Air travel: Implications for patients with pulmonary disease

DM Seminar presented by:
Dr. Vamsi Krishna
SR, Pulmonary medicine, PGIMER
Problems associated with Air Travel

Over 1 billion people air travel each year world over. Passengers traveling by air are exposed to following risks:

• Exposure to high altitude

• Risk of DVT

• Spread of Infectious diseases
Air travel: Pressurized cabins?

- Commercial aircraft are not pressurized to sea level, but to a relatively modest intermediate cabin altitude. (fuel efficient for jet engines and avoids much turbulence)

- Aircraft cabin altitude can thus approach 2438 m (8000 ft) while the aircraft is flying at 11582 m (38000 ft).

Cottrel JJ. Chest 1988;92:81-4
Effects of altitude on Oxygenation

- At altitude of 8000 ft, partial pressure of oxygen falls to a level, equivalent to breathing oxygen at FiO₂ of 15.1%
- In a healthy individual, PaO₂ falls to 53-64 mm Hg, SpO₂ falls to 85-91%
Magnitude of problem

- 5% of commercial airline passengers were ambulatory patients with some illness including chronic obstructive pulmonary disease (COPD).
  
  \[ \text{Iglesias R. Aerosp Med 1974; 45: 204-206} \]

- 10.2% of in-flight medical emergencies calls were respiratory in nature.
  
  \[ \text{Cottrel J. JAMA 1989; 262(12):1653-6} \]

- 17% of respiratory in flight emergencies resulted in diversion of air craft and was 3rd most common cause.
  
  \[ \text{Sirven JI. Neurology,2002;58:1739-44} \]
Magnitude of problem

Dowdall N. BMJ 2000;321:1336-1337
### Table 1 — Selected Surveys of In-Flight Medical Emergencies

<table>
<thead>
<tr>
<th>Category</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>61 (Speizer et al) 60 (Cummins and Schubach) 59 (Skjenna et al) 50 (Cottrell et al) 49 (Hordinsky and George)</td>
</tr>
<tr>
<td><strong>Locus</strong></td>
<td>Los Angeles  Seattle-Tacoma  Air Canada  United Air Lines  FAA</td>
</tr>
<tr>
<td><strong>Period</strong></td>
<td>10/1/85-3/31/86  9/1/86-8/31/87  1/1/88-12/31/88  7/1/86-6/31/87  8/1/86-7/31/87</td>
</tr>
<tr>
<td><strong>No. of passengers (× 10⁶)</strong></td>
<td>8.735  14.400  13.553  55,000  ns*</td>
</tr>
<tr>
<td><strong>In-flight incidents, No. (%)</strong></td>
<td>260 (0.003)  190 (0.001)  464 (0.003)  218 (0.0004)†  1,016†</td>
</tr>
<tr>
<td><strong>Categories of incidents, No. (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>34 (13)  21 (20)  235 (50.6)  34 (15.6)  177 (17.4)</td>
</tr>
<tr>
<td>Respiratory</td>
<td>20 (7.5)  15 (7.9)  48 (10.3)  22 (10.1)  94 (9.3)</td>
</tr>
<tr>
<td>Neurologic</td>
<td>49 (18.6)  23 (12.1)  33 (7.1)  72 (33)  256 (25.2)</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>69 (26.5)  28 (14.7)  59 (12.7)  ns*  109 (10.7)</td>
</tr>
<tr>
<td>Trauma</td>
<td>13 (5)  26 (13.7)  31 (6.7)  ns*  12 (1.2)</td>
</tr>
<tr>
<td>Other</td>
<td>76 (29.2)  60 (31.6)  58 (12.5)  90 (41.3)  368 (36.2)</td>
</tr>
<tr>
<td>Incidents/100,000 passengers</td>
<td>2.9  1.3  3.4  0.4  ...</td>
</tr>
<tr>
<td>In-flight deaths, No.</td>
<td>7  0  2  3  9</td>
</tr>
<tr>
<td>Medical kit uses, No.</td>
<td>—  —  167  362  1,016</td>
</tr>
</tbody>
</table>
Clinical strategy

Aim: To maintain PaO₂ of >50 mm Hg during travel

Target: High risk patients

Preflight assessment of in-flight PaO₂

Oxygen supplementation to needy
Preflight evaluation
Who should be evaluated?

- Severe COPD or asthma
- Severe restrictive disease, especially with hypoxemia
- Cystic fibrosis
- Recent Pneumothorax
- Pre-existing requirement for oxygen or ventilator support
- History of air travel intolerance with respiratory symptoms (dyspnea, chest pain, confusion or syncope)
- Risk of or previous venous thromboembolism
- Conditions worsened by hypoxemia (cerebrovascular disease, coronary artery disease, heart failure)
- Cases of Tuberculosis

BTS 2004 recommendations
Preflight evaluation

History & examination
- Spirometry
- SpO2
- ABG

Regression estimates of PaO2
- Hypoxia Inhalation Test
- 6 minute walk test
Predicting PaO$_2$

- PaO$_2$ of 68 or 72 at ground level predicts in cabin PaO$_2$ of 50 and 55 respectively (making correction for FiO$_2$, assuming constant A-a gradient)

- PaO$_2$ at sea level alone as a predictor may misclassify many patients as A-a gradient and PaO$_2$/ FiO$_2$ ratios do not remain same at altitudes.

Regression estimates of PaO\textsubscript{2}

- \[20.38 - (3 \times \text{altitude}) + 0.67 \times \text{PaO}_2 \text{ Ground (mmHg)}\]

- \[22.8 - (2.74 \times \text{Altitude}) + 0.68 \times \text{PaO}_2 \text{ Ground (mmHg)}\]
  Not dependant on spirometric values
  moderate COPD (FEV1 40%)
  \textit{Gong H. Am Rev Respir Dis 1984; 130:980-986}

- Eq 1: \[0.410 \times \text{PaO}_2 \text{ Ground (mmHg)} + 17.652\]
- Eq 2: \[0.519 \times \text{PaO}_2 \text{ Ground (mmHg)} + 11.855 \times \text{FEV1 (liters)} - 1.760\]
- Eq 3: \[0.453 \times \text{PaO}_2 \text{ Ground (mmHg)} + 0.386 \times (\text{FEV1\% pred}) + 2.44\]
  Moderate COPD (FEV1 33%)
  Addition of spirometric values improve prediction
### Regression estimates of PaO$_2$

<table>
<thead>
<tr>
<th>Equation</th>
<th>Rp</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.417(PaO2)+17.802$</td>
<td>0.756</td>
</tr>
<tr>
<td>$0.294(PaO2)+0.086(\text{FEV1%})+23.211$</td>
<td>0.804</td>
</tr>
<tr>
<td>$0.245 \ (PaO2)+0.171(\text{FEV1/FVC%})+21.028$</td>
<td>0.828</td>
</tr>
<tr>
<td>$0.228 \ (PaO2)+20.098(\text{FEV1/FVC})+22.258$</td>
<td>0.827</td>
</tr>
</tbody>
</table>

Addition of spirometric values improve prediction
Addition of more than one variable do not improve predictability much

*Dillard TA. Chest 1995;107:352-7*
Regression estimates of PaO₂

- No guidelines and recommendations on when and what formula to be used

- Some authors prefer use of regression estimate as first step and advice Hypoxia inhalation test, if PaO₂ is (50 +/- 3) mm Hg
Hypoxia Inhalation Test

Breathing 15% O2 by face mask/mouth piece  
Breathing in a body box with 15% O2  
Breathing Nitrogen with venturi mask (35-40%)

Monitor SpO2 &  
After 15-20 minutes measure PaO2

Creates FiO2 of 15%  
Estimate in flight PaO2  
But flight duration and cabin conditions are not reproduced.
Hypoxia Inhalation Test (HIT)

- PaO2 levels measured by HIT correlated with PaO2 levels measured with hypobaric exposure of 8000 ft.  
  
  _Dillard TA. Chest 1995;107;352-357_

- Results HIT correlated well with hypobaric exposure, but full equilibration took 20 minutes

  _Naughton MT. Am J Respir Crit Care 1995;152;1956-60_
Regression estimate Vs Hypoxia inhalation test
Vs Hypobaric simulation

- Regression estimates – easy to calculate
  - require PaO₂, FEV₁ only
  - do not require special gases and equipment

- 15.1% HIT within 2 hrs of 8000 ft hypobaric exposure had higher accuracy than regression estimates

  *Naughton MT. Am J Respir Crit Care 1995;152:1956-60*

- HIT performs as good as hypobaric simulation

  *Dillard TA. Chest 1995;107:352-7*
50 meter walk test

- Inability to complete walk test or moderate to severe dyspnea (assessed by VAS) could implicate necessity for oxygen onboard.

  \textit{BTS Recommendations 2002}

- Equating MRC 3 or 4 at FiO$_2$ 21\% to MRC 5 at FiO$_2$ 15\%

- No studies to validate this test.

- Questionable utility.
Pulse Oximetry

• Preflight assessment:
  BTS recommendations incorporate SpO2 into preflight assessment
  But confounded by smoking and transient hyperventilation

• Use in HIT:
  During acute hypoxia, pulse oximetry over-estimates PaO2
  Currently use of pulse oximetry in HIT not recommended as it is not studied
  and validated

• In-flight monitoring:
  Studies suggest SpO2 of >90% would maintain PaO2 of >50 mm Hg
    Bendrick GA. Aviat Space Environ Med 1995;66:40-44
  But its routine use for self monitoring by patients not recommended
SpO2

>95%

95-92%
No risk factors:
• Hypercapnia
• FEV1 <50%
• Lung cancer
• Severe restriction
• CAD & CVA

95-92%
With risk factors

Hypoxia inhalation test
15 min of 15.1% O2

>55 mm Hg

Walk test
May be helpful

Can travel without
Supplemental oxygen

55-50 mm Hg

Require supplemental
oxygen

<50 mm Hg
Pre flight evaluation in pediatric population

- Difficult to predict how an infant behaves in hypoxic environment. (presence of right to left shunt and fetal hemoglobin)

- Infants with respiratory disease in neonatal period and children with chronic respiratory diseases like cystic fibrosis should undergo pre flight evaluation.

- Young children and infants should undergo hypoxia inhalation test in body box
Infants with H/O Respiratory illness

Chronic respiratory illness

Spirometric evaluation of FEV1

FEV1 <50%

Hypoxia inhalation test

If SpO2 <90% Require oxygen

SpO2 >90%

FEV1 >50%

Do not require oxygen

Oxygen dependant children

Titration of oxygen during Hypoxia inhalation test

Provide oxygen at determined rate

BTS protocol
Preflight evaluation

- 24% of physicians measuring blood gas levels recommend in-flight oxygen when PaO2 < 7.3 kPa and 50% when PaO2 is 7.3-8.0 kPa.

- 65% of physicians using spirometry recommend oxygen when the FEV1 is < 40%

- 50% recommend oxygen when SaO2 < 90%, 33% when SaO2 is 90-94%.

- 10% physicians use predictive equations.

- More than half of specialists but fewer than 10% general physicians perform hypoxic challenge tests

Travel advice
Supplemental oxygen

• Supplementary oxygen is usually given at a rate of 2 -4 L/min.

• Given by nasal cannulae.

• In-flight oxygen need not be switched on until the plane is at cruising altitude, and may be switched off at the start of descent.

• For patients on oxygen at sea level, the rate should only be increased while at cruising altitude.
Supplemental oxygen

- Evaluation for oxygen requirement during HIT.

  2 l/min oxygen supplementation would suffice to maintain SpO₂ >90% in patients with severe obstruction and moderate restriction.

  Cramer D. Thorax 1996;51:202-203

- Empirical formulae:
  
  \[(\text{FiO}_2 \times \text{SBP}) \text{ at ground} = (\text{FiO}_2 \times \text{SBP}) \text{ at altitude}\]
Characters of 233 patients receiving In flight Oxygen  
*Gong jr. Chest 1992;101;1104-1113*

<table>
<thead>
<tr>
<th>Diagnostic categories</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>COPD</td>
<td>104 (44.6)</td>
</tr>
<tr>
<td>Asthma</td>
<td>15 (6.4)</td>
</tr>
<tr>
<td>Interstitial lung disease</td>
<td>14 (6.0)</td>
</tr>
<tr>
<td>Cystic fibrosis</td>
<td>3 (1.3)</td>
</tr>
<tr>
<td>Neuromuscular disorder</td>
<td>7 (3.0)</td>
</tr>
<tr>
<td>Pneumonia (recent)</td>
<td>11 (4.7)</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>3 (1.3)</td>
</tr>
<tr>
<td>Pulmonary hypertension</td>
<td>6 (2.6)</td>
</tr>
<tr>
<td>Lung cancer</td>
<td>18 (7.7)</td>
</tr>
<tr>
<td>Other malignancy</td>
<td>9 (3.8)</td>
</tr>
<tr>
<td>Cardiac disorder</td>
<td>72 (30.9)</td>
</tr>
<tr>
<td>Seizure disorder</td>
<td>6 (2.6)</td>
</tr>
</tbody>
</table>

Preflight oxygen therapy: 157 (67.4); 92 continuously
65 intermittently
General measures

• Carry well-filled reliever and preventer inhalers in their hand luggage

• Portable battery-operated nebulisers may be used at the discretion of the cabin crew.

• Spacers are as effective as nebulisers

• A full supply of all medication should be taken as hand luggage, preferably in the original packaging with pharmacy labels.
COPD

- 38% of patients with severe COPD had at least one airline trip within 2 year period.
- Only 27% of them consulted physician before trip
- 18.2% of them developed symptoms or signs during travel
  
  Dillard TA. Arch Int Med 1991;151:1793-1795

- Mean fall of SpO2 in patients with severe COPD was 11% (94 to 83%)
  
  Gong H. Am Rev Resp Dis 1984; 130:980-986

- Light exercise such as walking to bathroom without supplemental oxygen could produce severe hypoxia and near syncope in patients with severe COPD.
  
  Kramer RA. Chest; 1995 108: 1292-96

- Risk of pneumothorax in relation to size of bulla not studied
Indications for Hypoxia inhalation test in patients with COPD

Comorbid disease that may be affected by hypoxaemia

- Coronary artery disease
- Congestive heart failure
- Arrhythmias and other cardiac diseases
- Cerebrovascular disease
- Anemia
- Seizure disorders and other neurologic diseases
- Pulmonary vascular disease including pulmonary embolism

Symptoms manifested during prior air travel
- Recovery phase after acute exacerbation
- Tendency to hypoventilation with oxygen administration
- Prediction of altitude \( \text{Pao}_2 = 50 + 3 \text{ mm Hg} \) by regression equation
- Reassurance before embarking on air travel
Bronchial Asthma

• Around one third of in-flight respiratory emergencies are ascribed to asthma.

  Cottrel JJ. JAMA 1989; 262: 1653-6

• Patients with severe asthma needs pre flight evaluation of supplemental oxygen.

• Patients are advised to carry inhalers and other regular medications in hand baggage.

• Spacers are as efficient as nebulisers in emergency
Patients with moderate restriction (FEV1 50%), PaO₂ decreased from 10.4±1.6 kPa at sea level to 6.5±1.1 kPa at 8000 ft simulated altitude, and decreased further during light exercise (5.1±0.9 kPa).

PaO₂ at this altitude correlated positively with sea-level PaO₂ and transfer factor of the lung for carbon monoxide and negatively with PaCO₂.

PaO₂ increased to acceptable levels with an O2 supply of 2 L/min at rest and 4 L/min during 20 W exercise.

Christensen CC. Eur Respir J 2002;20:300-305

Patients with severe restriction especially those with hypoxia should undergo pre flight evaluation.

BTS recommendations 2004
Cystic Fibrosis

- Patients with FEV1 <50% should undergo hypoxia inhalation test
- Patients with desaturation (SpO₂< 90%), should receive supplemental oxygen.
- Low cabin humidity could increase risk of bronchospasm and retention secretions with associated risk of atelectasis
OSA

- Patients should alcoholic beverages before and during the flight.

- Should carry dry cell powered CPAP machine

- Patients with significant de-saturation should use CPAP while sleeping onboard.
Patients on LTOT

• Should increase flow of oxygen

• No studies to show how much to be increased

• Titration at Hypoxia Inhalation Test is suggested

• Arrangements for oxygen in airport and transport to be arranged before hand
Ventilator dependant patients

- Should have an escort competent enough to change the tube, perform suctioning and do manual breathing.

- Carry an additional tracheostomy tube and battery driven suction machine

- Monitor cuff pressure (a little air needs to be removed during ascent and a little air be introduced on descent)
Pneumothorax

• Relative expansion of humidified gas =

\[
\frac{(\text{initial pressure of the gas in the cavity at sea level} - 47)}{(\text{final pressure of gas in cavity} - 47)}
\]

• Gas expansion with altitude is significantly greater than predicted by Boyle’s law as applied to dry gas alone.

• The volume of gas in a non-communicating bulla/cavity will thus increase by 37.6% on ascent from sea level to 2438m (8000ft).
Pneumothorax

Current closed Pneumothorax

Spontaneous Pneumothorax treated
By non-surgical means

Spontaneous Pneumothorax treated
By surgical means

Traumatic Pneumothorax

Do not travel

• Safe after 1 week
• Avoid air travel for 1 yr if secondary spontaneous

Can travel safely

Safe after 2 weeks After resolution

BTS recommendations 2004
Deep Vein Thrombosis
DVT

- Economy class syndrome, traveler's thrombosis, flight related DVT
- Hypotheses for increased risk include restricted mobility, seated position, dehydration and alcohol ingestion
- Compression of popletial veins against seat edge
- Decreased cabin pressure and hypoxia can decrease fibrinolytic pathway

  *Gertler JP. J Vasc Surg 1993;18:939-946*

- Hypobaric environment leads to increased activated coagulation pathway

  *Bendz B. Lancet 2000;356:1657-58*
DVT and PTE

- 75% of post travel DVT were idiopathic against 38% in control group, suggesting air travel as an independent risk factor
  
  *Emile F. Chest 1999;115:440–444*

- Asymptomatic DVT occurs in nearly 10% of passengers
  
  *Scurr JH. Lancet 2001; 357:1485-1489*

- 11/61 deaths (in 3 yr duration) after arriving at Heathrow airport were due to PTE
  
  *Sarvesvaran R. Med Sci Law 1986;26:35-38*

- No increase in risk of DVT due to air travel (odds ratio of 1)
  
  *Rodemil A. The Lancet 2000;352:1492-92*
DVT

- Frequency of DVT was 1·0% (9/878, 95% CI 0·5–1·9), which included four cases of pulmonary embolism and five of deep venous thrombosis.
- Low to moderate risk population. NZATT study. Hughes RA The Lancet 2003; 362:2039-2044

- LONFLIT 1 study showed zero incidence of DVT in low risk population against 2.8% in high risk population (H/O DVT, malignancy, coagulation disorder or large varicose veins) after 12 hr air travel. Belcaro G. Angiology 2001;52:369-74

- Incidence of DVT increases with distance traveled:
  - <5000 km - 0.01 case/million
  - >5000 km - 1.5 case/million
  - >10,000 km - 4.8 case/million
Prevention of DVT: Stockings

- Elastic stockings prevented DVT in healthy people traveling by air (no one wearing stockings developed DVT, 10% of control group developed Doppler proven DVT).
  
  Scurr JH. Lancet 2001; 357:1485-1489

- LONFLIT 2: in high risk population (H/O DVT, malignancy, coagulation disorder or large varicose veins) showed, below knee stockings reduce incidence rate of DVT to 0.24% compared to 4.5% in controls (flight duration 12.4 hrs).
  
  Belcaro G. Angiology 2001; 52:369-74

- LONFLIT 4 study showed reduced incidence of DVT in low and moderate risk population (0/184 Vs 6/188) in long duration flight (11-12 hrs) but no added advantage in short duration flights (7-8 hrs).

  Belcaro G. Angiology 2003; 54: 143-54
Graduated compression stockings

LONFLIT 4 :
• 20-30 mm Hg at ankles

LONFLIT 5 *:
• Long haul flight in high risk patients
• Specific “Scholl flight socks”
• DVT incidence was 6 times greater in control group compared to stockings users
• Pressure at ankle was 14-17 mm Hg

Aspirin and LMW Heparin

5/9 patients with DVT/PTE were receiving aspirin


LONFLIT 3 study:
• 300 High risk patients defined as prior DVT, a coagulation disorder, obesity or severely limited mobility, malignancy within the preceding 2 years, or large varicose veins

• **No Tt** Vs **Aspirin** Vs **LMW** heparin
• 4 cases Vs 3 cases Vs none

• Supports use of LMW heparin in high risk cases (p 0.02 when compared to controls)

Other modalities

LONFLIT – FLITE study:

• High risk group
• Flight duration 7-8 hrs
• Used profibrinolytic agent pinokinase (pine bark extract and Nattokinase, fermented soya extract)
• 0% in Tt group Vs 5.4% in placebo group

Belcaro G. Angiology 2003;54(5):531-9
BTS recommendations: Risk stratification

Slightly increased risk:
- > 40 yrs
- Obesity
- Varicose veins
- Polycythemia
- < 72 hours from minor surgery

Moderately increased risk:
- Family history of VTE
- Pregnancy
- Post natal state
- Estrogen therapy
- Recent MI
- Limb paralysis
- Limb surgery or trauma

High risk for DVT:
- Previous VTE
- Thrombophilia
- Within six weeks of major surgery
- History of previous stroke
- Malignancy
Prophylactic measures: BTS recommendations

- Avoid sleeping pills & Avoid sleeping for long periods
- Consider graduated compression stockings

- Avoid alcohol
- Patients not receiving supplemental oxygen should remain mobile
- Do leg exercises

- Graduated compression stockings
- Consider Preflight Aspirin

- LMW Heparin
- Anticoagulation to INR of 2-3

Risk categories:
- Slightly increased risk
- Moderate risk
- High risk
Spread of Infectious Diseases
Tuberculosis

- Evidence of transmission was limited to crew members exposed to the index case for over 11 hours.

- Transmission was demonstrated only in a few passengers seated in close proximity to the index case, and only on a flight lasting more than eight hours.

  Thomas AK.
  
Tuberculosis

- Transmission of M. tuberculosis may occur during long (i.e. more than eight hours) flights, from an infectious source (a passenger or crewmember) to other passengers or crew members.

- Air travel does not carry a greater risk of infection with M. tuberculosis than traveling by rail, bus or attending conferences.

- To date, no case of active TB has been identified as a result of exposure while on a commercial aircraft.

*WHO: Tuberculosis and air travel: Guidelines 1998*
Prevention of spread of Tuberculosis

- Non infectious cases only could fly in commercial air crafts:
  HIV negative patients who have completed two weeks of effective anti tuberculous treatment.
  HIV positive patients three smear negative sputum examinations on separate days or a single negative sputum culture result are required.

- In case of ground delays >30 mins, adequate ventilation should be provided

- There is no evidence that air recirculation facilitates transmission of tuberculosis

*WHO: Tuberculosis and air travel: Guidelines 1998*
Other diseases

• Epidemiological studies suggest measles and influenza could spread during air travel
• No evidence that aircraft cabin air recirculation increases the risk for URI symptoms in passengers traveling aboard commercial jets.

Jessica NZ. JAMA. 2002;288:483-486
# Regression estimates of PaO₂

<table>
<thead>
<tr>
<th>Equation</th>
<th>Observed PaO₂</th>
<th>SE</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gong et al</td>
<td>50.14</td>
<td>1.47</td>
<td>6.1</td>
</tr>
<tr>
<td>Henry et al</td>
<td>44.92</td>
<td>1.42</td>
<td>6</td>
</tr>
<tr>
<td>Dillard Eq 1</td>
<td>47.39</td>
<td>0.87</td>
<td>3.68</td>
</tr>
<tr>
<td>Dillard Eq 2</td>
<td>47.39</td>
<td>1.25</td>
<td>5.3</td>
</tr>
<tr>
<td>Dillard Eq 3</td>
<td>47.39</td>
<td>1.25</td>
<td>5.31</td>
</tr>
<tr>
<td>Predicted from HIT</td>
<td>47.39</td>
<td>1.48</td>
<td>6.27</td>
</tr>
</tbody>
</table>
Advanced lung disease

- 21 Patients with severe diseases being transported for lung transplantation and thrombectomy
- Oxygen supplementation, pulse oximeter monitoring and medical escort
- 20 patients reached destination safely (distance ranging from 2500 to 13,181 kms)
- Careful preparation, sufficient oxygen supply, oximetric monitoring, and medical escort, almost any patient with severe lung disease can travel by air to any necessary destination

*Kramer MR. Chest, Vol 108, 1292-1296,*