Lung Transplant: Today

Internal Medicine Grand Rounds – August 9, 2013

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This is to acknowledge that Fernando Torres, M.D. has disclosed that he does have financial interests or other relationships with commercial concerns related directly or indirectly to this program. Dr. Torres will not be discussing off-label uses in his presentation.

LUNG TRANSPLANTATION TODAY

GRAND ROUNDS 8.9.2013

INTRODUCTION

The first human lung transplantation was performed in 1963 by Dr. James Hardy; thus this year we celebrate the 50th year of lung transplantation . Unfortunately, the first patient who underwent lung transplantation died within 48 hours of the surgery. Subsequently many physicians and leaders in the cardiothoracic surgery arena attempted to perform this dangerous procedure, all with poor outcomes. Survival at this time was days or few weeks. In 1980 cyclosporine became available as a novel immunosuppressive agent for solid organ transplant. With the introduction of cyclosporine, solid organs transplant survival started to improve with lung transplantation not fall behind. In 1982 Dr. Stanford completed the first successful heart lung transplant. The following year, in 1983 the first successful single lung transplant was performed and survival was better with the use of cyclosporine At that time lung transplantation was limited to single lung transplantation, and it is not until 1990 that sequential bilateral lung transplantation becomes the procedure of choice for certain illnesses. Over the subsequent years survival continued to improve however there were some patient types who were not able to accrue enough time on the waiting list to receive an organ. Thus in May 2005 UNOS, the organization that allocates organs to the transplant centers developed a new system called the lung allocation score (LAS). Organs are now allocated to recipients, based on severity of illness, rather than time on the waiting list. The score is a calculation of the likelihood of dying while waiting for a lung transplant for one year and the survival that the patient would have receiving a lung transplant. This year, we mark the 8th anniversary of the implementation of the LAS and patients have been allocated organs based on need.

INDICATION TO RECEIVE LUNG TRANSPLANT

There are no specific guidelines dictating how lung transplant centers determine which patients to transplant, but in general UNOS recommends that patients with advanced end stage lung disease be placed on the waiting list if their life expectancy is less than two years. In general transplant eligible patients are NYHA functional three or four with rehabilitation potential. Patients with advanced lung disease can be divided into four categories: patients with restrictive lung diseases which a prototype illness would be idiopathic pulmonary fibrosis, patients with obstructive lung diseases, in which the prototype disease would be emphysema, suppurative disease, where the prototype would be cystic fibrosis or other bronchiectatic diseases and vascular diseases where the prototype disease would be idiopathic pulmonary arterial

hypertension. We make different recommendations as to when to refer patients for lung transplantation based on the category of lung disease.

Suppurative Lung Diseases

The most common suppurative lung disease is cystic fibrosis. We believe these patients have a very poor survival, less than two years, when their force vital capacity is less than 40%, their force expiratory volume in 1 second (FEV1) is less than 30% or the PAO 2 is less than 60 mm of mercury. These criteria are from a study done in the 1990s and although multiple attempts have been made to look for better marker of survival, these remain the standard markers. Nutritional status is also considered.

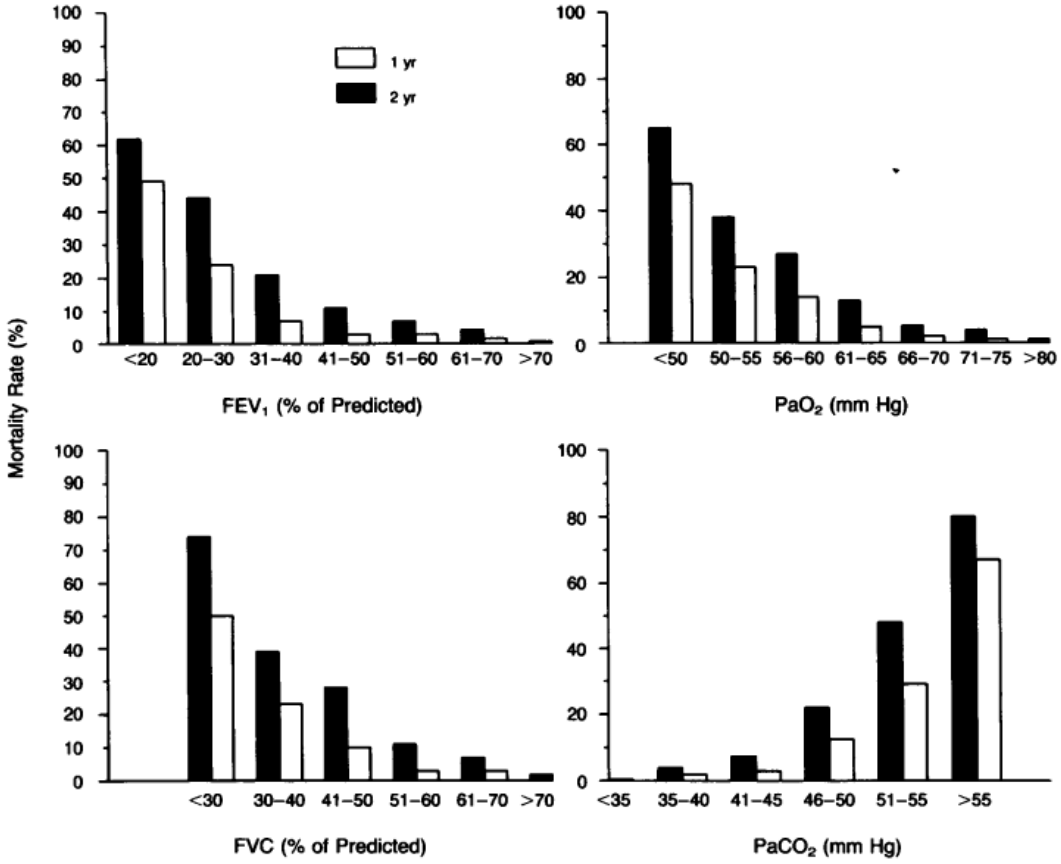


Figure 1. One-Year and Two-Year Mortality Rates among Patients with Cystic Fibrosis, According to Pulmonary-Function Variable. Values were calculated from pooled measurements. (None of the patients had PaO_2 values of 76 to 80 mm Hg.)

Cystic fibrosis patients tend to be fairly young, and because they have a suppurative disease, they require double lung transplantation. If a single lung transplant is performed, the native lung (lung not transplanted) would become infected and with the addition of immunosuppresion, would likely succumb to infection. For this reason, patients with cystic fibrosis or bronchiectasis

affecting both lungs will always undergo double lung transplantation. There are certain challenges with the cystic fibrosis population. Many are young and even the older patients in their 30s or 40s often lack maturity as they have often lead a sheltered life by their parents, which often leads to unpredictable social behavior after transplantation. Many patients will require extra social support to help prevent poor behavior. Cystic fibrosis patients also are predisposed to developing diabetes, and when placed on steroids or other immunosuppressive medications like tacrolimus they can develop significant diabetes. Good collaboration with the endocrinology department is essential for good diabetes management after transplantation.

Another concern with cystic fibrosis patients is that they have been exposed to antibiotics throughout their lifetime which often leads to resistant organisms in their airwaves. Most of these have been infected and colonized with pseudomonas aeroginosa and other organisms that can be very difficult to eradicate. One way in which we have attempted to affect resistance is by synergy testing in the microbiology laboratory. The idea being that combining antibiotics from more than one group may be more effective.

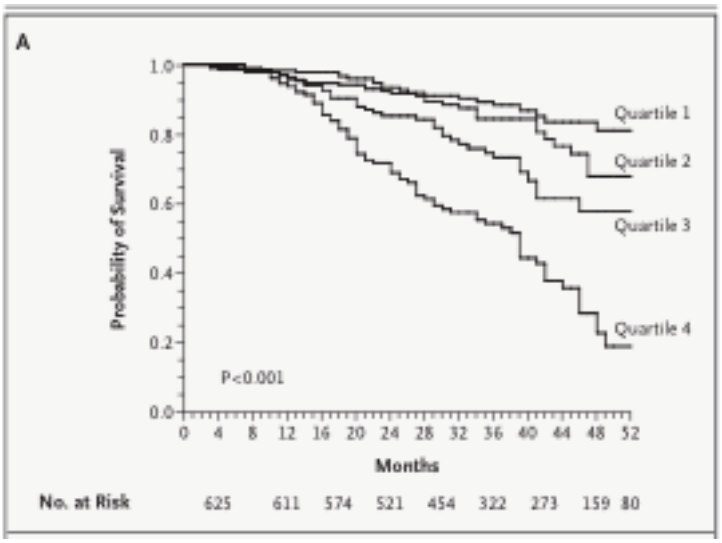
Unfortunately a recent study sponsored by the cystic fibrosis foundation determined that tailored antibiotic therapy did not affect the rate of deterioration in lung function. Thus the practice of using synergy studies has come into question. These very resistant organisms are extremely difficult to treat after lung transplantation. Especially, problematic organisms are mycobacterium abscessus and Borkholderia cepacia geno var 3. Each transplant program will have their own criteria of which specific organisms may be exclusionary for lung transplantation. Even though patients undergo double lung transplantation, the organisms are still present in the sinuses, the trachea and mediastinal lymph nodes and will infect the new lungs.

Obstructive lung disease

Obstructive lung diseases encompass illnesses such as emphysema, COPD, bronchiolitis obliterans and others. These patients have characteristic chest x-rays changes of hyper inflated lungs and flat diaphragms. In general, we tend to use the Bode Score Index to determine when emphysema patients should undergo lung transplantation. Historically, we used a force expiratory volume in1 second that was less than 25% after bronchodilators as a prediction of death within 2 years. The Bode Score Index, is more precise as it takes into consideration the 6 minute walk distance, a dyspnea scale and the body mass index. Calculating a Bode Score Index is fairly simple and can predict patient survival. The Bode Score Index ranges from 0-10, 10 being extremely ill with significant mortality where a Bode Score Index of 0 indicates a fairly healthy patient with a low mortality. A Bode Score Index between 6-7 has been used as the optimum time to undergo lung transplantation for patients who have advanced emphysema. The following table and graft describe the survival of patients depending of the Bode Score Index. Quartile 1 are patients with score 0-2, quartile 2 is 3-4, Quartile 3 is 5-6 and Quartile 4 is 7-10.

Table 2. Variables and Point Values Used for the Computation of the Body-Mass Index, Degree of Airflow Obstruction and Dyspnea, and Exercise Capacity (BODE) Index.*

Variable	Points on BODE Index			
	0	1	2	3
FEV_1 (% of predicted)†	≥65	50–64	36–49	≤35
Distance walked in 6 min (m)	≥350	250–349	150–249	≤149
MMRC dyspnea scale‡	0–1	2	3	4
Body-mass index§	>21	≤21		



Other types of obstructive lung disease include bronchiolitis obliteran, alpha-1 anti-trypsin deficiency, and others. Specifically, bronchiolitis obliterans can have a very aggressive course and has no effective treatments. Thus, these patients are placed earlier on the transplant waiting list.

Regardless of the type of obstructive lung disease, patients may be placed on the waiting list for either single or double lung transplantation. It has been noted that patients with emphysema who undergo single lung transplantation have the best one year survival rate of all lung transplantation recipients.

The main concern we have with this population is that patients tend to be older so they often have more co-morbidities like coronary artery disease, diabetes, hypertension, arrhythmias. Also often they have been exposed to steroids chronically with resulting osteoporosis. Because their mortality on the waiting list tends to be lower than for patients with other types of lung diseases, their lung adduction scores tend to be the lowest on the waiting list.

Restrictive lung diseases

The third group of patients are the restrictive lung diseases where the prototype is idiopathic pulmonary fibrosis and other types of fibrotic processes that cause significant mortality. Pulmonary fibrosis often has a very unpredictable progression, and most centers will be evaluating patients for transplant when they are first placed on oxygen. They then monitor the patients to determine the rate of disease progression. These patients tend to have a very poor survival on the waiting list, so most centers will tend to expedite their workup to undergo lung transplantation.

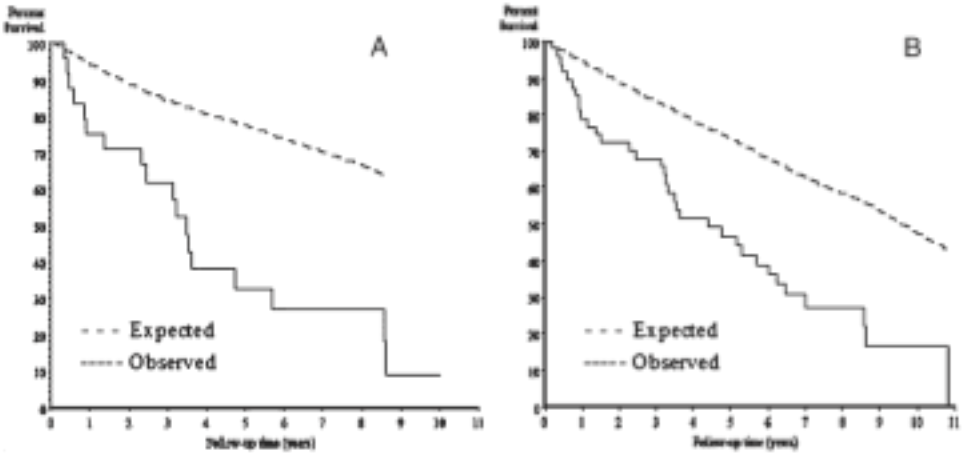


FIGURE 4. Observed and expected cumulative survival of patients from time of IPF diagnosis, between 1997 and 2005, among residents of Olmstead Country, Minnesota. Narrow criteria cases of IPF (log rank, $P < .0001$) (*A*). Broad criteria cases of IPF (log rank, $P < .0001$). See Figure 2 legend for expansion of the abbreviation.

These patients can undergo singular or double lung transplantation. There are conflicting results regarding survival after single vs. double lung transplant for patients with ILD. Regardless of whether they receive single vs. double lung transplants, these patients tend to develop antibodies against the donor organs at a higher rate then patients with other lung diseases. In addition, these patients tend to develop malignancies after transplantation. They have been exposed to steroids so they also have higher rates of osteoporosis, high blood pressure, obesity, and diabetes.

Pulmonary vascular disease

The fourth group of patients considered for lung transplantation are the patients who develop pulmonary vascular disease and the prototype illness for this group is idiopathic pulmonary arterial hypertension. This is a very challenging transplant population because they tend to have very high mortality on the waiting list and do not have good markers to predict which patients are going to have poor survival. The current lung allocation score unfortunately has not been able to predict accurately which population is at higher risk of dying within this group. There are recent publications showing that patients on the waiting list for lung transplantation due to

pulmonary arterial hypertension tend to die more often than predicted by the lung allocation score equation. So there have been multiple meetings with UNOS to encourage a change in the lung allocation score for these patients. Fortunately within the next six months the lung adduction score is going to be adjusted to improve the LAS scoring of these patients. Currently we monitor these patients by peforming cardiac catheterizations and echocardiograms, monitoring functional class, and following six minute walks. Once their six minute walk has dropped or they develop market elevation in their right atrial pressures we know these patients have a high mortality waiting for a lung transplant and they are then activated on the waiting list. UNOS has a mechanism of asking for an exception to the current LAS score for patients with iPAH and they are granted on a case by case basis.

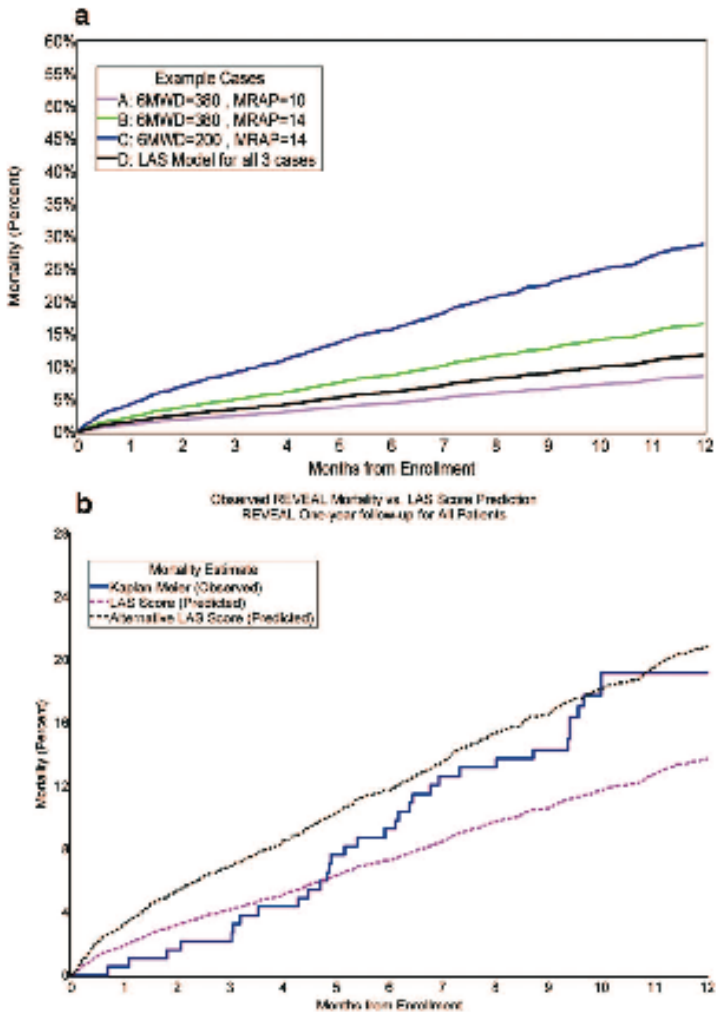


FIGURE 3. Examples of predicted mortality using a modified scoring system. (a) In this example, the following parameters were used for calculation of score: age=45 years, subgroup=idiopathic pulmonary arterial hypertension, body mass index=26 kg/m^2, systolic blood pressure=90 mm Hg, serum creatinine=0.9 mg/dL, supplemental oxygen=2 L at rest, absence of diabetes mellitus or ventilator requirement, New York Heart Association functional class III, forced vital capacity 90% of predicted, and pulmonary capillary wedge pressure of 12 mm Hg. (b) Comparison of observed and predicted mortality using the lung allocation score (LAS) and modified LAS for listable patients with a mean right atrial pressure (mRAP) of more than or equal to 14 mm Hg or a 6-MWD less than or equal to 300 m. Modified waitlist exponent=original waitlist exponent+0.7; if mRAP more than or equal to 14 mm Hg, −0.35; for every 100 m of 6-MWD, +1.0. 6-MWD, 6-min walk distance; REVEAL, Registry to Evaluate Early and Long-term PAH Disease Management.

In the past single lung transplantation was attempted with pulmonary arterial hypertension patients but carried very high mortality. The donor organ received the vast majority of the

cardiac output due to the lower pressure in the transplanted lung leading to significant lung injury of the transplanted lung. The remaining native lung would have very low perfusion and thus be prone to developing pulmonary infarcts and hemorrhage. Patients undergoing singular lung transplantation for PAH carried a mortality of about 30% at one month. Currently, lung transplantation has been limited to double lung transplants or Heart-Lung block transplantation if the heart is not felt to be strong enough to tolerate the surgery. Due to the significant collateral circulation and dilated capillary bed in patients with PAH, there is a higher incidence of bleeding complications peri-operatively.

Evaluation for lung transplantation

Once a patient is referred to a lung transplant program, an extensive evaluation is done to make sure there are no contraindications and it is safe to undergo transplantation. The specific components of the evaluation vary by center. The ultimate goals are to make sure that the recipient will have a good survival and that the center will make good use of that donor organ. Most of the tests that the transplant centers are going to do are undertaken to identify malignancies, unrecognized pulmonary emboli, coronary artery disease, peripheral vascular disease, hidden malignancies in the colon, and ensuring the patient has good renal function. Most of our immunosuppressant medications can affect renal and hepatic function. The patients are screened for hidden infections like hepatitis, HIV, syphilis, CMV and EBV virus. It is very important the patients have a psychological evaluation to make sure they are emotionally stable enough to undergo lung transplantation and will likely be compliant with medications and office visits that are essential for good survival after transplantation.

Lung Allocation Score

The lung allocation score (LAS), implemented in May 2005, is a score from 0-100 which ranks patients according to severity of illness. Prior to 2005 patients were ranked depending on the amount of time accumulated on the waiting list.. Unfortunately many end stage lung disease patients would die before transplantation simply because they had not accrued enough time. With the implementation of the LAS, baseline patient data is entered into the computer and, by an algorithm, it computes the probability of death waiting for a transplant and the likelihood of one-year survival after lung transplantation Each patient receives a score between 0-100, which can be raised when the patients become more ill.

Once patients are placed on the waiting list to undergo lung transplantation, they are required to reside within a three hour radius from the transplant center When an organ becomes available, patients are brought into the hospital and assessed to make sure they are stable enough to undergo transplantation. Once the patient is cleared for surgery, the patient is taken to the

operating room. The surgery can last up to 4 hours for a single lung transplantation and up to 8 hours for a double lung transplantation.

The waiting list urgency measure (WL_i), the area under the waiting list survival probability curve during the next 1 year, can be written mathematically as:

$$WL_i = \sum_{k=1}^{365} Height_k * Width_k = \sum_{k=1}^{365} S_{WL,i}(k-1) * 1\,day, \text{ for candidate i}$$

Transplantation Complications

Reperfusion Injury

The most common complication after lung transplantation is reperfusion injury, from damage of the capillary blood vessels. There is due to production of free oxygen radicals, platelet aggregation, neutrophil activation and immunological factors that cause capillary leak in the vascular bed of the new lung. This process creates extravasation of plasma into the alveoli of the new lungs usually between 12 to 96 hours after lung transplantation. Primary graft dysunction is the score used to grade the severity of reperfusion injury and ranges from a score of 0 to 3. Patient with scores of 0-1 tend to do will without residual complications. On the other hand, patients with scores of 2 and 3 often have problems in the future. There are many different ways to treat reperfusion injury, including positive airway pressure, diuresis, inhale NO and ventilating one lung versus another using single lung ventilation. In most cases reperfusion injury is reversible and patients tend to do fairly well.

Infection:

Another complication of transplantation is infection which can occur at various time after transplantation. Infections that occur within 7 days of transplantation are usually attributed to transmission from the donor versus infections after 7 days which are attributed to the recipient. Some infections such as cytomegalovirus (CMV) can damage the transplanted organs. Give the degee of immunosuppression after transplantation, it is important to monitor the activity of the virus Most centers use PCR technology to quantify the viral load and determine if the patient should be treated for an active infection. Most concerning are patients that have CMV mismatch, donor organ positive for CMV, recipient negative for CMV exposure. This particular population is extremely sensitive to CMV infection and if untreated can lead to demise of the transplanted organ and death. Ganciclovir or the pro-drug form of ganciclovir, valcyte is used as prophylaxis which is approached differently by different centers Data exists to support ganciclovir administration for 6 to 9 months though others centers such as UT Southwestern administer prophylaxis for life. CMV infections tend to occur the first month however depending on the serological status of the recipient, they can be seen during the first year. After

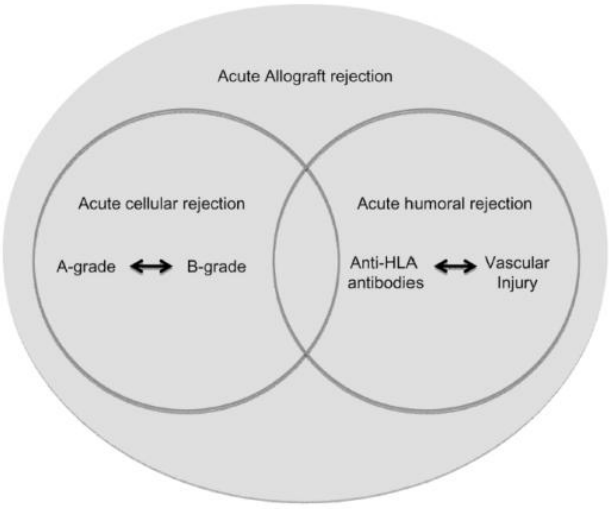
the first year when there is a decrease in immunosuppression, the incidence and rate of CMV tend to drop significantly, though still remain a potential complication after lung transplantation.

Fungal infections can also occur and generally occur somewhat later, unless transmitted by the donor organ. Aspergillous or nocardia infections are the most common of these infections and tend to occur 6 months or more after lung transplantation. Therapy for these organisms can be complex and lengthy.

Additional complications include leukopenia, thrombocytopenia, hepatitis, pneumonia, atypical lymphocytosis, ulceration of the GI tract, encephalitis, skin lesions, and opthamologic conditions.

Lung Transplant Rejection

Various degrees of rejection are often seen after transplantation. Acute cellular rejection is graded between A0 and A4 and represent the degree of inflammation around the blood vessels. A0 indicates no lymphocyte proliferation around the blood vessel and a 4 shows proliferation of lymphocytes and destructions of tissue around the blood vessels bridging between different blood vessels. Airway inflammation can also occur and is graded between B0 and B3, with a higher grade indicating more inflammation around the bronchial tree. Most episodes of rejection are treated by increasing the dose of immunosuppression with either methylprednisolone or lympholitic therapy.



More recently donor specific antibodies are being evaluated as a marker of acute humoral rejection. Though this science is in its infancy, over the next years, we hope to learn more about the implication of these antibodies.

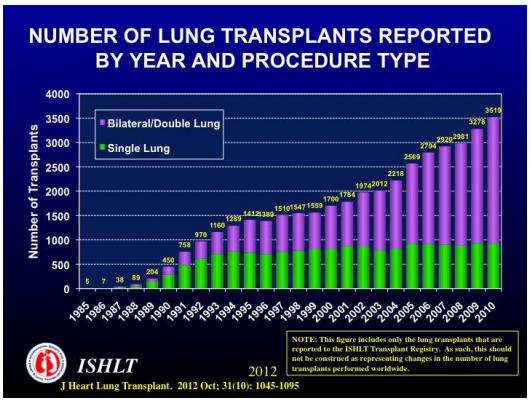
Unfortunately the use of lympholytic therapy will be associated with potential complications in the future. Different agents have been become available over the past decade to eliminate the lymphocytes. Unfortunately by eliminating lymphocytes we predispose the lung transplant recipient to more infections, and to certain types of lymphomas called post-transplant lymphoproliferative disorders. Epstein Bar virus (EBV) is associated with the lymphoproliferative disorders and tends to occur about 8 months after the use of lympholytic therapy. Patients may be asymptomatic or may have symptoms consistent with an EBV infection, such as simple pulmonary nodules or lesions in other organs. It is important to recognize this disease as the lesions can be eradicated by decreasing the level of immunosuppression. If the lesions are still present after decreasing the immunosuppression there are some antibodies against B cells which can potentially eliminate the malignancy and keep it in remission for many years.

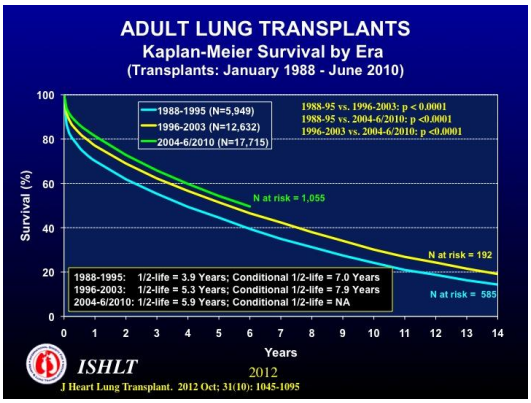
Early post-op period

In the perioperative period complications can occur that are related to the anastomosis between the donor organ and the recipient. Early after transplant infection can destroy the bronchial anastomosis, resulting in pneumomediastinum or pneumothorax. Most often these lesions will be recognized by routine surveillance bronchoscopies. Additionally, torsion of the pulmonary arteries and pulmonary veins can occur which can be repaired shortly after lung transplantation.

Outcomes after lung transplantation

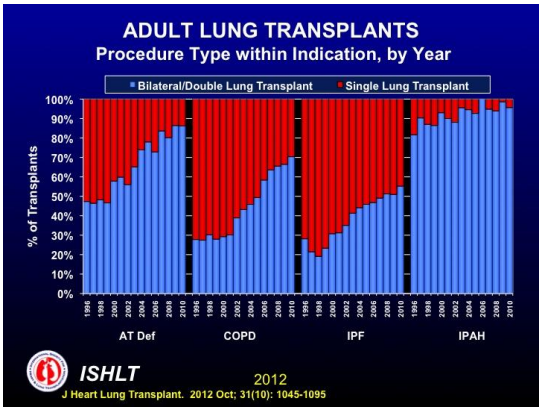
The number of single lung transplants performed in the United States has remained stable while the number of bilateral lung transplants has increased. Approximately, 3500 lung transplants are performed each year in the United States.

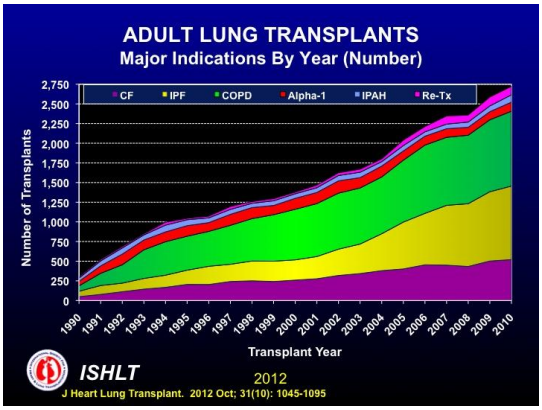




Survival has improved over the past 30 years with improvements in immunosuppression and overall patient management. Improved survival has been seen after 2005 when the lung

allocation score was adopted, but felt to relate not just to the new scoring but also to improvements in technology and early recognition of infections, rejection and other complications.

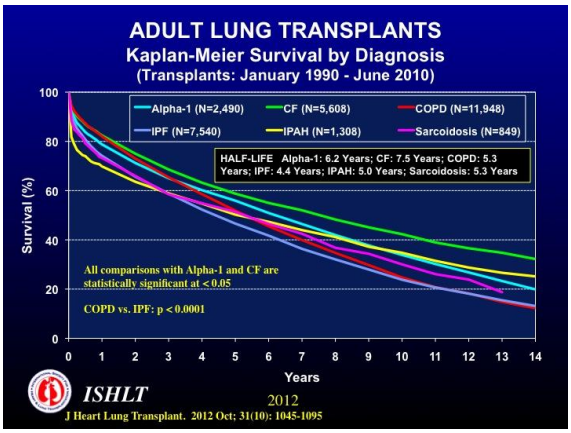


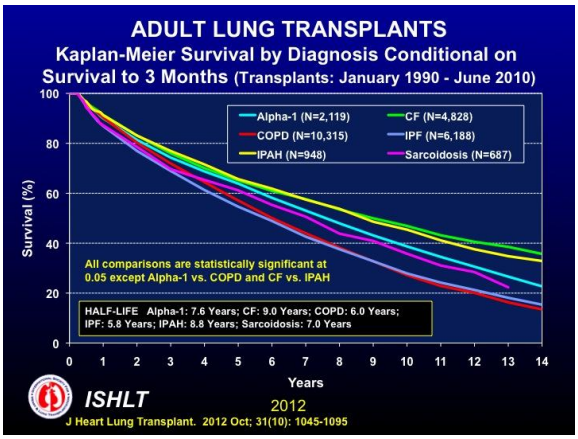


In the United States most lung transplants are for emphysema, followed by cystic fibrosis and then pulmonary fibrosis. Fewer transplants are performed pulmonary vascular disease, which when they do occur, require double lung transplantation. Fifty percent of patients undergoing transplant for pulmonary fibrosis will receive single lung transplantation. Double lung transplantation is becoming more common for patients with emphysema and alpha 1 antitrypsin deficiency. Most patient with cystic fibrosis will undergo double lung transplantation as single lung would become infected from the native lung.

The number of lung transplants has increased in the past 10 years due to the implementation of the lung allocation score in 2005. In this allocation system, pulmonary fibrosis patients have a higher ranking on the waiting list.

Survival





Patients who undergo lung transplantation for cystic fibrosis have the best 5 and 10 year survival. This is followed by patients who undergo lung transplantation due to alpha 1 deficiency then by pulmonary fibrosis and lastly, pulmonary hypertension. Interestingly the patients with pulmonary hypertension initially have poor survival, but if they survive 3 months after transplantation, they have one of the best survivals rates at 10-15 years.

Risk factors for one year mortality after lung transplantation include: re-transplant and pulmonary arterial hypertension. Emphysema patients have the lowest one year survival. Other risk factors for poor one year mortality are age of 65 and transplantation in centers performing less than 25 transplants per year.

WHAT IS NEW IN LUNG TRANSPLANTATION?

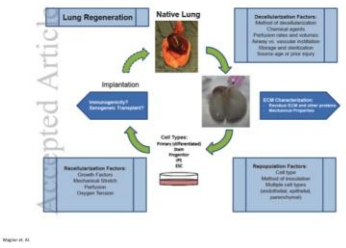
Over the past few years the lung transplant community has been working to increase survival of patients on the waiting list and increase organ availability for lung transplantation.

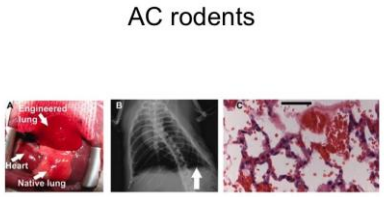
In the past patients with respiratory failure requiring mechanical ventilation were felt to be poor candidates for lung transplantation. Extra corporeal mechanical oxygenation (ECMO) is has been used to treat patients who are extremely ill with respiratory failure and cardiogenic shock for many years. However, over the past year ECMO is being used as a bridge to lung transplantation. The success of ECMO in this setting is due to the development of new cannulas which can be used for longer periods of time and allow for lower levels of anticoagulation. Also, the size and complexity of the ECMO machines has improved making it easier to manage patients in the ICU. Perfusionists are no longer needed to be present constantly to monitor the equipment and nurses are now able to manage the patients. There are now numerous reports in the literature where patients are placed on ECMO for periods of 10, 30, and 60 days while awaiting lung transplantation. This technology is portable enough to be taken to other hospitals where patients are placed on ECMO and then transported to the transplant facility.

Increase Organ availability

The future of lung transplantation may shift from cadaveric lungs to bioengineering of lung tissue to grow a new lung which can be placed into the recipient. Lung regeneration occurs by first performing decellurization of the lung tissue which can be achieved in several way: by using sequential treatment of lungs with detergents, hypotonic and hypertonic salt solutions, or by using enzymes to remove all cellular material but leave intact the extracellular matrix components, including collagens, elastin and laminin and thus retain the native structure of the lung. Currently, it is not clear which type of cells will have to be used to repopulate the scaffolds. There are different potential cells such as progenitor cells, stem cells, mature lung

endothelial or epithelial cells from the recipient. How these cells will go to the "right" place in the lungs and recellurize the scaffold is not clear but may be from alveoli, airway or blood vessels With this emerging science the potential exists for recipients to have a new lung with his own cells, perhaps eliminating the need for immunosuppression in the future. This technology is likely years away, but decellularization of the lungs has been achieved and many centers are working to develop ways to repopulate the scaffold organ with the proper cells.





The proof of concept for lung regeneration has been achieved in rodents, by decellularizing the lung and repopulating it with mixture of fetal lungs, endothelial cells and A549 carcinoma cells. This seems to have supported life in a rodent for a few days. Though some degree of gas exchange has been observed for up to 2 weeks, the resulting cellular architecture does not fully resemble that of the native lung and develops substantial fibrosis. This same technology has been done with pigs where a normal pig lung has been decellurized and then repopulated. In humans, research continues to determine the best way to repopulate the lungs.

XENO transplantation

Xeno transplantation has been studied for many years and involves the manipulation of genes to engineer lungs. Specific research is considering the growth of pig lungs which would not be recognized by the human immune system and potentially could be used in humans. We now know that human blood exposed to the endothelium of the pig lung will cause severe thrombosis in the vascular bed of the transplanted lung, due to the activation of vonWillebrand factor in the blood. The lung tissue of pigs has now been engineered in a way such that there is no activation of the vonWillebrand factor, thus removing that first complex challenge of xeno transplantation. Also researchers have learned how to engineer the lung tissue to avoid activation of the human immune system, by removing HLA's from the pig genome.

Certainly many additional issues will need to be addressed such as potential transmission of infections from pigs to humans. . Although great strides have been seen with xeno

transplantation, there remain many hurdles to be overcome before this technology becomes a reality.

Increased organ availability

Sadly, approximately sixty percent of donor organs are not suitable for transplantation for various reasons. Many times this is a decision made in the operating room while harvesting the organ. The decision of whether to accept an organ has to be made very quickly by the transplant physicians. A conservative approach is used where if the physicians are not confident the organ is a good match for the patient, the organ is turned down for transplantation. If these decisions did not have to be made so quickly, it is possible with more thorough evaluation that more organs could be considered acceptable for transplant

A new technology has been developed to get better access to organs, called the ExVivo system. In this system, the potential lungs are placed on a ventilator and the lungs are perfused. Cannulas perfuse a preservation solution through the pulmonary arteries and return the fluid through the veins. The fluid then is pumped back into the pulmonary arteries. This system keeps the organ alive long enough for the physicians to more thoroughly evaluate the mechanics of the organs, or take radiological x-rays of the organs. This system measures the oxygenation that the organ can produce and allows for manipulation the organ, such as introducing certain medications or particles which repair an organ and make it acceptable for transplant. This technology is in last phases with the FDA for approval for use in the medical field. Recent studies using this new technology have shown that up to 40% of lungs which would have been rejected in the traditional rapid approach, were deemed usable

Researchers are also studying ways in which to increase the distance an organ can be procured from the transplant center. For example, currently a lung transplant team would not accept an organ where it would take more than 6 to 9 hours to get the organ from the donor institution and implanted into the recipient as more complications are seen with longer times. The TransMedic system allows placement of the organ at explantation in a portable system which perfuses the organ with blood and ventilates the organ while you transport the organ from one side of the country to the other side of the country. This allows for expansion of the time period from harvesting to implantation in the recipient. This also may allow for less middle of the night urgent transplants as the procedure may be postponed until full hospital staffing is available.

CONCLUSION:

Over the past 2 decades surgical and medical advancements have lead to improved survival after lung transplantation. The new lung allocation score which is now severity based, has improved ranking for patients on the waiting list. There are many variable that affect survival after lung transplantation including the number of transplants a center is performing. At UT Southwestern, the number of lung transplants performed a year continue to be on the top 10 in the nation and our survivals are the best in the region.

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