 (4)</td>
<td>38 (8.4)</td>
</tr>
<tr>
<td>Fatigue /lethargy</td>
<td>23 (12)</td>
<td>28 (11)</td>
<td>51 (11)</td>
</tr>
<tr>
<td>Nausea /dizziness</td>
<td>14 (7)</td>
<td>22 (8)</td>
<td>36 (7.9)</td>
</tr>
<tr>
<td>Headache</td>
<td>11 (6)</td>
<td>28 (11)</td>
<td>39 (8.6)</td>
</tr>
<tr>
<td>Blue hands / nails</td>
<td>4 (2)</td>
<td>3 (1)</td>
<td>7 (1.5)</td>
</tr>
<tr>
<td>NO adverse effects</td>
<td>135 (68)</td>
<td>176 (67)</td>
<td>311 (68.5)</td>
</tr>
</tbody>
</table>
**Pneumothorax:**

Pneumothorax occurred in 10 women during flight (Table 2); mean and median age at the time was 34.5 years (range 24-49 years), with two women in their mid-20’s, five women in their 30’s, and two in their 40’s. Eight of the ten women had had at least one prior pneumothorax. Five women experienced a pneumothorax on a flight between 2001-fall 2003 (4 confirmed by chest x-ray), and five on flights prior to 2001 (4 confirmed by chest x-ray). One woman developed a pneumothorax on two separate flights.

Based on these results, the estimate of the risk of a pneumothorax in-flight was 2.2% (10 pneumothoraces during 454 flights), and risk estimate of pneumothorax per women flying was 4% (10 women with pneumothoraces among 276 women who flew).

**Follow-up of in-flight pneumothoraces**

We surveyed 9 of the 10 women (excluding one woman for whom we had no contact information but had some details regarding the pneumothorax incident from the original survey) and received detailed information regarding the event from 8 (Table 3). Eight of the ten pneumothoraces had been documented by chest x-ray. Eight of these women had had a least one previous pneumothorax prior to the pneumothorax in flight. None knew they had LAM prior to boarding the flight where the pneumothorax occurred; all had flown safely before. Four of the women indicated that they also had reactive airway disease/asthma.

Five women indicated that they had symptoms that may have suggested the presence of a pneumothorax prior to boarding the flight, including unusual shortness of breath (n=5), chest pain (n=2), burning (n=1), unusual fatigue (n=2), and difficulty walking (n=1). Furthermore, one of these women noted that she was also pregnant during the flight, and had unusual sharp chest pain the morning of the flight (prior to boarding).

Four women developed symptoms consistent with pneumothorax while in flight or soon after landing. Two women explained that they began to feel symptoms while at cruising at altitude (sudden sharp pain and shortness of breath in both). One also described difficulty breathing and continued pain on inspiration surrounding the area of the original sharp pain. The other two women indicated that symptoms were noted shortly after landing. One experienced shortness of breath and fatigue, and was hospitalized for 13 days and treated by chest tube drainage. The second woman described “severe chest pain in the front and back of my chest plus tremendous pressure, as well as pain in my neck and right arm”. Upon landing she was hospitalized for 1 week and treated with chest tube drainage followed by pleurectomy.
Table 3: Characteristics of Women who Experienced Pneumothoraces in flight (n=10).

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Age at Ptx in flight</th>
<th>Prior Ptx Y/N (#)</th>
<th>Symptoms: Prior to/ascent/cruising/descent</th>
<th>Main Symptoms</th>
<th>Treatment</th>
<th>Reactive airway disease Y/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39</td>
<td>24</td>
<td>Y (2)</td>
<td>Cruising</td>
<td>Sharp pain, SOB</td>
<td>Chest tube/pleurodesis</td>
<td>Y</td>
</tr>
<tr>
<td>2 (NR)</td>
<td>29</td>
<td>27</td>
<td>Y (5+)</td>
<td>Soon after landing</td>
<td>Chest pain</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>28</td>
<td>N</td>
<td>Prior to</td>
<td>SOB</td>
<td>Chest tubes</td>
<td>N</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
<td>30</td>
<td>Y (1)</td>
<td>Prior to</td>
<td>Sharp pain, burning, SOB</td>
<td>Hospitalized for observation (also pregnant)</td>
<td>N</td>
</tr>
<tr>
<td>5</td>
<td>36</td>
<td>34</td>
<td>Y (1)</td>
<td>Prior to</td>
<td>SOB, fatigue</td>
<td>Chest tube</td>
<td>Y</td>
</tr>
<tr>
<td>6</td>
<td>40</td>
<td>35</td>
<td>Y (5)</td>
<td>Prior to</td>
<td>Chest pain, SOB, nausea, unusual fatigue</td>
<td>Chest tube</td>
<td>n/a</td>
</tr>
<tr>
<td>7</td>
<td>56</td>
<td>35</td>
<td>Y (3)</td>
<td>Severe pain soon after landing</td>
<td>Severe chest pain, pressure</td>
<td>Chest tube, pleurectomy</td>
<td>N</td>
</tr>
<tr>
<td>8</td>
<td>52</td>
<td>49</td>
<td>Y (1)</td>
<td>Prior to</td>
<td>SOB, unusual fatigue</td>
<td>Pleurodesis with talc</td>
<td>Y</td>
</tr>
<tr>
<td>9</td>
<td>50</td>
<td>48</td>
<td>N</td>
<td>Cruising</td>
<td>Sudden sharp pain, followed by pain on inspiration, SOB</td>
<td>n/a</td>
<td>Y</td>
</tr>
<tr>
<td>10 UK</td>
<td>42</td>
<td>35</td>
<td>Y (2+)</td>
<td>n/a</td>
<td>Chest pain, SOB</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Legend:
Ptx = Pneumothorax; SOB = shortness of breath; NR = non respondent; n/a = data not available
Discussion

The present study is the largest air travel survey of LAM women to date, and provides some revealing, albeit retrospective, data on the experiences of air travel in women with LAM. It should be noted, however, that women who were wait-listed for, or who had undergone lung transplantation for end-stage disease were excluded from this study, therefore findings may not generalize to women with more advanced disease. Nonetheless, the group women who traveled by air had, on average, better dyspnea scores than those who did not, and there was a wide range in values of dyspnea scores for both women who flew and those who did not. Therefore, the participants include women with LAM who had differing severities of disease thereby affirming the generalizability of these results.

While hypoxemia-related problems such as dyspnea and chest pain occurred during air travel with LAM, these results reveal an approximate risk of 2% of pneumothorax. While the risk of pneumothorax is small, it was more likely in women with a prior history of pneumothorax, and occurred most frequently in women who were 30-39 years of age. Interestingly, there was circumstantial evidence to suggest that pneumothorax may have occurred before boarding in half of the cases. Ironically, our data indicate that most of the pneumothoraces occurred in women who did not know they had LAM, and counseling patients with known LAM on the safety of air travel based on these data must be made with caution.

The finding that adverse events plausibly related to hypoxemia commonly occurred in women who flew is important. Chest pain, fatigue/lethargy, nausea and vomiting, headache, and a drop in oxygen saturation during flight were reported by women with LAM. However, these factors alone may not necessarily prevent a patient wishing to travel from doing so. The availability of supplemental oxygen for patients with marginal preboarding oxygen saturations and good clinical health at the time of travel are reasonable prerequisites for safe air travel. Results of prior studies would suggest that symptoms related to reduced blood oxygen content at altitude would lead to considerable risk of symptoms in hypoxemic patients traveling by air [11, 16]; however, medical emergencies during flight in this group were rare, and may have been mitigated by the frequent use of supplemental oxygen during flight.

Of importance was the observation that anxiety regarding flying is very common. Anxiety may exacerbate symptoms of breathlessness, chest pain, and nausea, and is extremely important to consider prior to travel. It should be noted that reports of anxiety may have been reflective of a generalized fear of flying, or in response to being aware of the increased risk of adverse effects due to LAM. Anxiolytics may be considered for women at risk for disabling anxiety during commercial air travel.

In 2001 the US Federal Aviation Authority (FAA) issued a ruling requiring the inclusion of bronchodilator inhalers, and non-narcotic analgesics in medical kits on flights by April 2004.[10, 12] As useful as these agents may be, supplemental oxygen is the cornerstone of treatment for a hypoxemic patient who becomes symptomatic during flight.[19] The provision of supplemental oxygen must be arranged prior to flight. Suspected pneumothorax during flight should be treated with high flow oxygen by nasal cannula. Unfortunately, definitive medical care including drainage of the pleural space is generally not available prior to landing. Tension pneumothorax, or pneumothorax occurring in a patient with exhausted pulmonary reserves, can be life
threatening. Diversion to the closest airport with medical care should be considered if severe shortness of breath does not resolve with simple interventions such as oxygen or bronchodilator therapy.\[10]\n
It is generally advised in the literature that individuals who have a medical condition that is adversely affected by hypoxia or changes in pressure avoid travel. A simple test that has been proposed to assess one’s fitness for travel by flight is the ability to walk 46 meters (150 feet) without severe dyspnea or chest pain.\[10]\n
However, results were not correlated with disease severity at the time of flight, or with outcome. Recent research has focused on pre-flight assessment of patients to predict those at risk to develop adverse consequences.\[20-22]\n
Some methods utilized include assessment in a hypobaric chamber where arterial blood gas tensions are assessed \[21, 22\], or simulating cabin altitudes at rest and while walking after inhaling a hypoxic gas mixture.\[20\] Striving to identify passengers who are likely to develop hypoxemia may enhance safety of air travel, particularly in LAM patients with advanced disease.

The use of supplemental oxygen during air travel increased over time. This may in part reflect the progressive nature of the disease, but likely represents increasing recognition of the need for in-flight oxygen, and better accessibility. An increase in this percent could mean that patients with more severe disease are now flying (and using oxygen), whereas such patients may not have flown in the past. Unfortunately, accessibility to, and the cost of, oxygen was a significant barrier to travel in this group of women with LAM. Arranging for the use of supplemental oxygen can be difficult, and even if done in advance, adds to the stress of air travel. The ability to board aircraft with personal oxygen devices would greatly simplify air travel for all patients who require supplemental oxygen while traveling. In 2004, the FAA released a proposal facilitating the use of certain portable oxygen concentrator devices onboard aircraft thereby significantly simplifying advanced planning for patients who require supplemental oxygen.

Although this is the largest survey of women with LAM addressing the risk of air travel, the retrospective and cross sectional nature of this study warrants caution in interpretation. Another potential limitation is that we were looking at the incidence of pneumothorax among patients who flew. There may be important differences between those that flew, and those that chose not to. For example, it is possible that more severely ill patients did not fly, and that if they did, their risk might be greater. However, while results are dependent on historical recall of experiences, recall of significant medical events such as a pneumothorax in flight are likely to be reliable. Moreover, the rarity of the disease complicates the performance of large prospective studies on the experiences of air travel in LAM, and patient survey evidence is the only data that is currently available for making recommendations.

Although the current data do not allow for the identification of individual LAM patients who may be at increased risk of pneumothorax while flying, patients with LAM should be advised that the presence of any clinical symptoms such as unusual chest pain or shortness of breath prior to flight should preclude flying. A prior history of pneumothorax was present in almost all patients who suffered a pneumothorax in flight, but since two thirds of LAM patients suffer a pneumothorax at some point in their disease course, this is not a very discriminating feature when assessing risk of pneumothorax during flight. Advanced cystic disease with limited pulmonary reserves may enhance the health consequences of pneumothorax during flight, and
should be considered in the risk-benefit analysis before flying. Patients with borderline oxygen saturations on the ground should be evaluated for supplemental oxygen therapy during flight.

In summary, while many women had been advised not to use air travel, most traveled without the occurrence of serious adverse effects. Results of the present study provide preliminary information for patients with LAM and health care providers advising them, however, prospective study of patients at various stages of disease choosing to fly is warranted.
References: