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EDITOR'S NOTE

Dr. Manoj Durairaj

Heart Transplant Surgeon, MS, MCh. (AIIMS, New Delhi), FACC.

Director, Marian Cardiac Centre and Research Foundation.

Program Director, Department of Heart and Lung Transplantation, Sahyadri Hospitals, Pune.

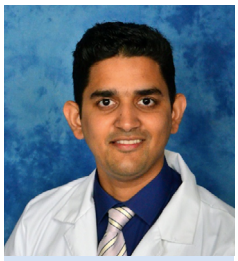
Dear Colleagues,

It is indeed a pleasure to bring to you the September 2021 issue of the Revival. Our guest author this month is one of the doyens of Lung Transplantation in the country. Dr Sunder has written a treatise on Lung Transplantation for this issue. The article has all the details, a practising physician would like to know regarding referral for transplant and the decision-making process while considering the option of lung transplant. For practising cardiothoracic surgeons, who are embarking on the lung transplant journey, this is an excellent article on work up of the recipient, donor selection, post-operative drug therapy and early and late outcomes post-transplant. Certain special scenarios specific to India have also been addressed.

On behalf of the Editorial team of the Revival, I thank Dr Sunder for this wonderful exposition and to all our readers I wish you "happy reading".

- Dr. Manoj Durairaj
Editor "The Revival"

SUB EDITOR



Dr. Talha Meeran

MBBS, MD, FACC, Consultant Cardiologist, Dept of Advanced Cardiac Sciences and Cardiac Transplant, Sir HN Reliance Foundation Hospital, Mumbai.

Dear Colleagues,

In this month's edition of REVIVAL, Dr T Sunder provides an excellent synopsis on Lung transplantation. The article also delineates the intricacies involved in selecting ideal donor lungs including appropriate size matching. Of note as well, Dr T Sunder highlights the practical challenges and limitations of performing lung transplants in a TB endemic country such as India where both donors and recipients could have latent TB. Nevertheless, his team's personal experience and now excellent medium term outcomes are encouraging and a ray of hope for all prospective lung transplant recipients in India.

Sincerely,
Dr. Talha Meeran
Sub Editor "The Revival"

PRESIDENTIAL MESSAGE

Prof. (Dr) V. Nandakumar

Director & Chief, Division of Cardio Vascular/Thoracic Surgery & Cardiac Transplantation, Metromed International Cardiac Centre, Calicut, Kerala.

Dear colleagues,

Greetings from the Society for Heart Failure and Transplantation.

September issue of the news letter 'The Revival' has a hot current topic - Lung Transplantation. Dr. Sunder, a pioneer in this field, has dealt with it in a precise manner covering all the relevant aspects of Lung Transplantation - from referral to management and follow up. Importance of early referral for assessment for transplantation is highlighted.

Covid 19 pandemic has presented many challenges for Lung transplant recipients. The number of patients with post covid pulmonary failures going for lung transplantation is expected to increase in the near future. Specific indications and problems in the management of such cases need to be sorted out.

- Prof. (Dr) V. Nandakumar
President

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Special thanks to Dr T. Sunder for authoring this month's article.

Designed by Maithili Kulkarni

LUNG TRANSPLANTATION – AN OVERVIEW

Dr T. SUNDER

MS (Gen), FRCS(Eng.), FRCS (Cardiothoracic), FCCP (USA)
Director- Lung Transplantation,
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Dr. T. Sunder currently heads and directs the Lung transplant programme at Apollo Hospitals, Chennai. He graduated (1987) from Stanley Medical College, Madras and got his Masters in General Surgery (1992) from his own Alma Mater. After a brief period in the Department of Cardiothoracic surgery at Madras Medical College, Chennai, he underwent further training in England for a period of 11 years. He qualified in Fellowship Examination Cardiothoracic Surgery (2002) and was a Consultant Cardiothoracic Surgeon in England.

He joined Apollo Hospitals, Chennai in 2003 and helped start the department of heart lung transplantation programme with his colleagues.

His special areas of interests include cardiopulmonary transplantation, mechanical circulatory support, pulmonary hromboendarterectomy, thoracic oncology. His academic interests include biostatistics and data analysis.

He serves as an Associate Editor for the Indian Journal of Thoracic and Cardiovascular Surgery, which is the official publication for the Indian Association for Cardiothoracic & Vascular surgeons.

He is also the Section editor for heart and lung transplantation for the Journal of Practice of Cardiovascular Sciences.

He is passionate about photography and enjoys landscape and architectural photography.

This article strives to give a brief overview of all aspects of lung transplantation(LT) – which is now an accepted therapy in appropriate patients with end stage lung disease (ESLD). This article aims to give a bird's eye view of LT to the pulmonologists and the general physicians. This article would also be of interest to the intensivists, anaesthetists and cardiothoracic surgeons interested in cardiopulmonary transplantation. A list of suggested further reading is provided at the end of this manuscript for those interested.

LT is-relatively a very young therapy when compared to renal transplantation and is now only 38 years old. Although first performed in 1963, the first two decades following the first attempt was fraught with complications – predominantly related to ischaemic complications in relation to the bronchial anastomosis and those related to immunosuppression and this procedure did not gain widespread acceptance, given its dismal outcomes. It was in 1983 a successful long term survivor was reported after LT and subsequently there were long term survivors following LT.

1. How does LT differ from other solid organ transplantations?

Except for skin, small bowel and lungs, all transplanted solid organs are "inside" the human body with no direct communication with the environment. The surface area of the lungs is also quire large with increased antigenic load. This in combination with direct environmental exposure makes the practice of lung transplantation more challenging.

2. REFERRAL FOR LT

Ideally early referral is preferred. A simple rule of the thumb is to consider referral to the transplant unit when the patient is being prescribed supplemental oxygen and long term oxygen therapy (LTOT). Prompt referral would allow the time required to meet the transplant unit, clarify doubts, allow adequate time for decision making and organising finances. Referral could be of 2 types.

2.1 Referral for candidacy assessment: This is to check and see if the patient is a transplant candidate. The outcome of this assessment would be one of three possibilities

i) The patient is not yet a candidate for LT – will have to be followed up

ii) The patient is a candidate and may be considered for wait-listing

iii) The patient is not a candidate and cannot be offered LT.

2.2 Referral for wait-listing for LT: In general, when the disease affects the lungs to such an extent that further no treatments help, no other therapeutic options remain – end stage disease ensues. In such instances, organ transplantation is a therapeutic option if,

(i) there are no absolute contra-indications,

(ii) the anticipated survival without a transplant is less than 50% in 2 years

(iii) greater than 80% chance of surviving 5 years from a medical perspective provided the grafted lung function is good

(iv) greater than 80% chance of surviving 90 days after LT.

3. INDICATIONS AND CONTRA-INDICATIONS FOR LT

Unlike other organs – where end stage failure from **any cause** forms an indication for transplantation, – in case of LT there are disease specific objective criteria for LT.

3.1. Disease specific indications for LT [1]:

3.1.1. Indications for LT in ILD:

- Decline in FVC >10% during 6-month follow-up or DLco >15% in 6 months
- Desaturation <88% or distance <250 m on 6-min walk test or >50 m decline in 6-min walk test over 6 months
- Pulmonary hypertension on catheterization or echocardiography with clinical deterioration
- Hospitalization due to respiratory decline, pneumothorax, or acute exacerbation

3.1.2. Indications for LT in COPD:

- Timing of listing (presence of one criterion is sufficient) BODE index ≥7 FEV1
- ≤15%-20% predicted
- Three or more severe exacerbations during the preceding year
- One Severe Exacerbation with Acute Hypercapnic Respiratory Failure
- Moderate-to-severe pulmonary hypertension

3.1.3. Indications for LT in IPAH:

- NYHA functional Class III or IV despite a trial of at least 3 months of combination therapy including prostanoids
- Cardiac index of <2 l/min/m2
- Mean right atrial pressure of >15 mmHg
- 6-min walk test of <350 m
- Development of significant haemoptysis, pericardial effusion, or signs of progressive

3.1.4. Indications for LT in cystic fibrosis/bronchiectasis:

- Chronic respiratory failure
- With hypoxia alone (PaO2 <60 mmHg)
- With hypercapnia (PaCO2 >50 mmHg)
- Long-term non-invasive ventilation therapy
- Pulmonary hypertension
- Frequent hospitalization
- Rapid lung function decline WHO Functional Class IV

3.2. Contraindications for LT:

3.2.1.1. Absolute contraindications

- Malignancy - active current malignancy
- Untreatable atherosclerotic disease
- Acute medical problems e.g., sepsis, myocardial infarction, liver failure
- Chronic virulent uncontrollable infection
- Active tubercular infection
- Significant chest or spinal deformity
- Significant obesity (BMI ≥35 kg/m2)
- Current nonadherence to medication Psychiatric issues No good support system Substance abuse

3.2.1.2. Relative contraindications

- Age >65
- BMI 30-34 kg/m2
- Severe malnutrition
- Severe osteoporosis
- Previous chest surgery
- Mechanical ventilation or ECLS
- Colonization with virulent organisms Hepatitis B/C
- Diabetes with end-organ damage

4. DECISION MAKING PROCESS WHILE CONSIDERING OPTION OF LUNG TRANSPLANTATION:

This is largely based on objective clinical criteria and comprises of 2 main analyses.

4.1. Risk-benefit analysis: Possible risks in the operation versus anticipated benefits from the operation. If this analysis leans towards more of benefit, then LT is considered. If on the other hand, the risks are prohibitive, then LT is not advised.

4.2. Risks with LT versus risks without LT: The anticipated risks with LT are weighed against possible risks if the patient did not have LT. If the risks with LT are significantly less, then LT is advised.

5. RECIPIENT FACTORS:

5.1. Work up Specific for LT are listed below in detail.

- **Respiratory System:** This is fully evaluated to confirm that end stage has reached and that there are no other non-transplant options available. Investigations include PFT, ABG, CT Chest with contrast, 6 MWT, lung biopsy (in appropriate cases), V-Q scan.
- **CVS:** Echocardiogram, ECG, Coronary angiogram in appropriate cases, Right heart catheterisation
- **Oesophageal assessment:** OGD, pH and impedance manometry, fluoroscopy to assess for GERD.
- **ENT:** To look for and assess sinuses – especially in cases of CF. Adequate drainage and toileting prior to LT is needed in these patients.
- **Frailty and muscle weakness:** This needs to be assessed and optimised as much as can be done.

5.2. Workup common to all transplantation:

- Blood group, tissue typing and panel reactive antibodies(PRA)
- Comprehensive Infectious disease screening
- Whole body PET scan to rule out malignancy
- Dexa scan: to rule out osteoporosis and possible fracture risk.
- Endocrine system: Assessment of diabetes (Hba1c), thyroid function, adrenal assessments, vitamin D levels
- Hepatic system: USG abdomen, fibro scan (if needed) , liver function tests
- Renal system: Biochemical urine and blood parameters, USG, CT of the renal system.

5.3. Waitlisting, deterioration, and mortality on WL – MV/ ECMO bridge to LT:

Once evaluated and candidacy for LT has been established, the patient is wait-listed. The patient is in touch with the transplant team. Any deterioration is brought to the notice of the transplant unit. End stage lung disease – often develop increasing oxygen requirements. They require admission with increasing oxygen supplementation – titrating to HFNC, NIV and at time s, if required MV. Often, gas exchange is not improved with MV, in which case ECMO may be required.

While using MV or ECMO as a bridge to LT may be a lifesaving therapy, the outcomes and associated risks of LT done using MV or ECMO as a bridge is inferior to LT performed in patients without MV or ECMO.

Mortality while awaiting organ transplant does occur, especially in cases of lungs where we rely only on deceased donors for organs – unlike the liver and kidneys. More so, using the standard criteria for selection for donor lungs – only 17 to 20 % of lungs offered for donation are useable. By using extended criteria, this may increase up to only 35 % of lungs being usable.

The COVID 19 pandemic has had significant effects on the donation rates and has added to the challenges of LT.

6. DONOR FACTORS:

6.1. DONOR EVALUATION:

6.1.1. Characteristics of an ideal donor:

6.1.2. Standard Criteria [2,3]:

- Age less than 55 years
- ABO compatible
- Size matched
- Ventilated for a short duration
- No history of chest trauma or previous chest surgeries, no aspiration
- Non-smoker or less than 20 pack-years
- Normal CXR and CT scan of lungs (which is now mandatory in view of COVID 19)
- Normal bronchoscopy with no or minimal secretions (negative grams stain)
- paO2 400 on 100 % FiO2.

6.1.3. Extended criteria [4,5]:

- Age more than 55 up to 75 years
- Prolonged ventilation
- paO2 less than 300 on FiO2 of 100%, but above 200
- Chest injury with pneumothorax and ICD
- Consolidation on CT Scan
- Gram stain positive for organisms
- Fever, leucocytosis

6.2. TYPES OF DONOR ORGANS:

- Good organ: who fulfils the standard criteria – usable if the blood group and size matches
- Bad organ: Not usable
- Marginal donor: Who does not fulfil the standard criteria, still not as bad as bad organ

6.3. DECISION MAKING in the choice of donor organs:

The decision to use a good organ or decline a bad organ is easy and straightforward.

The challenge in decision making is only with regards to the marginal organ.

6.3.1. Scenario 1: If the recipient is very stable, then the marginal organ may be declined for him (the ever present dilemma being -one doesn't know when and if a next organ will be available and will this patient be stable until then?)

6.3.2. Scenario 2: If the recipient is critical either on the ventilator or ECMO, then consideration of a marginal organ becomes a little easier. Given that the recipient is on ECMO or ventilator and is critically unwell, a marginal organ may be chosen since the options are limited and one doesn't know if he will survive till the next organ (if and when available) is offered.

6.4. SIZE MATCHING OF DONOR ORGANS:

Size matching is quite important since small lungs in a large cavity (COPD) may leave a residual air space with a propensity of recurrent collections. Similarly, a large organ may be tight fit in a small chest cavity causing difficulty in closure or compressive atelectasis.

While chest volumes and total lung capacity (TLC) the recipient can be calculated beforehand, it cannot be done so for the donor. Hence predicted TLC can be looked form charts derived based on height and sex. The ratio of the predicted TLC of the donor to that of the recipient is calculated and ratio between 0.8 to 1.2 is deemed acceptable.

Large lungs, if have to be used due to the recipient condition, can be handled by non-anatomical stapling of the protruding parts or by an anatomical resection – middle lobectomy on the right and ligulectomy on the left side.

7. LUNG TRANSPLANTATION SURGERY:

7.1. Types of LT:

7.1.1. Single Lung Transplantation (SLT):

As the name implies, only one diseased lung is removed and transplanted. The poorer functioning lung of the two is transplanted. While SLT have short term benefits such as lesser perioperative mortality and morbidity and adequate functional relief, the long-term benefits deteriorate over time when compared to DLT.

It is nowadays done in patients who are elderly above the age of 65, where the lesser perioperative risks are more relevant than the anticipated long term benefits – in view of their advanced age. Furthermore, the age-related physiological reductions in functional reserve among other organ make SLT more attractive than DLT in elderly patients – given the risk-benefit analysis.

SLT is contra-indicated in infectious pathologies such as cystic fibrosis and bronchiectasis. It is also not preferable in IPAH – where there will be a residual high PVR in the remaining native lung with resultant diversion of all the right ventricular outflow -preferentially into the "low-PVR" new lung. This causes flooding and an increased incidence of PGD. However, some units have described SLT in IPAH.

Thus, end stage lung disease due to ILD or COPD in elderly patients form the majority of patients in whom SLT is done.

7.1.2. Double Lung Transplantation (DLT):

DLT is ideally the treatment of end stage lung disease due to all causes. In view of the increased duration of the operation – the perioperative risks are higher than SLT, however this initial bump is more than offset by improved long term outcomes following DLT.

7.1.3. Heart and lung transplantation (HLT):

When there are patients with end stage combined heart and lung failure, HLT is considered. The common scenario includes – Eisenmenger syndrome, ischaemic cardiomyopathy with irreversible pulmonary hypertension, IPAH with severe RV and LV dysfunction, ILD with severe biventricular failure.

There is a higher incidence of HLT India when compared to the West. This is an unique situation which merits explanation. This variation in practice is due to the late presentation of patients in India – where both heart and lung are involved.

Earlier referral for either isolated lung or heart transplantation in the West – has brought down the incidence of HLT.

8. DRUG THERAPY SPECIFIC TO LUNG | TRANSPLANTATION:

8.1. IMMUNOSUPPRESSION:

8.1.1. Induction therapy: Currently we use,

- **IL2 receptor antagonist:** basiliximab 20 mg IV on Day 0 (soon after anaesthesia) and Day 4.
- **Steroid:** Methylprednisolone 500 mg IV after anaesthesia and 250 mg just prior to release of the clamp of each lung.

8.1.2. Maintenance therapy: Triple therapy consisting of

- **Calcineurin inhibitor:** Tacrolimus aiming for levels between 12 to 15
- **Antiproliferative:** Mycophenolate
- **Steroids**: Prednisolone on a rapidly tapering regimen to 0.2 mg/kg body weight

8.1.2. PROPHYLACTIC ANTIMICROBIAL THERAPY:

- **Co-trimoxazole:** as a prophylaxis against pneumocystis and toxoplasma infections
- **Ganciclovir:** as a prophylaxis against viral infections such as Cytomegalovirus
- **Voriconazole:** as a prophylaxis against Fungal infections – such as aspergillus

9. COMPLICATIONS:

9.1. EARLY COMPLICATIONS:

Only those complications SPECIFIC to LT are discussed here. General immediate complications such as bleeding, AKI which occur post-op are not discussed here.

9.1.1. Hyperacute rejection:

This is a very rare occurrence– given that patients are well

worked up pre-operatively. May occur in sensitised individuals despite therapy (discussed later).

9.1.2. Primary Graft Dysfunction (PGD):

PGD refers to a deterioration in lung function – which is not due to rejection, fluid overload or other such causes. It is thought to be a "reimplantation" response" and usually manifests within 72 hours of LT. It may be graded based on PF ratio, CXR findings into Grade 0,1,2 and 3 (Table 1). PGD usually responds to ventilatory adjustments, Nitric oxide therapy and judicious fluid management. In about 20% of cases, Grade 3 PGD which is severe, occurs and may require a brief period of ECMO to meet the oxygen demands of the body until such time the grafted lung recovers.

Table – 1: 2016 International Society of Heart Lung Transplantation definition of Primary Graft Dysfunction [6].

PGD Grade	Pulmonary edema on CXR	PaO2/FiO2 Ratio
Grade 0	No	Any
Grade 1	Yes	>300
Grade 2	Yes	200 – 300
Grade 3	Yes	< 200

PF Ratio: is PaO2 in mm Hg divided by FiO2 used as a decimal number (range from 0.2 to 1.0)

9.1.3. Gastroparesis and Paralytic ileus:

This occurs not uncommonly after LT and most often responds to conservative measures. Vagal neuropraxia which occurs during dissection of posterior hilum, electrolyte imbalance – specially potassium, opioid use are all thought to contribute. A period of rest to bowel with frequent aspirations, IV supplementation and prokinetics often suffice.

9.1.4. Air leaks, pneumothorax, pleural effusions:

Air leaks are often alveolar and often settle spontaneously, provided high ventilatory pressures are not required. Pneumothoraces, when small and well drained by chest tubes usually settle spontaneously. Sometimes, pleural effusions tend to occur after the drains have been removed and may need percutaneous aspirations.

Significant air leak with loss of tidal volumes in ventilator and collapsed lungs mandate an immediate bronchoscopy to assess the bronchial anastomosis. Any obvious bronchial dehiscence, though very rare, in early post-operative period with air leak and lung collapse needs surgical repair. This can be challenging because bronchus is posterior and access may be difficult. This emphasises the need for a check bronchoscopy prior to chest closure to ensure adequate patent and barostatic anastomosis.

9.2. SHORT TERM COMPLICATIONS:

9.2.1. Acute Rejection:

Acute rejection can occur as early 3 to 4 weeks after transplant. They can be either acute cellular rejection (ACR) or antibody mediated rejection (AMR). They manifest by worsening symptoms of breathlessness, sputum, desaturation with increasing oxygen requirements and opacities of CXR. Lab test, bronchoscopy and BAL for Gram stain and culture are needed to rule in or rule out infection. CT Scan of chest and trans bronchial lung biopsy (TBLB) would be needed for diagnosis. Donor specific antibodies (DSA) and C4d staining in the biopsy will help diagnose AMR.

ACR would require pulse steroid therapy – intravenously. AMR, would require plasmapheresis, pulsed steroids, rituximab and IV globulins.

9.2.2. Infections:

Infections are common and prophylactic antimicrobials are given for the first 6 months to a year. In view of the immunosuppression, opportunistic infections (OI) are common and a high degree of suspicion is needed to diagnose these. Close liaison with the infectious disease expert is mandatory in diagnosing and managing these patients.

9.2.3. Airway Complications [7]:

Airway complications ranges from 5 to 20 % of cases and could be ischaemia, stenosis or dehiscence. Most often mucosal ischaemia settle spontaneously. Percutaneous bronchoscopy interventions may be needed for stenosis and dehiscence. The intervention may range from simple balloon dilatation to injection of mitomycin, deployment of stents. A consensus statement by ISHLT

9.2.4. Side Effects of Drugs / Toxicity:

Important side effects of the drugs used after LT include, but not limited to, the following – which may requires dose alteration or temporary cessation of the drug.

- **Tacrolimus:** Nephrotoxicity, neurotoxicity, rise in Hba1c.
- **Mycophenolate:** bone marrow suppression with cytopenias – most commonly leucopenia
- **Steroids:** Fluid and salt retention, weight gain, hypertension, hyperglycaemia, increased susceptibility to infections
- **Ganciclovir:** Bone marrow suppression
- **Voriconazole:** Hepatic dysfunction
- **Septran:** Fixed drug eruption, hyperkalaemia

9.3. LATE COMPLICATIONS:

9.3.1. Chronic Rejection – Chronic Lung Allograft Dysfunction (CLAD):

This manifest as worsening breathlessness and decline in FEV1. About 50% of patients develop CLAD within 5 years of LT. They could be either **obstructive type** (Bronchiolitis Obliterans Syndrome -**BOS** or Neutrophilic Responsive Allograft Dysfunction **NRAD**) or **restrictive type** (Restrictive Allograft Syndrome – **RAS**).

CLAD does not respond to increased immunosuppression. Patients with NRAD respond to low dose Azithromycin. Other options include extracorporeal photopheresis, total lymphoid irradiation or re-transplantation.

9.3.2. New Onset Diabetes after transplantation (NODAT):

This is a common and serious complication which occurs from 2% to 50% of patients following all solid organ transplantation. Steroids, tacrolimus play a role in the development of NODAT. They can cause cardiovascular complications which can result in considerable morbidity and at time mortality. Hence, close watch should be kept and NODAT should be treated aggressively.

9.3.2. Malignancies:

Malignancies are the second most common cause of death after 5 to 10 years post LT. Prolonged immunosuppression can lead to malignancies. LT patients require more immunosuppression and hence have higher degree of malignancy. The most common cancers in LT patients are non-melanomatous skin cancers, followed by lung cancers and post-transplant lymphoproliferative disease (PTLD)[8]

10. SURVIVAL FOLLOWING LT:

10.1. WESTERN LITERATURE:

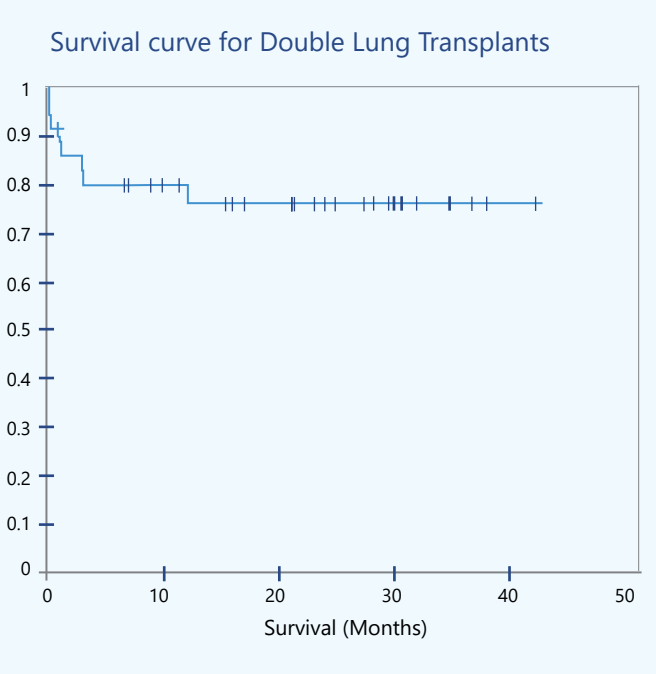
The current 1- and 5-year survival following LT is 85 % and 59% respectively. The median survival following LT differs based on the disease for which LT was done as listed below.

DISEASE	MEDIAN SURVIVAL (years)
Cystic Fibrosis	8.9
COPD with Alpha 1 antitrypsin deficiency	6.7
COPD without Alpha 1 anti-trypsin deficiency	5.6
ILD	4.8

10.2. OUR RESULTS:

Till date, we have performed 58 isolated LTs out of which 51 were DLT and 7 were SLT. In addition, we have performed 30 combined HLTs which also includes 1 patient who underwent combined heart -lung and kidney transplantation. **Our 3-year survival following DLT is 76.2%.**

Analysis of overall survival for Double Lung Transplants has shown a 3-year survival of 76.2 % (Fig 1).



11. SPECIAL SCENARIOS IN LT SPECIFIC TO INDIA :

11.1. Tuberculosis (TB):

India is a TB endemic country. Impact of TB in recipient selection and donor assessment is considerable. In the donor, due to time constraints, TB cannot be categorically excluded. However, in the recipient, patients can be fully evaluated for TB. Those patients with active TB need full treatment prior to listing. Patients with positive Mantoux, but no disease are considered to have latent tuberculous infection (LTBI). They will need prophylactic chemotherapy with INH. Post LT, a high degree of suspicion is required. Proven TB will need cautious chemotherapy looking out for drug interaction.

11.2. Muscle weakness and frailty:

This is a major issue and a lot of patients with ESLD get physically deconditioned and start limiting their physical activities due to hypoxia and eventually become bed bound. This leads to generalised muscle weakness. The worsening lung condition with increasing oxygen requirements makes even mastication a challenge and nutrition suffers. These patients are therefore nutritionally, physically deprived and therefore need nutritional and physical rehabilitation.

LT in a weak and frail patient leads to prolonged ventilation – making them vulnerable to ventilator associated pneumonia (VAP), airways complications if prolonged positive pressure ventilation is required. Such patients often need a slow wean with a tracheostomy.

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