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A LUNG TRANSPLANT CLINICAL PATHWAY PROPOSAL FOR THE AMERICAN UNIVERSITY OF BEIRUT MEDICAL CENTER (AUBMC) TRANSPLANT PROGRAM

by
SARINE RITA OHANNES MALKDJIAN

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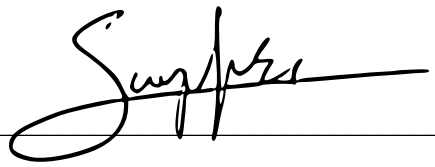

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ABSTRACT
OF THE PROJECT OF

Sarine Rita Ohannes Malkdjian for Master of Science in Nursing
Major: Adult Gerontology Clinical Nurse Specialist Track

Title: A Lung Transplant Clinical Pathway Proposal for the American University of Beirut Medical Center (AUBMC) Transplant Program

Lung transplantation is the last resort, yet a breakthrough for patients with advanced lung disease, who have been worsening clinically despite optimal treatment, with a limited life expectancy. It is indicated for patients with advanced chronic obstructive pulmonary disease, interstitial lung disease, cystic fibrosis and pulmonary hypertension.

Since performing and managing a lung transplant is complex, certain guidelines have to be used to organize the process. A clinical/ care pathway, as defined by the European Pathway Association, is a dynamic step-by-step flow of an agreed set of organized care processes for a specific population during a specified period. Its purpose is to optimize the complex care delivered to this population while promoting safety and improving immediate and future outcomes.

In Lebanon, the only hospital that has performed a lung transplant is the American University of Beirut Medical Center. However, the transplant program lacks a lung transplant clinical pathway although two transplants have been already performed in the last three years. Thus, the purpose of the proposed project is the development of an evidence based, up-to-date, standardized clinical pathway for patients planned for lung transplantation.

The available literature on lung transplantation and the latest guidelines on management of the recipient peri-operatively were reviewed, as well as clinical pathways used by lung transplant programs in university hospitals. Accordingly, a clinical pathway was developed to guide the process peri-operatively, focusing on the pre-operative preparation for the surgery, the intra-operative management, and the immediate post-operative plan of care up to discharge from the hospital. For each time period, the corresponding assessment activities, diagnostic tests, medications, treatments, education and consultation are emphasized.

The proposed pathway will be submitted to a multidisciplinary team for discussion and review and presented to the medical center administration for approval. Next, implementation planning with a multidisciplinary taskforce and actual integration will take place. Also, meetings will be held with the Epic team to transform the pathway into an Epic workflow. Education sessions will be given to the transplant multidisciplinary team involved in the care of these patients before launching the program.

As for the evaluation plan, process evaluation will monitor the implementation of the clinical pathway. Outcome evaluation will be done during hospital stay such as length of stay, incidence of primary graft dysfunction, and nosocomial infections. Following discharge, re-admission rates, incidence of chronic rejections, and quality of life will be monitored for the impact evaluation.

The proposed project, once implemented, is expected to standardize the care for this critical population of lung transplant recipients and promote positive patient outcomes.

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CHAPTER 1

BACKGROUND AND SIGNIFICANCE

Lung transplantation is a last resort, but a breakthrough in the treatment of patients with advanced lung disease who have been worsening clinically despite maximum pharmacological and surgical interventions, and who have a limited life expectancy with their current course of treatment (Hachem, 2020). The present median survival after lung transplantation worldwide is a bit above six years, which increases to past eight years if the recipient survives at least the first 12 months post transplant (Khush, Cherikh, Chambers, Rossano, & Stehlik, 2018). Survival has improved significantly from a median of 4.3 years during the periods of 1990 till 1998 to 6.5 years during 2009 until 2016 (Khush et al., 2018).

Lung transplantation is indicated for patients with advanced chronic obstructive pulmonary disease (COPD), interstitial lung disease, cystic fibrosis and pulmonary hypertension (Van der Mark, Hoek, & Hellemons, 2020). In Lebanon, the prevalence of COPD was reported at 9.7% (Waked et al., 2011) but there are no statistics about the prevalence of other pulmonary disorders. Although a lifesaving treatment modality, lung transplantation is a very complex high-risk surgery that requires a lot of preparation, meticulous management of the transplant recipient, as well as early identification and treatment of associated complications. Thus, it is important to ensure the presence of guidelines to ensure that all necessary treatment steps are carried out based on empirical evidence.

The aim of this project is to develop a clinical pathway for lung transplantation for use at the American University of Beirut Medical Center, the only center that

performs this surgery in Lebanon, with a proposal for its implementation and evaluation.

1.1. Background

The first lung transplant in humans was performed in 1963 after years of experimental research on animals, mainly on dogs. The patient had obstructive left lung carcinoma with pneumonia and renal failure. The patient died 18 days post procedure secondary to renal complications and nosocomial infection (Panchabhai, Chaddha, McCurry, Bremner, & Mehta, 2018). More attempts were made until clinical successes were achieved in the 80s. The first successful heart-lung transplantation was performed for idiopathic pulmonary hypertension (IPAH). Then, the first successful single lung transplantation (SLT) for idiopathic pulmonary fibrosis (IPF) was performed, followed by the first double lung transplantation (DLT) for emphysema in 1986. The successes were due to advanced surgical procedures and the introduction of cyclosporine as an immunosuppressant. Ever since, more and more hospitals have been adopting and performing lung transplants (Venuta & Van Raemdonck, 2017).

These surgical and medical advancements have provided hope for thousands of patients struggling with severe respiratory conditions; patients who, unfortunately, no longer have any alternative treatment options. However, it is key to note that not every patient with a terminal lung disease is a candidate for lung transplant. The provider has a major role in identifying possible candidates and referring them to lung transplant centers for assessment and evaluation.

The International Society of Heart and Lung Transplantation (ISHLT) outlines the criteria appropriate for referral for transplantation evaluation based on the patient's

underlying disease. The recently reviewed criteria include the following, COPD that is progressive with “clinical deterioration despite maximal treatment including medication, pulmonary rehabilitation, oxygen therapy, nocturnal non-invasive positive pressure ventilation; BODE score 5-6 with additional factors present suggestive of increased risk of mortality mainly frequent acute exacerbations, increase in BODE score >1 over past 24 months, pulmonary artery to aorta diameter > 1 on CT scan, FEV1 20-25% predicted; poor quality of life unacceptable to the patient”. As for ILD, “referral should be made at time of diagnosis, even if a patient is being initiated on therapy, for histopathological usual interstitial pneumonia (UIP) or radiographic evidence of a probable or definite UIP pattern; any form of pulmonary fibrosis with forced vital capacity (FVC) of < 80% predicted or diffusing capacity for carbon monoxide (DLCO) < 40% predicted; any form of pulmonary fibrosis with one of the following in the past 2 years, relative decline in FVC ≥ 10%, relative decline in DLCO ≥ 15%, relative decline in FVC ≥ 5% in combination with worsening of respiratory symptoms or radiographic progression; supplemental oxygen requirement either at rest or on exertion; for inflammatory ILDs, progression of disease despite treatment”. As for cystic fibrosis, “referral for lung transplantation should occur when meeting any of the following criteria despite optimal medical management including a trial of elexacaftor / tezacaftor / ivacaftor if eligible, forced expiratory volume in one second (FEV1) < 30% predicted in adults, FEV1 < 40% predicted in adults and any of the following, six-minute walk distance < 400 meters, PaCO2 > 50 mmHg, hypoxemia at rest or with exertion, pulmonary hypertension (PA systolic pressure > 50 mmHg on echocardiogram or evidence of right ventricular dysfunction), worsening nutritional status despite supplementation, 2 exacerbations per year requiring intravenous antibiotics, massive

hemoptysis (>240 mL) requiring bronchial artery embolization, pneumothorax; FEV1 < 50% predicted and rapidly declining based on pulmonary function testing or progressive symptoms; any exacerbation requiring positive pressure ventilation". As for pulmonary arterial hypertension (PAH), the patient should be referred when there is "significant RV dysfunction despite appropriate PAH therapy; need for intravenous or subcutaneous prostacyclin therapy; progressive disease despite appropriate therapy or recent hospitalization for worsening of PAH; scleroderma; large and progressive pulmonary artery aneurysms; signs of secondary liver or kidney dysfunction due to PAH; potentially life-threatening complications such as recurrent hemoptysis (Leard et al., 2021).

The society also has set candidacy considerations that the patients have to meet to be considered for transplant. These include having "more than 50% risk of death from lung disease within two years if lung transplantation is not performed, having more than 80% likelihood of surviving at least 90 days after lung transplantation, and having more than 80% likelihood of 5-year post-transplant survival from a general medical perspective provided that there is adequate graft function" (Weill et al., 2014, p. 3).

Other considerations include the type of surgery, whether a single lung transplantation (SLT), a double/bilateral lung transplantation (DLT/BLT), a cadaveric lobar transplants (CLT), a living donor lobar transplantation, or a heart-lung transplantation (HLT). The selection of type of surgery depends largely on the underlying disease. However, when the decision comes down to SLT versus DLT, DLT provides better survival outcomes. Recommendations are to perform DLT when it is an

option, specifically for candidates with severe pulmonary hypertension (Antończyk, 2020).

The complete process of lung transplantation is a complex journey, requiring quality care, keen management, and close follow-up by different disciplines. Nevertheless, the rewarding aspect of this arduous process is that the patient's recovery is associated with a significant improved quality of life and a great survival advantage (Fuller & Fisher, 2013). This is mostly observed in patients with cystic fibrosis, interstitial pulmonary fibrosis, and pulmonary hypertension (Fuller & Fisher, 2013). The process is divided into major steps, which are further organized by specific timelines and guidelines. In brief, it starts by identifying the patient as per the criteria stated above, referring him/her to the transplant center, evaluating his/her condition, calculating the lung allocation (LAS) score, and setting the waiting list rank. The LAS score was introduced in 2005 by the United Network for Organ Sharing in the United States lung allocation policy. It is a calculated number that helps prioritize the waiting list candidates for lung allocation based on the severity of illness and the post-transplant survival **.** It identifies the urgency of a transplant in order to reduce wait-list mortality and avoid futile transplants. The LAS is dependent on seventeen patient-related variables, mainly age, weight and height, underlying diagnosed disease, pulmonary function, oxygen requirements, ventilation requirements, presence of pulmonary hypertension, 6-min walked distance and renal function (Van der Mark et al., 2020). Once a donor is identified, the recipient is prepped and sent for surgery. The patient is managed postoperatively in an intensive care unit, then moved to a regular floor once stable. Upon discharge, follow up is initiated based on a timeline set with the patient.

1.2. Significance

Since performing and managing a lung transplant is complex, certain guidelines have been constructed to organize the process and yield positive outcomes. Guidelines provide specific recommendations for therapeutic interventions with strong empirical support. However, they do not necessarily provide a chronologic stepwise guidance for practitioners managing patients who undergo a complex treatment modality such as lung transplant.

A clinical pathway or a care pathway is coined by the European Pathway Association (2005) as a dynamic step-by-step flow of an agreed set of organized care processes for a specific population of patients during a specified period. It entails transforming the set guidelines and evidence-based data into algorithms (Kuntz, 2019). The purpose of the pathway is to optimize the complex care delivered to this specialized patient population while promoting safety, improving immediate and future outcomes and prognoses, and maximizing the use of available and appropriate resources (Lawal et al., 2016).

1.3. Lung Transplant at the National Level

The only body responsible for the process of lung transplantation in Lebanon is the National Organization for Organ and Tissue Donation and Transplantation (NOD-lb), a governmental institution led by the Lebanese Ministry of Health (MOH). It is responsible for the supervision of all organ donations and transplantations (NOD-lb, n.d.) in the country. Once a patient is deemed a candidate for lung transplant, he/she is listed on the NOD waiting list. This is done by firstly completing the NOD waiting list form by the transplant coordinator and having it reviewed and signed by the transplant

surgeon (cardiothoracic), the pulmonologist, and the patient. The form, with all the required documents and tests, is then submitted to the NOD for registration. To note, patients are required to pay a waiting list registration fee that is renewed for every listing.

Nationally, the only hospital that has performed a lung transplant is the American University of Beirut Medical Center-AUBMC (Republic of Lebanon Ministry of Public Health, 2019). However, the transplant program lacks a clinical pathway for lung transplant although two transplants have been already performed in the last three years (Hallak, R., personal communication, September 2020). The clinical management and whole process of these patients were based on the already set-up clinical pathway for kidney transplant, in addition to the input of expert pulmonary and cardiothoracic physicians. Thus, setting up a lung transplant clinical pathway will help guide the process and create an up-to-date standardized plan of care that will impact patient outcomes positively.

The purpose of the proposed project is to develop an evidence-based clinical pathway for patients undergoing lung transplantation, focusing on the pre-operative, intra-operative, and immediate post-operative phase, with a recommended implementation and evaluation plan. The pre-transplant phase, which mainly includes the identification, referral, evaluation, waiting list ranking, and donor identification will not be included in the proposed clinical pathway for the purpose of this project but will be briefly discussed in Chapter 2. This project focuses mostly on the recipient from hospital admission through the transplant surgery, up to discharge from the hospital.

CHAPTER 2

REVIEW OF THE LITERATURE

The following section will cover the available literature on clinical pathways (CPWs) and the challenges to the implementation of standardized care, and clinical pathway integration in complex processes such as lung transplantation. Also, the outcomes of implementing CPW will be discussed. In addition, some of the available clinical pathways in lung transplant will be reviewed. Finally, the lung transplant process will be briefly discussed.

2.1. Definition of a Clinical Pathway (CPW)

Clinical pathways, also referred to as care pathways, critical pathways, or care maps have been present and in use since the 80s in the USA, and since the 90s in Europe. Their purpose is to standardize the care processes within a specific timeframe, while providing quality care for patients with better outcomes and optimized usage of the available resources (Lawal et al., 2016). CPWs are intended to have "the right people, doing the right things, in the right order, at the right time, in the right place, with the right outcome" (Allen, Gillen, & Rixson, 2009, p.80).

The European Pathway Association (EPA) defines care pathways as a method of consensual decision making for an explicit patient population during a specified period of time, defined by a list of characteristics. The characteristics include, "an explicit statement of the goals and key elements of care based on evidence, best practice, and patient expectations; of the facilitation of the communication, coordination of roles, and sequencing the activities of the multidisciplinary care team, patients and their relatives;

the documentation, monitoring, and evaluation of variances in implementation and outcomes; and the identification of the appropriate resources" (European Pathway Association, 2005).

Lawal et al. (2016) revised the already proposed operational definition of a clinical pathway in 2010 by Kinsman et al. The original definition stated that an intervention had to meet the first criterion and any three of the remaining four in order to be considered a CPW. The criteria were as follows, "the intervention was a structured multidisciplinary plan of care, the intervention was used to channel the translation of guidelines or evidence into local structures, the intervention detailed the steps in a course of treatment or care in a plan, pathway, algorithm, guideline, protocol or other 'inventory of actions' the intervention had timeframes or criteria-based progression, and the intervention aimed to standardize care for a specific clinical problem, procedure or episode of healthcare in a specific population" (Kinsman et al., 2010, p.2). The new definition merged criteria three and four, narrowing the checklist into three criteria. An intervention now has to meet all the criteria in order to be considered a CPW (Lawal et. al., 2016).

Nevertheless, standardizing the care in case of complex processes and procedures, such as lung transplantation, requires keen attention to the facilitators and the obstacles for the successful implementation of this novel change. Moreover, a clinical pathway for lung transplantation has to take into consideration multiple elements during its development. Lung transplant targets different patient populations, from the young cystic fibrosis patients to the older patients with chronic obstructive pulmonary disease (COPD) who present with multiple co-morbidities. This brings about disease-specific management considerations that must be tailored to each group, while

also taking into consideration the donor lung's characteristics. To note, a key aspect in the plan of care in the lung transplant process is the prevention of complications.

2.2. Barriers to the Implementation of CPWs

Evans-Lacko and colleagues (2010) were able to identify, from the available literature, the barriers and facilitators for the implementation of care pathways in general settings. Many obstacles may alter the clinical involvement of the health care team and the adoption of clinical pathways. These mmight be faced at either the level of the staff, the organization, or might be affected by external factors. Moreover, barriers could be encountered at any of the three stages of the process; during development, during implementation itself, and/or during the evaluation phase. The obstacles identified during the design phase were "lack of staff involvement, lack of awareness/familiarity, lack of applicability to certain clinicians, conflicting information, mixed attitudes regarding standardization of care/artistic aspect of practice, medicalised language alienating other disciplines, time constraints, available resources/facilities, insufficient staff, and increased cost" (Evans-Lacko et al., 2010, p.3).

Similarly, Jabbour et al. (2018) emphasized the importance of identifying and understanding the present and anticipated barriers that may affect the implementation of a CPW, this time in a complex clinical setting, the emergency department (ED). The authors discussed the importance of how CPWs bridge evidence-based data into organized clinical practice through customized systems, yet are limited by inconsistent implementation methods. An effective implementation requires attention to the current and the anticipated barriers. The study, using a qualitative descriptive design, yielded seven major themes and 85 sub-themes for barriers and facilitators related to CPW

implementation. The discrete themes were the following, “clinical pathway tools and standardization, pediatric/patient-specific issues, professional issues, team dynamics, strategies for success and sustainability, hospital resources and processes, and quality and process improvement” (Jabbour et al., 2018, p.4). The investigators also examined three levels of impact, namely the ED health professional, the ED team, and the hospital context. The authors noted that change in behavior is not solely related to the behavior of the individual health care provider, but is actually aggravated by barriers created by the system. A motivated physician or an ambitious nurse is not enough if the rest of the team does not support the new change, or if the system as a whole does not back up this type of change. According to Jabbour and colleagues (2018), in order to accomplish a change in behavior, one or more of the components of the Behavior Change Wheel must be altered. The model is named COM-B-model, derived from Capability, Opportunity and Motivation, which together yield a change in Behavior. “Capability represents the ability to engage in thought or physical processes necessary for the behavior, opportunity is the environmental or social factors that influence behavior, and motivation is the conscious belief and the unconscious held emotions that direct behavior” (Jabbour et al., 2018, p. 11). The authors concluded that the data would help in designing implementation strategies for clinical pathways (Jabbour et al., 2018).

Researchers in The Netherlands also highlighted how the successful application of a clinical pathway requires a change in the culture (Kolk et al., 2017). Using a pre-post research design, they studied the implementation of a CPW (after its development by nurses) to guide the management of cardiac surgery patients and its impact on blood pressure, blood loss from chest tubes, and electrolyte control. While there are many protocols and guiding material for cardiac surgery post-operative patient care,

compliance and adherence to them is inconsistent. Hence, the realization that the integration of a CPW will bring forth a critical change in the ICU nursing and medical teams' daily and hour-to-hour clinical practice is key to its design and implementation. Therefore, preceding the actual implementation, great effort was put on identifying the potential obstacles and facilitators in this specific ICU complex setting, in order to fine tune the integration strategy; thus a barrier-facilitator analysis was conducted. Nurses initially displayed a negative attitude towards standardizing their nursing work. This was tackled in the intensive training provided by key nurses and the pathway developers to prevent non-compliance. Results following the training showed improvement in cardiac surgery protocol adherence from 44% to 90% (P=0.01) after the implementation of the clinical pathway (Kolk et al., 2017).

To our knowledge, there are no published studies that examined the influence of CPWs on the outcomes of lung transplant recipients. A 30-question survey by King et al. (2017) on early post-operative management strategies in lung transplant patients with 52 international lung transplant clinicians showed variability and deviation from the international recommended guidelines. There were differences in the methods used for venous thromboembolism prophylaxis, sedation and analgesia, mechanical ventilation and management of primary graft dysfunction, fluid management, post-operative pulmonary hypertension (PH) management, and chest tube management. This hindrance emphasizes the need for a standardized set of protocols.

Despite the complex multifaceted nature of management of lung transplant recipients, there are factors that promote the opportunity to develop and implement a clinical pathway for these patients. In fact, a common barrier to the design and implementation of CPWs in many fields is the absence of the definition of the

beginning and the end of an episode of care. However, in transplantation, the different steps are highly regulated with defined timings, which easily sets the grounds for a CPW (Pavlakis & Hanto, 2012). Pavlakis & Hanto (2012) also recommended that CPWs need to be integrated into an Electronic Medical Record (EMR) with automatic tracings for any deviation from the pathway.

In summary, the prerequisite to the implementation of CPW is identification of facilitators and barriers, and interventions to address these factors while developing the pathway.

2.3. Outcomes Associated with the Implementation of CPWs

As the studies on lung transplant and clinical pathways are scarce, the literature on processes that are as complex as lung transplantation such as cardiac surgery, kidney transplant and heart transplant will be discussed.

Kutrin & Stuck (2009) coined the statement "standardize to excellence", as clinical pathways have been used for decades at a children's hospital in California, USA with significant improvements in clinical outcomes and decrease in costs. The uptake of clinical pathways by clinicians can improve the quality of care through the increased use of validated practices, decreased variance in the care delivered by physicians, and standardization of care processes (Kutrin & Stuck, 2009). Kolk and colleagues (2017) discovered that more patients in a post-operative cardiac surgery clinical pathway group received early treatment for electrolyte imbalances and BP control as compared to those in the control group, 98% as compared to 47% and 93% as compared to 49% respectively, with a $P<0.001$ for both outcomes. Guertin et al. (2021) revised an already implemented heart transplant clinical pathway in a leading

heart transplant program at a US medical center because of an increase in the index of length of stay (LOS). It was reintroduced after modification and its effect on LOS was studied through a retrospective study.The LOS decreased from 23 to 15 days (P=0.041) following modification of the pathway.

A scoping review by Shabaninejad et al. (2018) identified and classified indicators that are measured following clinical pathway implementation. The indicators were divided into input indicators, processes and output indicators, and outcome indicators. For the input indicators, most studies focused on the significant effect of CPW on decreasing hospital costs. As for process indicators, the majority of studies showed a reduction in the average LOS through the application of standardized care processes, which in turn lowered costs and resource utilization. Finally, outcome indicators were the most frequently studied category of indicators, with the most studied sub-categories being the rate of complications, readmissions, clinical indicators, patient satisfaction, and mortality rate. No significant effect of CPWs on mortality rate and readmission rates were found. As per Rotter et al. (2012), CPWs used for surgeries yielded a decrease in hospital acquired complications mainly bleeding and infections.

A quality improvement project by Seawright & Taylor (2011) compared the use of a post-operative clincial pathway for adult recipients of a deceased donor kidney transplant with charts from the seven months of the previous year retrospectively. The control group had a mean patient LOS of 4.76 days as compared to a mean of four days in the clinical pathway group (P=0.048). Readmission rates did not differ between the two groups. The pathway in itself helped nurses meet all of the patients' daily goals. All patients in the clinical pathway group were converted to oral medications within the first 24 hours, compared to only 20% of patients in the control group (P<0.001).

Approximately 80% of the clinical pathway group had no inappropriate CD3 lab studies charged, compared with 8.9% in the control group ($P < .001$).

The only study of lung transplant recipients was by Currey et al. (2010) who studied prospectively the outcomes of implementing management guidelines post lung transplantation (n=56) as compared to the outcomes of a historical control group (n=53). The intervention group had a significantly lower primary graft dysfunction severity than the control and lower fluid resuscitation ($P=0.01$) and vasopressor use (P value approached significance at 0.07). There was no association between the use of the guideline and the duration of mechanical ventilation or mortality; this could be due to the small sample size and study design (Currey et al., 2010). Randomized Controlled trials are needed in this area.

2.4. International Guidelines for Lung Transplantation

The International Society for Heart and Lung Transplantation (ISHLT), the European Respiratory Society (ERS), the American Thoracic Society (ATS), and the American Association for Thoracic Surgery (AATS) lack international practice guidelines or consensus statements for the perioperative management of lung transplantation, in addition to the absence of a standardized anesthetic management (Thakuria et al., 2016). Most of the guidelines are focused on the selection criteria for lung donors and lung recipients, the psychosocial evaluation of transplant candidates, as well as research on identifying and managing complications such as the chronic lung allograft dysfunction. Lung transplant centers have created their own guidelines and pathways based on physician experiences and research-based outcomes, with a lot of data extrapolated from general ICU populations, such as management of mechanical

ventilation peri-operatively and veno-thromboembolism prophylaxis (Barnes et al., 2015).

2.5 Examples of Lung Transplant CPWs

A Guide to the Care of Lung Transplant Recipients at Brigham and Women's Hospital (BWH) is not a clinical pathway but a document of more than one hundred pages that covers extensively the process of lung transplantation at BWH. This guide was developed by the medical center's physicians and clinical pharmacists. Unfortunately, it appears that the nursing team were not involved. The guide takes into consideration responsibilities of the multidisciplinary team, the peri-operative management, disease-specific management, and the different algorithms and protocols that might or will be needed during lung transplantation. For instance, they have developed a guideline for evaluating transplant candidates and donors with proof of viral hepatitis exposure. Moreover, they have guidelines for steroid dosing and tapering, guidelines for anticoagulation dosing, and algorithm for leukopenia, a calcineurin inhibitor management protocol, and many more (Brigham and Women's Hospital, 2019).

The University of Washington (UW) Medicine (2017) has developed and integrated a lung transplant clinical care pathway that provides a step-by-step guidance for the management of patients pre-operatively and all the way through the discharge planning and follow-up. The pathway is divided into four milestones. Each milestone represents a phase in the lung transplant process. The first milestone represents the pre-operative and intra-operative phase. The second milestone is the post-operative phase in the intensive care unit (ICU). The third milestone is the post-operative phase in the

regular ward. Finally, the fourth and last milestone is the post-discharge plan. To note, each milestone is highlighted by the number of anticipated stay days required for that specific phase. The milestones consist of nursing and medical care-plans, including the responsibilities of the different members of the multidisciplinary team. For example, for days one through three during the ICU milestone, the RN will perform bedside swallowing test once the patient is extubated and advance diet from clear to regular gradually as tolerated. The patient's nutritional needs will be assessed by the dietician simultaneously. The physical therapist and the occupational therapist will evaluate the patient's mobility and plan the care accordingly. Spontaneous breathing trials will be initiated since extubation is expected at this point if the patient is stable and eligible (UW Medicine, 2017).

In conclusion, each institution has its own lung transplantation CPW developed and catered to meet the needs of its target population, while applying evidence-based practices through the feedback of the multi-disciplinary team and optimizing the use of the available resources.

2.6. The Lung Transplant Process

The journey of transplant starts at the level of the provider when he/she identifies patients who might be appropriate candidates for evaluation by lung transplant centers and eventually be placed on the national waiting list. The earlier the identification, the better the patient's clinical status optimization, the better the outcomes. Once the candidate is referred, extensive multidisciplinary evaluation is done by the transplant center to determine the potential risks and benefits of lung transplantation with regards to his/her condition and underlying disease. The patient,

patient's support system including the family, and transplant specialists together determine whether placing the patient on the list would be appropriate. The evaluation includes all sorts of tests to identify any factors that might hinder the success of the transplant. Some of these include laboratory tests, assessment for prior or current infections, breathing tests, imaging, cardiac tests, screening tests review, assessment of gastric esophageal reflux and gastric emptying, and vaccination review. These tests change according to the patient's age and co-morbidities (Hachem, 2020).

Once all labs and tests are completed, patient is listed on the NOD waiting list. When a matching donor is identified, the recipient is contacted to present to the hospital to proceed with the process. During a patient's stay, the process of lung transplantation is divided into three main phases; the immediate pre-operative phase, the intra-operative phase, and the immediate post-operative phase- which is further divided into the intensive care unit stay and later-on the regular floor stay. The section below describes the main features in each phase based on the guidelines reviewed above.

2.6.1. The immediate pre-operative preparation.

Once a recipient is identified by NOD-Lb, a retrieval team is sent to the location of the donor for full examination of the donor lungs and its retrieval, if approved. The recipient is called in for crossmatch and size-matching and is taken into the operating room for prepping once the donor lung is on its way. Due to the urgency of the process, during their transplant evaluations, recipients would have been already screened for blood group, HLA typing, and anti-HLA antibodies. Moreover, a list of preparatory tests is required as a preparation for potential recipients. To note, recently, ex-vivo lung perfusion (EVLP) techniques have been used to preserve donor lungs during

procurement (Hirche et al., 2015). Some of the steps to be considered immediately before the surgery include the immunosuppression induction, antimicrobial prophylaxis, venous thromboembolism prevention measures, lab tests, cultures, deep breathing exercises, reflux management and aspiration prevention.

2.6.2. The intra-operative interventions.

In the operating room, major decisions are taken depending on multiple factors. The type of procedure depends on the underlying disease and the available procured lungs, whether single lung, sequential double, lobar live donor, or heart-lung transplant. Vital considerations for the operation include fluid management and maintaining hemodynamic stability, the type of sedation and pain management, the need for extracorporeal circulatory support (cardiopulmonary bypass (CPB) versus extracorporeal membrane oxygenation (ECMO), the ventilator settings, the need for use of nitric oxide, administration of stress-dose steroids and immunosuppression, surgical technique, chest tubes insertion, and anastomosis considerations. To note, a dual-lumen large bore endotracheal tube is used for intubation in order to facilitate a one-lung ventilation, easy clearance of secretions and easy access for bronchoscopies (Hartwig & Klapper, 2020).

2.6.3. The immediate post-operative phase.

This phase encompasses the management post-operatively, once the patient is transferred out of the operating room and primarily into the intensive care unit. There are multiple vital considerations during this phase. It mainly consists of decisions on the ventilatory support settings and weaning, extracorporeal life support, sedation, pain

management, spontaneous awakening and breathing trials, bronchoscopy, fluid and hemodynamic management, chest tube drainage monitoring, venous thromboembolism prevention, immunosuppression initiation and maintenance, infection prevention, early detection of primary graft rejection, blood test monitoring, nutrition and swallowing tests, initiation of early mobility, and prevention and detection of early post-operative complications. Moreover, some important nursing interventions include daily discussion about removal of central line and foley catheters, surgery site wound dressing assessment, introduction of breathing exercises, cough protocol, and incentive spirometer usage.

Once the patient is stabilized, weaned and extubated, he/she is transferred to an intermediate care unit or regular floor. The minimum stay is twenty four to forty eight hours in the ICU according to Brigham and Women's Hospital's expedited lung transplant pathway (2019) and an expected length of stay of five to seven days according to the University of Washington Medicine's clinical lung transplant pathway (2017). During the patient's stay in the regular ward, management usually focuses on rehabilitation and discharge planning. The nurse's role is to set the medication regimen for the patient, advancement oral diet and assessment of his/her tolerance and risk for aspiration, bridging pain medications to the oral route, follow-up on labs, follow up with physical therapy and occupational therapy interventions, involving caregivers in the discharge plan of care, encouraging breathing exercises, while involving all members of the multidisciplinary team in the care.

Prevention and early detection of post-operative complications are crucial. The immediate and early complications discussed in the literature include both surgical and medical ones; primary graft rejection, large airway complications, acute rejection,

vascular anastomotic complications, diaphragm injury, pleural complications, infections including local wound infections, acute kidney injury, arrhythmias, hematologic (bleeding and thromboembolism) and gastro-intestinal complications (Soetanto et. al, 2021). Integrating prevention evidence-based strategies in the lung care pathway is key.

At AUBMC, introducing a CPW is not an uncommon change as the transplant program already adopts a CPW for kidney transplant. Thus, the proposal of a lung transplant CPW will be of a similar flow, based on evidence-based data while taking into consideration the available resources in the institution and the country. The content of the pathway will include the aforementioned lung transplant process in a chronological step-by-step order.

CHAPTER 3

PROPOSED LUNG TRANSPLANT CLINICAL PATHWAY

This chapter describes the main components of the proposed lung transplant pathway. The pathway covers the period from when a matching donor is identified, the recipient is informed, followed by pre testing and surgery, post-operative period till discharge of the transplant recipient from the hospital. The full pathway is included in Appendix I.

Once a potential donor is identified, a matching recipient is contacted and asked to remain stand-by and to stay NPO until he/she is re-contacted. Once donor lung is confirmed for compatibility, the recipient is contacted to present to the hospital in order to start with the lung transplant process. The transplant pathway is divided into four phases: The immediate pre-transplant preparation phase, the lung transplant procedure, the post-transplant cardiac surgical unit (CSU) phase, and the post-transplant regular ward phase. The clinical pathway is further divided into six sections that are namely: 1) the pre-operative holding area and intra-operative considerations, 2) the post-operative day (POD) zero that includes the management immediately post-surgery, 3) POD one till three and 4) POD four till six, which covers the CSU management, and 5) POD seven till ten and 6) POD eleven till fourteen that encompass the patient on the regular ward. The pathway helps guide the multi-disciplinary team on the evidence-based management for each day spent by the lung recipient in the hospital.

The clinical management categories covered in the pathway within each section include laboratory tests, imaging and procedures to be done; vital signs and hemodynamic monitoring; fluid intake and output management; all the medications to

be given [*immunosuppressants, antimicrobials*, proton pump inhibitors (*PPI), PRN medications, key home medications, pain and comfort meds*, deep vein prophylaxis (*DVT) prophylaxis*]; lines, drains and wound management; respiratory management; all applicable nursing treatments including the bundles, diet, activity, education, discharge planning; consultations and any other relevant intervention.

To note, the pathway is developed to cover a length of stay of up to fifteen days. This estimate may vary depending on the patient's condition, disease, and if any complications arise during their stay. The duration was depicted as such based on the literature and based on the clinical pathways reviewed before, mainly the Brigham and Women's Hospital pathway, the University of Washington pathway, and Duke University Hospital pathway. At AUBMC, the two cases of lung transplant stayed for up to 48 hours in the CSU and one week on the regular ward. The following section summarizes the main milestones in the lung transplant recipient journey.

3.1. Consents

It is very important to explain the procedures that the patient will undergo and the risks that they carry. This would have already been covered when they were listed for transplant but must be reiterated when a donor becomes available. Consenting is done by the provider performing the surgery. Informed consent for the surgery in itself and consent for the anesthesia are signed by the patient or the guardian if the patient is unable to provide signature. During hospital stay, informed consents for blood product administration (if needed) and bronchoscopies are also signed. Consents for the same procedure serve up to six months within the same admission as per AUBMC policies (Policy PFR-MUL-001).

3.2. Laboratory tests and imaging

Once the recipient arrives to the pre-admission unit (PAU) on the same day of surgery, blood tests are immediately drawn to prepare the patient for the surgery. Some of the major lab tests that are essential pre-surgery include, direct HLA-antibodies, typing and crossmatch, CBC and Differential, (CBC-D) Chemistry-9, liver function tests, and coagulation panel. A chest x-ray and a baseline EKG are also done. Point of care testing glucose monitoring is done as per the unit's protocol. Sputum culture is taken when bronchoscopy is done during the operation. Sputum culture is also taken from the donor to adjust prophylactic antibiotics according to culture results (Brigham and Women's Hospital, 2019)

Post operatively, CBC-D and chem-9 are repeated, along with arterial blood gases to adjust the ventilator settings. During the patient's stay in the CSU on POD 0, CBC-D, Chem-9, coagulation profile and the ABGs are repeated every six hours for the first 24 hours then repeated on daily basis. Once the patient is transferred to the regular ward, CBC-D, Chem-9, and coagulation profile are repeated on daily basis until discharge. Chest X-ray is done on daily basis as well, and in case of suspicion of primary graft dysfunction, CT chest is done.

Serum Tacrolimus (refer to 3.5 for tacrolimus mechanism of action) level is monitored starting POD 2 and checked every 2-3 days as the margin for adequate immunosuppression and toxicity is narrow. Trough level is monitored after 12 hours from previous dose and immediately before the next one. Target levels during hospital stay are kept on the upper levels of 8-12ng/ml or 12-15ng/ml (Hardinger & Magee, 2020).

3.3. Vital Signs and Hemodynamic Monitoring

Each unit has its own protocol for vital signs and hemodynamic monitoring. In the pre-admission unit, vital signs are taken once. Once the patient reaches the operating room, vital signs monitoring becomes continuous through continuous blood pressure monitoring via the arterial line and continuous hemodynamic monitoring through the Swan Ganz catheter. Once patient is received in the CSU, monitoring is as per the CSU protocol, which is every one hour including central venous pressure (CVP), pulmonary capillary wedge pressure (PCWP), and cardiac output (CO) / cardiac index (CI). Pulmonary capillary wedge pressure is kept at 5 to 15 mmHg, while continuously monitoring for adequate urine output, adequate oxygen delivery, and blood pressure.

3.4. Fluid Intake and Output

Strict monitoring of fluid intake and output is crucial. It is important to maintain adequate filling pressures and cardiac output. However, fluid resuscitation vs escalating inotropes has to be balanced out since post-operatively it is expected to have increased vascular permeability and a disrupted lymphatic drainage, which will contribute to pulmonary edema and lead to one of the major complications post lung transplant, which is primary graft dysfunction (Snell et al., 2017). Thus, fluid resuscitation should be aimed to maintain CO while minimizing pulmonary edema with filling pressure measurements. Patients should be weighed daily. Restriction of fluids in medication preparation is recommended. Moreover, once the patient is hemodynamically stable, diuresis is initiated to maintain a negative balance (Brigham and Women's Hospital, 2019)

3.5. Medications

Most of the management of the patient post lung transplant depends on the medications administered peri-operatively to prevent immediate and long-term complications, especially rejection.

3.5.1. Immunosuppressants

Immunosuppressants are among the most vital medications for the long-term survival of the lung recipient. However, there are no immunosuppressants that are FDA approved in the US exclusively for lung transplantation. Variances occur in worldwide approved medications as well (Cochrane et al., 2020) Immunosuppression is given primarily as induction and post-operatively as maintenance. The most common and the main drug used for induction is Basiliximab, a monoclonal antibody that acts as an interleukin-2 receptor antagonist that decreases circulating T-cells without their depletion. Other induction drugs include anti-thymocyte globulin (ATG) and alemtuzumab but these are associated with more side-effects. Induction Basiliximab is administered intra-operatively and then repeated on day four post-op. Intraoperatively, two other drugs are also given mainly Methylprednisolone, a corticosteroid, at the time of each reperfusion to decrease the risk of reperfusion injury, and Mycophenolate Mofetil, an anti-proliferative agent (Cochrane et al., 2020)

The maintenance immunosuppression regimen adopted by most transplant centers is the triple drug therapy, which consists of a calcineurin inhibitor or CNI (Tacrolimus or cyclosporine), an anti-proliferative agent (Mycophenolate or Azathioprine), and corticosteroids. Most centers use Tacrolimus (TAC) as their choice of CNI instead of cyclosporine since it is associated with a decrease in the incidence of

acute rejection and bronchiolitis obliterans syndrome. TAC inhibits interleukin-2 and interferon-gamma, which results in the inhibition of T-cell activation and proliferation (Cochrane et al., 2020). The initial IV infusion is a continuous infusion over 24 hours, usually started after a minimum of six hours post-transplant. It is later bridged to either sublingual (unavailable at AUBMC), or oral or enteral route every 12 hours, usually on an empty stomach. Serum trough level targets of TAC differ from center to center but are usually initially set on the higher end 8-12ng/ml or 12-15ng/ml and adjusted post-discharge. The target is lower when there is an infection and higher when there is a possible rejection. Trough level monitoring is usually done starting POD2, 12 hours from the previous dose, immediately before the next one. It is checked every two to three days. Doses are adjusted accordingly (Hardinger & Magee, 2020).

As for the anti-proliferative agent, Mycophenolate is mostly the drug of choice. It works by depleting guanosine nucleotides in T and B lymphocytes, which inhibits the proliferation of T and B cells. The drug is given within 72 hours post-operatively every 12 hours IV or orally on an empty stomach. Serum levels are not monitored. Finally, glucocorticoids have long been used as essential maintenance immunosuppressants. The protocol used during hospital stay is very variable across the different centers. The usual dose is a higher IV dose for the first two days and then maintained on a lower IV or oral dose, and later on tapered down for a lifelong oral dose (Chung & Dilling, 2020)

3.5.2. Antimicrobials

Another important class of drugs in lung transplant is the antimicrobials. Antimicrobial coverage is vital in lung transplant as recipients are at very high risk of developing infections. The antimicrobial protocol aims at providing coverage

prophylactically for the most common infections. Moreover, it is important to take into consideration the recipients and the transplanted lung's risks and prior colonization to set and adjust antimicrobials accordingly. This is done by checking previous cultures and by taking new sputum cultures from the recipient operatively and the donor's lung during procurement.

The anti-microbial prophylaxis starts pre-operatively and continues post-operatively. It is modified according to the results of sensitivity testing of donor and/or recipient along the patient's stay. The dose is adjusted according to the creatinine clearance as well. The most used antibiotics during the pre-operative phase include, Gram Positive coverage with Vancomycin prior to incision, Gram Negative coverage with 4th generation cephalosporin: Cefepime prior to incision or broad- spectrum penicillin Piperacillin/tazobactam, and anti-fungal candida coverage with Fluconazole (Fishman & Alexander, 2020).

Post-operatively the same drugs are continued until culture results are out or in case of any nosocomial infections. Vancomycin is continued for a total of 7-10 days or until chest tubes are removed while monitoring serum levels. Cefepime is also continued up to 10 days. Bactrim is started on POD 7 and continued for life three times weekly for pneumocystis pneumonia prophylaxis, while providing prophylaxis coverage for other pathogens mainly Listeria monocytogenes and Toxoplasma gondii. As for fungal infection prophylaxis, Fluconazole is given once before surgery or intra-operatively for candida prophylaxis and continued for up to ninety days. Inhaled Amphotericin B is given daily for four days then weekly until discharge. Moreover, Nystatin swish and swallow is given four times daily for oral candidiasis for a total of six months. (Fishman & Alexander, 2020).

The choice of antivirals, mainly for cytomegalovirus (CMV) prophylaxis, depends on the donor and recipient CMV status. Universal prophylaxis is preferred over pre-emptive therapy (Kotton et al., 2018). The latter involves monitoring CMV in the blood and starting antivirals when a certain level is reached. When the donor is CMV positive and the recipient is negative, the risk for recipient CMV infection is highest and IV Ganciclovir is started. It is switched to oral Valganciclovir once oral intake is tolerated and is continued for six to twelve months. If the donor is CMV positive and recipient is also positive, or if the donor is negative and the recipient is positive, then the same regimen is given but for a minimum of six months. If both donor and recipient are negative, it is considered a low risk and routine prevention for CMV is not recommended. These patients are maintained on Acyclovir orally/enterally for Herpes and Varicella Zoster Virus (VZV) prophylaxis for a duration of 3 to 6 months. To note, Ganciclovir and Valganciclovir coverage includes VZV and herpes (Kotton et al., 2018). Antiviral doses are adjusted according to creatinine clearance and weight.

3.5.3. Proton Pump Inhibitors

Gastric reflux management is essential with lung transplantation as it has been associated with chronic lung allograft dysfunction (CLAD), a major complication post-surgery. Thus, patients are maintained on a proton pump inhibitor such as Esomeprazole. If the reflux persists and aspiration is present, total or partial fundoplication is considered pre or post-surgery (Carney et al., 2019).

Venous Thromboembolism Prophylaxis

Post-surgery, patients are at a moderate risk of developing venous thromboembolism (VTE), whether a deep vein thrombosis or a pulmonary embolism.

They are maintained on prophylactic doses of anticoagulation, mainly low-molecular weight heparin or unfractioned heparin (if creatinine clearance is less than 20-30ml/min) unless they have a history of VTE which will necessitate higher dosage. Anticoagulation is continued throughout hospitalization (Brigham and Women's Hospital, 2019).

3.5.4. PRN medications

As for the "as needed" medications, the list includes a laxative mainly Lactulose orally/enterally twice daily and an anti-emetic mainly Metoclopramide IV drip every eight hours. Lactulose and Metoclopramide have no drug-drug interactions with the antimicrobials and immunosuppressants. As for glycemic control, the hyperglycemia protocol includes insulin sliding scales of different intensities and the hypoglycemia protocol entails a step by step correction with D30W. To note, glycemia management should be followed up with the endocrinology team if blood glucose remained uncontrolled.

3.5.5. Chronic home medications

Essential chronic home medications are resumed starting POD1 after being adjusted to creatinine clearance and liver enzymes, and after checking drug-to-drug interactions with the rest of the medications, mainly the immunosuppressants and antimicrobials. The rest of the home medications are re-introduced during the patient's stay in the regular ward.

3.6. Pain and comfort

Pain management and sedation protocols intra-operatively are controlled by the anesthesiologist. Once the patient moves to the CSU, the critical care pain management and sedation protocols are applied. Throughout the patient's stay in the CSU, spontaneous awakening trials (SATs) are attempted from POD1 along with spontaneous breathing trials (SBTs) for early extubation. However, pain management should be maintained at an adequate level as the patient has a surgical wound, chest tubes, lines and endotracheal tube that are a major source of pain. Pain management plan should be continued even if the patient is extubated. If pain is not well controlled, the pain team is consulted.

3.7. Lines, drains, and wound management

A peripheral IV access is secured for the patient in the pre-admission unit to receive all the pre-medication and be prepped for surgery. Intra-operatively, the insertion of an indwelling catheter for strict fluid balance monitoring, a gastric or post-pyloric feeding tube for nutrition and medication administration, an arterial line for continuous blood pressure monitoring, and a Swan Ganz for hemodynamic monitoring, intravenous fluid resuscitation, and medication administration are inserted. The surgical procedure depends on the type of lung transplant whether single or bilateral, which subsequently affects the size and location of the wound. Two chest tubes are usually inserted at the end of the surgery.

During the patient's stay in the ICU, the wound is assessed every four hours for any bleeding, dehiscence or discharge. The dressing is changed by the surgery team daily and as indicated. Chest tubes are monitored for drainage and air leak and

considered for removal when no air leak is present, total serosanguineous drainage is less than 200 mL per 24 h, and/or less than 20 mL/h for the three consecutive hours prior to planned removal. The Swan Ganz catheter is kept as long as hemodynamic monitoring is indicated. Indwelling Foley catheter is kept for accurate output measurement and in cases of retention; however, its removal is discussed daily during rounds.

3.8. Respiratory management

In the PAU, the patient's prior oxygen delivery method. Intubation is done in the operating room. Inhaled nitric oxide is usually used intra-operatively, especially in patients with increased pulmonary artery hypertension in order to decrease the possibility of the development of right ventricular dysfunction. It is gradually weaned when patient is moved to the CSU. Extracorporeal membrane oxygenator (ECMO) or cardiac bypass is considered in case of severe hemodynamic instability and is decided by the surgeon. ECMO is usually preferred as it is associated with less complications than cardiac bypass. Bronchoscopy is done intra-operatively to check for the integrity of the anastomosis and to assess for any bleeding.

In the ICU, the decision on the ventilatory support settings and weaning is an important one as primary graft dysfunction (PGD) is a common complication within the first 72 hours post-transplant and is associated with increased mortality. PGD is histologically similar to the acute respiratory distress syndrome and recommendations are to apply lung-protective settings to prevent lung injury. Post-surgery, vascular permeability and a disrupted lymphatic drainage are expected to occur. Thus,avoiding pulmonary edema is key. If no complications are present, weaning and SBT is initiated

within hours or days after transplant after performing SAT. Flexible bronchoscopy is done prior to extubating every patient to clear plugs from distal airways and assess lung conditions and the anastomoses (Hartwig and Kappler, 2020), and might be repeated before discharge and later on at week four, at three months, at six months, and at twelve months (Martinu et al., 2020)

For patients requiring ECMO post-operatively, ventilatory support is kept until discontinuation of ECMO. Tracheostomy is considered in cases where progress is slow and the patient still cannot be weaned off the ventilatory support. A very important protocol that the patient has to abide by post extubation is the ICough protocol. The ICough protocol emphasizes the importance of pulmonary hygiene, coughing, deep breathing exercises, use of incentive spirometry, oral care, head of bed elevation and ambulation to decrease the incidence of pneumonia and risk of unplanned intubation (Cassidy et al., 2013).

3.9. Nursing treatments

Nursing management and treatments involve all the nursing interventions implemented by nurses for critically ill immunocompromised respiratory patients to yield positive outcomes and decrease the patients' length of stay. The level of care depicts the interventions implemented by the nurses. In the CSU, the care provided is continuous one-to-one care. In the regular ward, the nurse:patient ratio is also one-to-one but interventions are less invasive and less frequent. It is important to emphasize the role of the nurses in the implementation of all the care bundles. The most important ones include, catheter associated urinary tract infection (CAUTI), central line associated

blood stream infection (CLABSI), ventilator associated events (VAE), surgical site infection bundles. CAUTI, CLABSI, and VAE bundles
emphasize the importance of early removal of invasive catheter/ tube through daily assessment of its need in daily rounds. Other interventions of the care bundles include the evidence-based methods of handling and care of the lines, the CAUTION STAFF bundle (Policy COP-NSG-056) to prevent CAUTIs, the CHOOSE NO VAP bundle (AUMBC Policy COP-CR-013) to prevent VAEs, and CLABSI FREE bundle to prevent CLABSIs (AUBMC Policy COP-NSG-054).

3.10. Nutritional support

Diet is an essential part of the recipient's lung transplant journey as it will help with meeting his/her energy needs and wound healing. The transplant recipient is kept NPO when getting contacted for a possible lung match. Post-operatively on POD 0, the recipient is kept NPO and usually has a gastric or post-pyloric enteral tube in place. The dietician is consulted throughout the patient's stay in the hospital for nutritional needs calculation and is expected to provide recommendations for the diet regimen to be implemented. Diet should be advanced gradually, as tolerated and as deemed safest as per the patient's condition. Enteral feeding follows the critical care feeding protocol, volume-based feeding. A speech therapist is consulted after extubation to assess the patient's swallowing, aspiration risk, dysphagia, laryngeal injury, and vocal cord injury or paralysis, and thus how safe they are to start oral intake; whether food, liquids, or medications. When diet is resumed, the patient is advised to be out of bed sitting up in a chair while receiving oral intake. Aspiration precautions are essential during meals.

3.11. Mobility and physical therapy

Lung transplant recipients undergo physical and pulmonary rehabilitation prior to surgery, that is during their waiting time in preparation for surgery, and therapy is continued post-operatively. Early mobilization is crucial. It is part of the the ICU ABCDEF bundle which includes: Assess, Prevent, and Manage Pain, Both Spontaneous Awakening Trials (SAT) and Spontaneous Breathing Trials (SBT), Choice of analgesia and sedation, Delirium: Assess, Prevent, and Manage, Early mobility and Exercise, and Family engagement and empowerment (Henderson, 2019). The physical therapist is consulted to resume therapy starting POD 1 with active and passive range of motion according to the patient's Richmond Agitation Sedation Scale (RASS). Lower limb resistance training and upper limb lifting and strengthening exercises are also done. Once extubated, the patient is ambulated to chair primarily then ambulated in the room multiple times per day. Physical and pulmonary rehabilitation are continued after discharge (Langer, 2015).

3.12. Education and discharge teaching

Lung transplant is a complex journey and requires high adherence to the treatment regimen by the recipient to prevent early and latent complications. Thus, teaching starts from the time the recipient is identified for lung transplant and is listed on the waiting list. Pre-transplant preparations include exercise, pulmonary rehabilitation, compliance to the strict medication regimen, and frequent imaging and testing. The recipient is also prepared by the transplant team on what to expect during and post-surgery. It is important for the patient to be adherent to the regimen during his stay and have his support system like his/her spouse or significant other involved in the

care throughout the whole journey. Moreover, it is very important to provide teaching on the discharge plan as it involves schedules of medications and follow-up procedures, blood tests, and imaging.

3.13. Consults

Most of the consults are already part of the transplant team mainly the physical therapist, the dietician, and the social worker/psychologist, since they would be managing the care of the patient while they are listed. Once the patient is admitted for surgery, they are notified to proceed with their interventions peri-operatively. Other consults include the speech therapist whose input and clearance are vital to the decision of resuming oral medications and oral diet, the endocrinologist for glycemic control, and the pain team for adequate pain management. Any other team can be consulted at any time in case of any need for specialist opinion and intervention. The clinical pharmacist is always on board and is expected to provide input during multidisciplinary rounds.

3.14. Other Considerations

The patient should be kept on reverse isolation as he/she is maintained on immunosuppressants and is it at increased risk for nosocomial and opportunistic infections. When walking outside of the room, the patient should wear a surgical face mask at all times. Wound care is done only by the surgical team daily and/or as indicated. Daily multidisciplinary rounds should be done to discuss the patient's holistic plan of care. Blood transfusion is associated with increased risk of PGD and thus minimizing peri-operative blood transfusion is crucial. Blood transfusions are given

according to Hgb (<7mg/dl) and hemodynamic and fluid balance status. Syrett & Huang (2020) discuss the need for randomized controlled trials for the assessment of the efficacy of standardized point-of-care coagulation testing and targeted transfusion guidelines in lung transplantation.

Some immediate complications post lung transplantation to look out for include hyperacute rejection, acute rejection and PGD. Hyperacute rejection occurs intra-operatively immediately post reperfusion. It results from antibodies directed against donor antigens and is visualized by swelling of the lung during surgery. Prevention is key by performing leukocyte cross-match testing. The management is by plasmapheresis and intravenous immunoglobulins; however prognosis is poor and rarely is the graft salvageable (Hachem, 2021) On the other hand, acute rejection, a cell-mediated rejection activated by donor antigens, occurs mostly within six months post-transplant and is manifested by alveolar infiltrates on the chest x-ray, hypoxemia and fever. Acute rejection is sometimes asymptomatic and thus surveillance flexible bronchoscopy with transbronchial biopsies is essential during the first year post transplant. Management of acute rejection is done by optimizing immunosuppression, giving high-dose steroids, and sometimes antithymocyte globulin and lymphoid irradiation. Finally, PGD, a major non-infectious complication, occurs within 72 hours with early signs of progressive hypoxia with decreased PaO2/FiO2 ratio, and new radiographic opacities in the allograft. Management includes negative fluid balance, lung protective ventilation, use of NO, ECMO, and re-transplant as last resort (McShane et al., 2012).

CHAPTER 4
PROPOSED IMPLEMENTATION AND EVALUATION PLAN

As discussed in Chapter Two, the implementation of the lung transplant clinical pathway into practice requires joint forces of every member of the multidisciplinary team involved in the care of the lung recipient, in order to ensure compliance and adherence to the pathway to yield positive outcomes on the patient. The literature reviewed in Chapter Two emphasizes the importance of taking into consideration the possible obstacles that will hinder the successful implementation of a clinical pathway while implementing the pathway. Jabbour et al. (2018) discussed three levels of impact identified from the implementation of a clinical pathway in a complex setting that affect the course of integration and bring about barriers; the hospital context, the team as a whole responsible to take care of the patient, and the individual health professional. Targeting these three levels will affect the implementation process positively.

4.1. Implementation of the Pathway

The proposed pathway will be submitted to a multidisciplinary team that includes physicians involved in lung transplant, the transplant coordinator the critical care CNS, clinical pharmacy, respiratory therapy, dietician, physical therapist, RN representatives, social worker/psychologist, and head of the division of respiratory and critical care medicine, for discussion and approval. Once the pathway is approved, a proposal is prepared that includes the rationale for the pathway, its components, needed resources (human and material), and an evidence-based cost effectiveness analysis. The medical center nursing and medical administrations will then be approached for review and approval of the pathway. This ensures the hospital's support of the pathway and

support of the autonomy of the multidisciplinary team in using the pathway. Once the proposal is submitted and approved, all healthcare providers who are part of the transplant team will be involved in the process. When a consensus is reached and the final plan for the implementation of the clinical pathway is agreed upon, it will be submitted to the health information system *Epic* team of the American University of Beirut Medical Center (AUBMC) in order to depict the most feasible way of integrating it into the system. Meetings will be held with the *Epic* team until the workflow is created and is ready to be pushed to production.

Furthermore, for proper implementation and to increase compliance and adherence to the pathway, education sessions will be put in place to disseminate the information to the healthcare providers in coordination with the clinical educators of the Clinical and Professional Development Center at AUBMC. Sessions will include the admission criteria, preliminary testing and psychological counseling of potential lung transplant recipients, a step-by-step pathway content dissemination from PAU to discharge, as well as the proper documentation of the pathway interventions on *Epic*. These education sessions will be included in the orientation program of newly hired registered nurses and the surgery interns who are assigned to the CSU/ICU. Sessions for the nurses will be repeated to ensure all those involved can attend, since they work different shifts. A similar approach will be done to cover all attending physicians and fellows, pharmacists, dietitians, etc… Once all relevant documents are prepared, such as standard order sets for PAU and discharge, flow sheets for monitoring vital signs, labs, etc…, an implementation date will be set. Once the pathway is implemented, the critical care CNS will further coach the nurses and other health care providers in its implementation.

4.2. Pathway Evaluation

As lung transplant is an infrequent process, the evaluation will encompass process evaluation and impact evaluation. Evaluation will be done over a period of three years since this procedure is not done frequently. The process evaluation will include monitoring the use of the pathway and its immediate effects and outcomes. Medical and nursing adherence to the clinical pathway as opposed to the use of off-pathway regimens, will be assessed. Each section of the pathway will have a parallel evaluation section with an added column where a tick will be included for every intervention implemented. A row at the end will serve for documenting any variance in the implementation of the protocol, with rationale. For instance, if an alternative to the medication recommended for a given period was used, this will be noted in the variance row with an explanation of the reason for the change like patient allergic to the drug, or having a comorbidity that constitutes a contraindication for using the drug.

Any challenges or obstacles faced throughout the use of the pathway by the nurses and doctors will be monitored. This will be done using regular interviews when a transplant patient gets admitted in order to identify any problems that are faced during the implementation. The collected data will be used to introduce amendments to the pathway in order to improve the process and outcomes.

The outcome evaluation will be done during hospital stay and the time period after discharge. In-hospital indicators include length of ICU stay, mechanical ventilation days, death in ICU, death in hospital, primary graft dysfunction, nosocomial infections (VAP, CLABSI, CAUTI, SSI), VTE, BUN and Creatinine values within one week of transplant, and total hospital length of stay (Currey et al., 2010). The impact evaluation will address long-term outcomes that will be observed, including re-admission rates and

causes, incidence of acute and chronic rejection, infections, medical complications commonly encountered post lung transplant such as bone loss, hypertension, hypercholesterolemia, diabetes mellitus, renal malfunction, leukopenia, lymphoproliferative disorders and skin cancer (Brigham and Women's clinical pathway), re-transplant listings, and quality of life index. Moreover, the Lung Transplant Index proposed by Hayes et al. (2019) can be used for long term monitoring assessment, namely patient's medication knowledge, medication adherence, annual laboratory tests performed, annual diagnostic testing, education provided on environmental exposure, routine preventive services, annual nutrition assessment, psychosocial assessment, social work assessment, as well as pain and other complaints assessment.

4.3. Conclusion

Lung transplant has become the last resort but an option for patients with end-stage lung disease that is refractory to all other medical and/or surgical interventions. Worldwide, the number of annual lung transplants has increased, especially with the survival range being above 5 years and up to 10 for some conditions (Hoetcher & Dossow, 2016). In the US and Europe, lung transplant programs in university hospitals are adopting clinical pathways for the step-by-step management of lung transplant recipients as it is a complex process and requires close follow-up and management in order to decrease complications, especially rejection within one year of transplant.

Adopting a lung transplant clinical pathway by the transplant program at AUBMC will organize the care, treatment, and management provided to this patient population and decrease the incidence of complications. Advanced practice nurses and

clinical educators have a key role in the development of, compliance with and evaluation of the impact of a clinical pathway on lung transplant outcomes at AUBMC.

APPENDIX

The Proposed Lung Transplant Clinical Pathway for AUBMC

Lung Transplant Pre-op Holding Area and Intra-Operative Considerations and Interventions	
Level of Care	Pre-admission Unit (PAU)
Consents	Get Informed consents from patient - Surgery and Anesthesia
Laboratory tests & imaging	Direct HLA-antibodies
	Typing cross-match
	CBC-D
	Chem 9
	ABGs
	LFTs
	Coagulation Panel - aPTT, PT, INR, D-dimer, Fibrinogen
	CXR
	EKG
	Take Sputum culture during bronchoscopy in the operating room (OR)
	Glucose monitoring point of care testing (POCT) as per pre-admission unit protocol
Vital Signs and Hemodynamic monitoring	As per pre-admission unit protocol then continuous monitoring of hemodynamics during surgery.
Fluid Intake and Output	Accurate I/O intra-operatively. Fluid management as per anesthesiologist
Medications	
Immunosuppression	Basiliximab 20 mg IV Drip once
	Methylprednisolone 500 mg-1000 mg once at time of each re-perfusion
	Mycophenolate Mofetil 1000 mg IV drip once
Antimicrobial	Prior to incision Gram positive coverage - Vancomycin 1 gram IV drip once
	Prior to incision Gram negative coverage - 4th generation cephalosporin, Cefepime 1-2 grams IV drip once or broad spectrum penicillin, Tazocin 4.5 grams IV drip once
	Antifungal candida prophylaxis - Fluconazole 400 mg IV drip
Proton pump inhibitor (PPI)	Esomeprazole 40 mg IV drip once
PRN medications	Antiemetic- Metoclopramide 10 mg IV drip every 8 hours
	Hyperglycemia Protocol
	Hypoglycemia Protocol
Pain and sedation	Pain management in the PAU is provided as needed. Patients once arrive to the OR, they are started on sedatives, anesthetics, and pain medications as per Anesthesiologist
Venous thromboembolism (VTE) prophylaxis	Mechanical (Sequential Compression Device) and Low Molecular Weight Heparin (Lovenox 40 mg) or unfractioned heparin (if creatinine clearance <

	20-30ml/min) 5000 units
Lines and drains and wounds management	Insert peripheral access
	Insert indwelling catheter in the operating room
	Swan-Ganz insertion for hemodynamic monitoring and intravenous medication administration
	Arterial line (A-line) insertion for BP monitoring
Respiratory Management	Continue prior oxygen supplementation. Intubation in OR. During OR consider ECMO. Consider inhaled Nitric Oxide.
Nursing Treatments	Bathing with Chlorhexidine 2% and shaving with surgical clipper
Nutritional support	NPO
Mobility & physical therapy	As tolerated
Education and discharge planning	Explain procedures and treatment plans to the patient & family. Explain what to expect post-operatively including tubes and lines. Review clinical pathway with patient and family.
Consults	Consult psychologist/social worker who is already on board from the beginning of the transplant process.
Other considerations	Reserve Cardiac Surgical Unit with reverse isolation precautions; attempt to provide HEPA filter for positive pressure filtration
	Blood product preparation: irradiated and leukocyte reduced packed red blood cells (PRBC), fresh frozen plasma (FFPs)

Post-operative Day 0: Day of surgery (POD0)	
Level of Care	Cardiac Surgical Unit (CSU)
Consents	Blood products and Bronchoscopy
Laboratory tests & imaging	CBC-D every 6 hours for 24 hours
	Chem9 every 6 hour for 24 hours
	Coagulation profile every 6 hours for 24 hours
	Arterial Blood Gases (ABGs) post-operatively and as indicated
	Glucose moitoring POCT as per CSU protocol every 1 hour if highly uncontrolled or every 4 hours
Vital Signs and Hemodynamic monitoring	As per CSU protocol- Hourly vitals; Hourly hemodynamics : CVP, PCWP, CO/CI
Fluid Intake and Output	Strict accurate I/O. Fluid resuscuitation for adequate filling pressures. Avoid large volume resusitation.
Medications	
Immunosuppression	Calcineurin inhibitor- Tacrolimus : Initial IV dose 0.03-0.05 mg/kg/day continuous infusion over 24

	hours in a glass or non-PVC bag. Start infusion minimum after 6 hours post-transplant
Antimicrobial Agents (modify according to cultures and sensitivities of donor and/or recepient)	
Antibiotcs	Cefepime 2 grams every 8 hours
	Vancomycin 15 mg/kg every 12 hours with therapeutic monitoring
Antifungals	5ml Nystatin swish four times daily (100,000 units per ml)
Antivirals (Depends on donor & recepient CMV status) -adjusted according to creatinine clearance & weight	*(Depends on donor & recepient CMV status) -adjusted according to creatinine clearance & weight*
	Cytomegalovirus (CMV) Donor +/ Recepient - Highest risk IV Gancyclovir 5mg/kg qday
	CMV Donor +/ Recepient + IV Gancyclovir 5mg/kg qday
	CMV Donor - / Recepient + IV Gancyclovir 5mg/kg qday
	CMV Donor -/ Recepient - Lowest risk. Routine prevention not recommended. Start Acyclovir 400mg per enteral route every 12 hours for Herpes and Varicella Zoster Virus prophylaxis
PPI	Esomeprazole 40 mg IV drip daily
PRN medications	Antiemetic- Metoclopramide 10mg IV drip every 8hours
	Laxative- Lactulose 30 ml enterally twice daily
	Hypoglycemia Protocol
	Hyperglycemia Protocol
Chronic home medications	Resume vital medications if not contraindicated, according to renal and liver function tests
Pain and comfort	Pain and sedation management as per the critical care pain and sedation protocol. Avoid over-sedation.
VTE prophylaxis	If received unfractioned heparin before OR, give unfractioned heparin (if creatinine clearance < 20-30 ml/min) 5000 units q 12 hours or 8 hours). Not before 12 hours post-op
Lines and drains and wounds management	Keep chest tubes. Monitor drainage.
	Keep A-line for blood withdrawal and BP monitoring
	Keep Swan Ganz catheter for hemodynamic monitoring, fluid resuscitation, and medication administration
	Keep indwelling urinary catheter for accuarte I/O
	Wound assessment every 4 hours
Respiratory Management	Consider applying lung protectice ventilator settings, especially if on ECMO
	Volume Control or Pressure Control. To calculate

	Tidal Volume (TV), use Predicted Body Weight (dependent on height and gender)
	Start with TV 6ml/kg (as per donor height) with a PEEP of 10 *cm H_2O*
	Pulmonary Fibrosis TV 6 ml/kg with a PEEP of 8 cm H_2O
	COPD with single lung TV 8ml/kg with a PEEP of 12 cm H_2O
	Keep plateau pressure <30 cm H_20
	Keep Peak Inspiratory Pressure <30 cmH_20-
	If presents with inhaled NO, start weaning.
Nursing Treatments	One-to-one care
	Bundles implementation: CAUTI; CLABSI; VAE ; surgical site infections (SSI)
	Position every 2 hours
Nutritional support	NPO
Mobility & physical therapy	Complete bed rest
Education and discharge planning	Update family on patient's status and the plan of care.
Consults	Consult Endocrinology team if dextro is highly uncontrolled
Other interventions	Daily or as indicated wound care by surgery team
	Daily multidisciplinary round
	Transfusion according to Hgb and hemodyanmic and fluid balance status.

POD 1-3	
Level of Care	Cardiac Surgical Unit (CSU)
Laboratory tests & imaging	Serum tacrolimus trough level target 5-15 ng/ml or 8-12 ng/ml or 12-15 ng/ml. Trough level monitoring after 12 hours from previous dose immediately before the next dose (Start from day 2). Check every 2-3 days. Change dose with increments of 0.5- 1mg per dose.
	CBC-D daily
	Chem9 daily
	Coagulation profile daily
	LFTs daily
	Vancomycin trough before fourth dose
	Arterial Blood Gases (ABGs) daily and as indicated
	CXR daily
	Glucose moitoring POCT as per CSU protocol every 1 hour if highly uncontrolled or every 4 hours

Vital Signs and Hemodynamic monitoring	As per CSU protocol- Hourly vitals, CVP; PCWP; CO/CI every 4-8hours
Fluid Intake and Output	Weigh Daily. Medication fluid resitriction. Diuresis to keep negative balance but if normal hemodynamics
Medications	
Immunosuppression	Antiprofilerative - Mycophenolate mofetil (MMF) Start within 72 hours at 1000 mg (may increase to 1500 in case of rejection) every 12 hours IV or enterally (on an empty stomach)
	Corticosteroids- Glucocoticoids: Methylprednisolone 125 mg every 8-12 hours for a total of 4 doses then Methylprednisolone 0.4-0.8 mg/kg/day
	Calcineurin inhibitor- Tacrolimus : 0.05 mg/kg every 12 hours per enteral route (take on an empty stomach or 2 hrs after meal)
Antimicrobials (modify according to cultures and sensitivities of donor and/or recepient)	
Antibiotcs	Cefepime 2 grams every 8 hours
	Vancomycin 15 mg/kg every 12hours with therapeutic monitoring
Antifungals	Inhaled Amphotericin B daily for 4 days then weekly until discharge (100mg if intubated, 50 mg if extubated)
	5ml Nystatin swish four times daily (100,000 units per ml)
	Fluconazole 400mg Ivdrip daily
Antivirals	*(Depends on donor & recepient CMV status) -adjusted according to creatinine clearance & weight*
	CMV Donor +/ Recepient - Highest risk IV Gancyclovir 5 mg/kg qday, switch to oral route when patient is extubated and able to swallow; Valgancyclovir 900 mg orally qday
	CMV Donor +/ Recepient + IV Gancyclovir 5 mg/kg qday, switch to oral route when patient is extubated and able to swallow; Valgancyclovir 900 mg orally qday
	CMV Donor - / Recepient + IV Gancyclovir 5 mg/kg qday, switch to oral route when patient is extubated and able to swallow; Valgancyclovir 900 mg orally qday
	CMV Donor -/ Recepient - Lowest risk. Routine prevention not recommended. Start Acyclovir 400 mg per enteral route every 12 hours for herpes and VZV prophylaxis
PPI	Esomeprazole 40 mg IVdrip daily
PRN medications	Antiemetic- Metoclopramide 10 mg IV drip every 8 hours
	Laxative- Lactulose 30 ml enterally twice daily
	Hyperglycemia Protocol
	Hypoglycemia Protocol
Chronic home medications	Resume vital home medications if not contraindicated, according to renal and liver function tests
Pain and comfort	Pain and sedation management as per the critical care pain and sedation protocol. Avoid over-sedation. Start Spontaneous Awakening Trials (SAT) and Spontaneous Breathing Trials (SBT) on POD1. Maintain adequate pain

	management
VTE prophylaxis	Mechanical devices (SCDs) and LMWH (Lovenox 40mg daily starting POD1 if not contraindicated) or unfractioned heparin (if creatinine clearance < 20-30 ml/min) 5000 units q 12 hours or 8 hours)
Lines and drains and wounds management	Chest tube management- Consider removal when no air leak, total serosanguineous drainage < 200 mL/24 h, and/or < 20 mL/h for the three consecutive hours prior to planned removal
	Conisder central line removal and peripheral line insertion when hemodynamic monitoring is no longer indicated and patient off pressors/inotropes.
	Wound assessment every 4 hours.
	Keep A-line for blood withdrawal and blood pressure monitoring
Respiratory Management	Consider applying lung protectice ventilator settings especially if on ECMO
	Volume Control or Pressure Control. To calculate Tidal Volume (TV), use Predicted Body Weight (dependent on height and gender)
	Change settings according to ABGs, lung mechanics, imaging, and clinical changes.
	Keep plateau pressure <30 cm H20
	Keep Peak Inspiratory Pressure <30 cmH20
	Bronchoscopy prior to extubation
	Apply ICough protocol when extubated.
Nursing Treatments	One-to-one care
	Bundles implementation: CAUTI; CLABSI; VAE ; SSI
	Position every 2 hours
Nutritional support	Adjust and advance enteral diet as per dietician's recommendations.
Mobility & physical therapy	Active and passive range of motion according to patient's Richmond Agitation Sedation Scale (RASS). Lower limb resistance training. Ambulate to chair when extubated.
Education and discharge planning	Discuss goals of care with patient and family. Provide teaching on cough protocol. Discuss medication regimen.
Consults	Dietician; physical therapist; speech therapist ; Endocrinology team; social worker/psychologist
Other considerations	Daily or as indicated wound care by surgery team
	Daily multidisciplinary round
	Transfusion according to Hgb and hemodyanmic and fluid balance status.

POD 4-6	
Level of Care	Cardiac Surgical Unit (CSU)
Laboratory tests & imaging	Serum tacrolimus trough level target 8-12 ng/ml or 12-15 ng/ml. Trough level monitoring after 12 hours from previous dose immediately before the next dose. Check every 2-3 days.
	CBC-D daily

	Chem9 daily
	LFTs
	Coagulation profile daily
	Arterial Blood Gases (ABGs) daily
	Vancomycin trough prior to fourth dose following an adjustment in dose
	Glucose moitoring POCT as per CSU protocol every 1 hour if highly uncontrolled or every 4 hours
	CXR daily
Vital Signs and Hemodynamic monitoring	As per CSU protocol- Hourly vitals.
Fluid Intake and Output	Fluid resitriction. Diuresis to keep negative balance but if normal hemodynamics. Strict accurate I/O
	Weigh Daily at 7am
Medications	
Immunosuppression	Basiliximab 20 mg IV Drip on POD 4 **only.**
	Antiprofilerative - Mycophenolate mofetil (MMF) 1000 mg (may increase to 1500 in case of rejection) every 12 hours IV or enterally/orally if tolerated (on an empty stomach)
	Corticosteroids- Glucocoticoids: Methylprednisolone 0.4-0.8 mg/kg/day or switch to oral Prednisone 0.5-1 mg/kg/day if tolerated
	Calcineurin inhibitor- Tacrolimus : 0.05 mg/kg every 12 hours orally or per enteral route (take on an empty stomach or 2 hrs after meal). Change dose with increments of 0.5- 1 mg per dose according to level.
Antimicrobials (modify according to cultures and sensitivities of donor and/or recepient)	
Antibiotcs	Cefepime 2 grams every 8 hours
	Vancomycin 15mg/kg every 12hours with therapeutic monitoring
Antifungals	5 ml Nystatin swish four times daily (100,000 units per ml)
	Inhaled Amphotericin B daily for 4 days then weekly until discharge (100 mg if intubated, 50 mg if extubated)
Antivirals	*(Depends on donor & recepient CMV status) -adjusted according to creatinine clearance & weight*
	CMV Donor +/ Recepient - Highest risk IV Gancyclovir 5 mg/kg qday, switch to oral route when patient is extubated and able to swallow, Valgancyclovir 900 mg orally daily
	CMV Donor +/ Recepient + IV Gancyclovir 5 mg/kg qday, switch to oral route when patient is extubated and able to swallow, Valgancyclovir 900 mg orally daily
	CMV Donor - / Recepient + IV Gancyclovir 5 mg/kg qday, switch to oral route when patient is extubated and able to swallow, Valgancyclovir 900 mg orally daily
	CMV Donor -/ Recepient - Lowest risk. Routine prevention not recommended. Start Acyclovir 400 mg per enteral route every 12 hours for Herpes and VZV prophylaxis

PPI	Esomeprazole 40mg IVdrip daily
PRN medications	Antiemetic- Metoclopramide 10 mg IV drip every 8hours
	Laxative- Lactulose 30 ml enterally or orally twice daily
	Hyperglycemia Protocol
	Hypoglycemia Protocol
Chronic home medications	Resume vital medications if not contraindicated, according to renal and liver function tests
Pain and comfort	Pain and sedation management as per the critical care pain and sedation protocol. Daily SAT & SBT. Maintain adequate pain management.
VTE prophylaxis	Mechanical (SCDs) and LMWH or unfractioned heparin (if creatinine clearance < 20-30 ml/min) 5000 units q 12 hours or 8 hours)
Lines and drains and wounds management	Discontinue Swan Ganz if hemodynamically stable and not on inotropes. Insert peripheral IV lines (if not already available)
	Keep A-line for blood withdrawal
	Chest tube management- Consider removal when no air leak, total serosanguineous drainage < 200 mL/24 h, and/or < 20 mL/h for the three consecutive hours prior to planned removal
	Discontue indwelling catheter If no longer indicated
	Wound assessment every 4 hours.
Respiratory Management	Bronscoscopy prior to extubation
	Extubate to high flow nasal cannula (HFNC) if has increased oxygen needs. Wean to Non-rebreather, then face mask, then nasal cannula as tolerated.
	Apply ICough protocol once extubated.
Nursing Treatments	Hourly round- One-to-one care
	Bundles implementation: CAUTI; CLABSI; VAE ; SSI
	Position every 2 hours if still intubated
Nutritional support	Swallowing assessment by speech therapist, if passes start oral diet clear fluids with aspiration precaution.
Mobility & physical therapy	Active range of motion. Lower limb resistance training. Upper limb lifting and strengethening exercises. Ambulate to chair. Ambulate in room.
Education and discharge planning	Discuss goals of care with patient and family. Provide teaching on cough protocol. Discuss medication regimen.
Consults	Dietician; physical therapist; speech therapist ; Endocrinology team; social worker/psychologist; pain team if needed
Other considerations	Daily or as indicated wound care by surgery team
	Daily multidisciplinary round
	Transfusion according to Hgb and hemodyanmic and fluid balance status.

POD 7-10	
Level of Care	Medsurg (10 North)
Laboratory tests & imaging	Serum tacrolimus trough level target 8-12 ng/ml or 12-15 ng/ml. Trough level

	monitoring after 12 hours from previous dose immediately before the next dose. Check every 2-3 days.
	CBC-D daily
	Chem9 daily
	Coagulation profile daily
	Vancomycin trough prior to fourth dose following an adjustment in dose
	CXR daily
	Glucose monitoring POCT every 4 hours or as per endocrinologist
Vital Signs and Hemodynamic monitoring	As per unit protocol- vitals every 4 hours
Fluid Intake and Output	Fluid resitriction. Diuresis to keep negative balance.
	Weigh Daily at 7am
Medications	
Immunosuppression	Calcineurin inhibitor- Tacrolimus: 0.05 mg/kg every 12 hours orally (take on an empty stomach or 2 hrs after meal)
	Antiprofilerative - Mycophenolate mofetil (MMF): 1000 mg-1500 mg every 12 hours orally (On an empty stomach)
	Corticosteroids- Glucocoticoids: Prednisone 0.5-1 mg/kg/day
Antimicrobials (modify according to cultures and sensitivities of donor and/or recepient)	
Antibiotcs	Cefepime 2 grams every 8 hours for a total of 7-10 days
	Vancomycin 15 mg/kg every 12 hours for 7-10 days or until chest tubes are removed- therapeutic monitoring
	Bactrim double strength (160/800 mg) 1 tablet orally 3 times weekly starting POD 7 , lifelong
Antifungals	Fluconazole 400 mg orally daily
	Inhaled Amphotericin B 50 mg weekly until discharge
	5ml Nystatin swish and swallow four times daily (100,000 units per ml)
Antivirals	CMV Donor +/ Recepient - Highest risk Valgancyclovir 900 mg orally daily
	CMV Donor +/ Recepient + Valgancyclovir 900 mg orally daily
	CMV Donor - / Recepient + Valgancyclovir 900 mg orally daily
	CMV Donor -/ Recepient - Lowest risk. Routine prevention not recommended. Start Acyclovir 400 mg orally BID for herpes and VZV prophylaxis (3-6 months)
PPI	Esomeprazole 40 mg IVdrip daily
PRN medications	Antiemetic- Metoclopramide 10 mg IV drip every 8 hours
	Laxative- Lactulose 30 ml orally twice daily
	Hyperglycemia Protocol
	Hypoglycemia Protocol

Chronic home medications	Continue vital home medications if not contraindicated, according to renal and liver function tests
Pain and comfort	Adequate pain management.
VTE prophylaxis	LMWH or unfractioned heparin (if creatinine clearance < 20-30 ml/min) 5000 units q 12 hours or 8 hours)
Lines and drains and wounds management	Keep peripheral IV lines.
	Assess wound dressing every 4 hours.
	Chest tube management- Consider removal when no air leak, total serosanguineous drainage < 200 mL/24 h, and/or < 20 mL/h for the three consecutive hours prior to planned removal
Respiratory Management	Apply ICough protocol
	Wean Oxygen
Nursing Treatments	Hourly round
	Bundles implementation: SSI
Nutritional support	Advance diet if well tolerated. Apply aspiration precautions. Follow up with speech therapist and dietician
Mobility & physical therapy	Active range of motion. Lower limb resistance training. Upper limb lifting and strengethening exercises. Ambulate to chair. Ambulate out of room.
Education and discharge planning	Discuss goals of care with patient and family. Provide teaching on cough protocol. Discuss medication regimen : immunosuppression and antimicrobials
Consults	Dietician; physical therapist; speech therapist ; Endocrinology team; social worker/psychologist; pain team if needed
Other considerations	Daily or as indicated wound care by surgery team
	Daily multidisciplinary round
	Transfusion according to Hgb and hemodyanmic and fluid balance status.
	Keep on reverse isolation. When walking outside of room, apply surgical face mask on patient's face.

POD 11-15 (EXPECTED WEEK OF DISCHARGE)	
Level of Care	Medsurg (10 North)
Laboratory tests & imaging	Serum tacrolimus trough level target 8-12 ng/ml or 12-15 ng/ml. Trough level monitoring after 12 hours from previous dose immediately before the next dose. Check every 2-3 days.
	CBC-D daily
	Chem-9 daily
	Coagulation profile daily
	LFTs daily
	CXR daily
	Glucose monitoring POCT every 4 hours or as per endocrinologist
	Surveillance Flexible bronchoscopy with broncheoalveolar lavage and transbronchial biopsy as per transplant surgeon and pulmonologist

Vital Signs and Hemodynamic monitoring	As per Medsurg protocol- vitals every 4 hours
Fluid Intake and Output	Fluid resitriction. Diuresis to keep negative balance.
	Weigh Daily at 7am
Medications	
Immunosuppression	Calcineurin inhibitor- Tacrolimus: 0.05 mg/kg every 12 hours orally (take on an empty stomach or 2 hrs after meal)
	Antiprofilerative - Mycophenolate mofetil (MMF): 1000 mg-1500 mg every 12 hours orally (On an empty stomach)
	Corticosteroids- Glucocoticoids: Prednisone 0.5-1 mg/kg/day
Antimicrobials (modify according to cultures and sensitivities of donor and/or recepient)	
Antibiotcs	Stop Cefepime and Vancomycin
	Bactrim double strength (160/800 mg) 1 tablet orally 3 times weekly starting lifelong
Antifungals	Fluconazole 400 mg orally daily until a total of 90 days
	Inhaled Amphotericin B 50 mg weekly until discharge
	5ml Nystatin swish and swallow four times daily for 6 months (100,000 units per ml)
Antivirals	CMV Donor +/ Recepient - Highest risk Valgancyclovir 900 mg orally qday (6-12 months)
	CMV Donor +/ Recepient + Valgancyclovir 900 mg orally qday (min 6 months)
	CMV Donor - / Recepient + Valgancyclovir 900 mg orally qday (min 6 months)
	CMV Donor -/ Recepient - Lowest risk. Routine prevention not recommended. Start Acyclovir 400 mg orally BID for Herpes and VZV prophylaxis (3-6 months)
PPI	Esomeprazole 40 mg orally daily
PRN medications	Antiemetic- Metoclopramide 10mg IV drip every 8 hours
	Laxative- Lactulose 30 ml orally twice daily
	Hyperglycemia Protocol
	Hypoglycemia Protocol
Chronic home medications	Continue vital medications if not contraindicated, according to renal and liver function tests. Add all home medications gradually and check drug-drug interactions.
Pain and comfort	Bridge to oral pain medications
VTE prophylaxis	LMWH or unfractioned heparin (if creatinine clearance < 20-30 ml/min) 5000 units q 12hours or 8 hours)
Lines and drains and wounds management	Keep peripheral IV line.
	Assess wound dressing every 4 hours.
	Apply ICough protocol
Respiratory	Wean Oxygen

Management	Surveillance Flexible bronchoscopy with broncheoalveolar lavage and transbronchial biopsy as per transplant surgeon and pulmonologist
Nursing Treatments	Hourly round
	Bundle implementation: SSI
Nutritional support	Advance diet to regular if well tolerated. Apply aspiration precautions, Have meals in chair. Follow up with speech therapist and dietician
Mobility and physical therapy	Ambulate to chair 3 times daily. Ambulate multiple times per day. Limb strengthening exercises.
Education and discharge planning	Provide teaching on medication regimen. Provide a schedule with timings, doses, and blood tests.
	Provide teaching by physical therapist for home exercises
	Provide teaching on follow-up check-up appointments, bronchoscopies, laboratory testings in the form of a schedule
	Pulmonary rehabilitation
	Reinforce cough protocol.
	Provide teaching on healthy lifestyle
	Involve caregiver and support system in all teachings and plan of care
Consults	Dietician; physical therapist; speech therapist ; Endocrinology team; social worker/psychologist; pain team if needed
Other considerations	Daily or as indicated wound care by surgery team
	Daily multidisciplinary round
	Keep on reverse isolation. When walking outside of room, apply surgical face mask on patient's face.

REFERENCES

Allen, D., Gillen, E., & Rixson, L. (2009). The effectiveness of integrated care pathways for adults and children in health care settings: A systematic review. *JBI Library of Systematic Reviews, 7*(3), 80-129. https://doi.org/10.11124/jbisrir-2009-182

Antończyk, R., Stącel, T., Urlik, M., Latos, M., Kręt, M., Borowik, D., Wajda-Pokrontka, M., Zawadzki, F., Tatoj, Z., Przybyłowski, P., Zembala, M., Ochman, M., & Nęcki, M. (2020). Single lung transplant vs double lung transplant: A single-center experience with particular consideration for idiopathic pulmonary arterial hypertension. *Transplantation*

Barnes, L., Reed, R. M., Parekh, K. R., Bhama, J. K., Pena, T., Rajagopal, S., Schmidt, G. A., Klesney-Tait, J. A., & Eberlein, M. (2015). Mechanical ventilation for the lung transplant recipient. *Current Pulmonology Reports, 4*(2), 88-96.

Brigham and Women's Hospital (2019, April). *Survival Guide to the BWH Lung Transplant Service.* https://www.brighamandwomens.org/assets/BWH/surgery/transplantation/pdfs/lung-tx-guide-to-management.pdf

Carney, K. C., Bronzell-Wynder, T., & Gronek, K. (2019). Lung transplant for the critical care nurse. Critical Care Nursing Clinics of North America, 31(3), 285-302. https://doi.org/10.1016/j.cnc.2019.05.001

Cassidy, M. R., Rosenkranz, P., McCabe, K., Rosen, J. E., & McAneny, D. (2013). I COUGH: Reducing postoperative pulmonary complications with a multidisciplinary patient care program. *JAMA Surgery, 148*(8), 740-745. https://doi.org/10.1001/jamasurg.2013.358

Chung, P. A., & Dilling, D. F. (2020). Immunosuppressive strategies in lung transplantation. Annals of Translational Medicine, 8(6), 409-409. https://doi.org/10.21037/atm.2019.12.117

Cochrane, A. B., Lyster, H., Lindenfeld, J., Doligalski, C., Baran, D., Yost, C., Shullo, M., Schweiger, M., Weill, D., Stuckey, L., Ivulich, S., Scheel, J., Peters, L., Colvin, M., Dawson, K., Girgis, R., Weeks, P., Tse, T., Russell, S., . . . Page, R. L. (2020). Report from the 2018 consensus conference on immunomodulating agents in thoracic transplantation: Access, formulations, generics, therapeutic drug monitoring, and special populations. *The Journal of Heart and Lung Transplantation, 39*(10), 1050-1069. https://doi.org/10.1016/j.healun.2020.06.024

Currey, J., Pilcher, D. V., Davies, A., Scheinkestel, C., Botti, M., Bailey, M., & Snell, G.(2010). Implementation of a management guideline aimed at minimizing the severity of primary graft dysfunction after lung transplant. *The Journal of Thoracic and Cardiovascular Surgery, 139*(1), 154-161. https://doi.org/10.1016/j.jtcvs.2009.08.031

European Pathway Association (2005). *Care Pathways*. Retrieved from http://e-p-a.org/care-pathways

Evans-Lacko, S., Jarrett, M., McCrone, P., & Thornicroft, G. (2010). Facilitators and barriers to implementing clinical care pathways. *BMC Health Services Research, 10*(1), 182-182. https://doi.org/10.1186/1472-6963-10-182

Fishman, J.A. and Alexander, B.D. (2020). Prophylaxis of infections in solid organ transplantation. *UpToDate*. Retrieved from https://www-uptodate-com.ezproxy.aub.edu.lb/contents/prophylaxis-of-infections-in-solid-organ-

transplantation?search=LUNG%20TRANSPLANT%20SEROLOGIC%20TESTING%20PREOP&source=search_result&selectedTitle=5~150&usage_type=default&display_rank=5

Fuller, J., & Fisher, A. J. (2013). An update on lung transplantation. *Breathe (Lausanne, Switzerland), 9*(3), 188-200. https://doi.org/10.1183/20734735.001913

Guertin, L., Earle, M., Dardas, T., & Brown, C. (2021). Post-heart transplant care pathway's impact on reducing length of stay. *The Journal of Heart and Lung Transplantation, 40*(4), S290-S290. https://doi.org/10.1016/j.healun.2021.01.823

Hachem, R. (2019). Lung transplantation: General guidelines for recipient selection. *UpToDate.* Retrieved from https://www-uptodate-com.ezproxy.aub.edu.lb/contents/lung- transplantation-general-guidelines-for-recipient-selection?search=Lung%20transplantation: %20General%20guidelines%20for%20recipient%20selection&source=search_result&select edTitle=1~150&usage_type=default&display_rank=1

Hachem, R. (2020). Lung transplantation: General guidelines for recipient selection. *UpToDate.* Retrieved from https://www-uptodate-com.ezproxy.aub.edu.lb/contents/lung- transplantation-general-guidelines-for-recipient-selection?search=Lung%20transplantation: %20General%20guidelines%20for%20recipient%20selection&source=search_result&select edTitle=1~150&usage_type=default&display_rank=1

Hachem, R. R. (2021). Evaluation and treatment of antibody-mediated lung transplant rejection. *UpToDate.* Retrieved from https://www-uptodate-com.ezproxy.aub.edu.lb/contents/evaluation-and-treatment-of-antibody-

mediated-lung-transplant-rejection?search=%20Evaluation%20and%20treatment%20of%20acute%20lung%20transplant%20rejection&topicRef=4655&source=see_link#H390634452

Hardinger, K. & Magee, C.C. (2020). Pharmacology of cyclosporine and tacrolimus. *UpToDate.* Retrieved from https://www-uptodate-com.ezproxy.aub.edu.lb/contents/pharmacology-of-cyclosporine-and-tacrolimus?search=%20tacrolimus&source=search_result&selectedTitle=2~146&usage_type=default&display_rank=1

Hartwig & Klapper (2020). Lung transplantation: Procedure and postoperative management. *UptoDate.* Retrieved from https://www-uptodate-com.ezproxy.aub.edu.lb/contents/lung-transplantation-procedure-and-postoperative-management?search=LUNG%20TRANSPLANT&source=search_result&selectedTitle=3~150&usage_type=default&display_rank=3#H14

Hayes, D. Jr., Feeney, B., O'Connor, D. J., Nicholson, K. L., Nance, A. E., Sakellaris, K. K., Dempster, N. R., Groh, J. D., and Kirkby, S. E. (2019). Lung transplant index: a quality improvement initiative. *Pediatric Quality and Safety*, 4:, e209; doi: 10.1097/pq9.0000000000000209; Published online September 19, 2019

Henderson, P. (2019). Nurses' role in implementing the ABCDEF bundle. *Critical Care Nurse, 39*(3), 13-13. https://doi.org/10.4037/ccn2019760

Hirche, T. O., Knoop, C., Hebestreit, H., Shimmin, D., Solé, A., Elborn, J. S., Ellemunter, H., Aurora, P., Hogardt, M., Wagner, T. O. F., & ECORN-CF Study Group (2014). Practical guidelines: Lung transplantation in patients with cystic

fibrosis. *Pulmonary Medicine, 2014*(2014), 621342-22. https://doi.org/10.1155/2014/621342

Hoechter, D. J., & Von Dossow, V. (2016). Lung transplantation: From the procedure to managing patients with lung transplantation. Current Opinion in Anaesthesiology, 29(1), 8-13. https://doi.org/10.1097/ACO.0000000000000268

Jabbour, M., Newton, A. S., Johnson, D., & Curran, J. A. (2018). Defining barriers and enablers for clinical pathway implementation in complex clinical settings. *Implementation Science : IS, 13*(1), 139-139. https://doi.org/10.1186/s13012-018-0832-8

Khush K. K., Cherikh W. S., Chambers D. C., Rossano, J. W., Stehlik, J. (2018). The International Thoracic Organ Transplant Registry of the International Society for Heart and Lung Transplantation: Thirty-fifth Adult Heart Transplantation Report – 2018; Focus Theme: Multiorgan Transplantation. *Journal of Heart and Lung Transplant, 37,* 1155–1168. https://doi.org/10.1016/j.healun.2018.07.022

King, C. S., Valentine, V., Cattamanchi, A., Franco-Palacios, D., Shlobin, O. A., Brown, A. W., Singh, R., Bogar, L., & Nathan, S. D. (2017). Early postoperative management after lung transplantation: Results of an international survey. *Clinical Transplantation, 31*(7), e12985-n/a. https://doi.org/10.1111/ctr.12985

Kinsman, L., Rotter, T., James, E., Snow, P., & Willis, J. (2010). What is a clinical pathway? development of a definition to inform the debate. *BMC Medicine, 8*(1), 31-31. https://doi.org/10.1186/1741-7015-8-31

Kolk, B. M., Boogaard, M. H. W. A., Brugge-Speelman, C. T., Hol, J., Noyez, L., Laarhoven, K., Hoeven, H., & Pickkers, P. (2017). Development and implementation of a clinical pathway for cardiac surgery in the intensive care unit: Effects on protocol adherence.

Kotton, C. N., Kumar, D., Caliendo, A. M., Huprikar, S., Chou, S., Danziger-Isakov, L., Humar, A., & The Transplantation Society International CMV Consensus Group (2018). The third international consensus guidelines on the management of cytomegalovirus in solid organ transplantation. Transplantation, 102(6), 900-931. https://doi.org/10.1097/TP.0000000000002191

Kuntz (2019). What Do We Mean When We Talk About "Clinical Pathways"? *Journal of Clinal Pathways*, *5*(1), :36-39. doi:10.25270/jcp.2019.02.00060

Kurtin, P. & Stucky, E. (2009). Standardize to excellence: Improving the quality and safety of care with clinical pathways. *The Pediatric Clinics of North America, 56*(4), 893-904. https://doi.org/10.1016/j.pcl.2009.05.005

Kurtin, P. & Stucky, E. (2009). Standardize to excellence: Improving the quality and safety of care with clinical pathways. *The Pediatric Clinics of North America, 56*(4), 893-904. https://doi.org/10.1016/j.pcl.2009.05.005

Langer, D. (2015). Rehabilitation in patients before and after lung transplantation. *Respiration*, *89*(5), 353-362. https://doi.org/10.1159/000430451

Lawal, A. K., Rotter, T., Kinsman, L., Machotta, A., Ronellenfitsch, U., Scott, S. D., Gooidge, D., Plishka, C., & Groot, G. (2016). What is a clinical pathway? refinement of an operational definition to identify clinical pathway studies for a cochrane systematic review. *BMC Medicine, 14*(1), 35-35. https://doi.org/10.1186/s12916-016-0580-z

Lawal, A. K., Rotter, T., Kinsman, L., Machotta, A., Ronellenfitsch, U., Scott, S. D., Gooidge, D., Plishka, C., & Groot, G. (2016). What is a clinical pathway? refinement of an operational definition to identify clinical pathway studies for a cochrane systematic review. *BMC Medicine, 14*(1), 35-35. https://doi.org/10.1186/s12916-016-0580-z

Leard, L. E., Holm, A. M., Valapour, M. , Glanville, A. R., Attawar, S., Aversa, M., Campos, S.V., Christon, L. M., Cypel, M., Dellgren, G., Hartwig, M. G., Kapnadak, S. G., Kolaitis, N. A., Kotloff, R. M., Patterson, C. M., Shlobin, O. A., Smith, P. J., Solé, A., Solomon, M., Weill, M., Wijsenbeek, M. S., Willemse, B.W.M., Arcasoy, S. M., Ramos, K. J. (2021). Consensus document for the selection of lung transplant candidates: An update from the International Society for Heart and Lung Transplantation. *The Journal of Heart and Lung Transplantation.* https://doi.org/10.1016/j.healun.2021.07.005

Martinu, T., Koutsokera, A., Benden, C., Cantu, E., Chambers, D., Cypel, M., Edelman, J., Emtiazjoo, A., Fisher, A. J., Greenland, J. R., Hayes, D., Hwang, D., Keller, B. C., Lease, E. D., Perch, M., Sato, M., Todd, J. L., Verleden, S., von der Thüsen, J., . . . bronchoalveolar lavage standardization workgroup (2020). International society for heart and lung transplantation consensus statement for the standardization of bronchoalveolar lavage in lung transplantation. *The Journal of Heart and Lung Transplantation*, 39(11), 1171-1190. https://doi.org/10.1016/j.healun.2020.07.006

McShane, P. J., Ruiz, L. G., & Garrity, E. R. (2012). Chapter 75 - lung transplantation. (Fourth ed., pp. 882-903). Elsevier Inc. https://doi.org/10.1016/B978-1-4557-0792-8.00075-1

NOD-lb, (n.d.). *Organ Donation*. https://www.nodlb.org/en/organ-donation/about-organ-transplantation/how-patient-registered-national-waiting-list

Panchabhai, T. S., Chaddha, U., McCurry, K. R., Bremner, R. M., & Mehta, A. C. (2018). Historical perspectives of lung transplantation: Connecting the dots. *Journal of Thoracic Disease, 10*(7), 4516-4531. https://doi.org/10.21037/jtd.2018.07.06

Pavlakis, M., & Hanto, D. W. (2012). Clinical pathways in transplantation: A review and examples from beth israel deaconess medical center: Clinical pathways and transplantation. *Clinical Transplantation, 26*(3), 382-386. https://doi.org/10.1111/j.1399-0012.2011.01564.x

Republic of Lebanon Ministry of Public Health (2019). *Hasbani Visits the Patient who Underwent the First Lung Transplant Surgery in Lebanon at AUBMC.* Retrieved from https://www.moph.gov.lb/en/Pages/127/20147/hasbani-visits-the-patient-who-underwent-the-first-lung-transplant-surgery-in-lebanon-at-aubmc

Rotter, T., Kinsman, L., James, E., Machotta, A., Willis, J., Snow, P., & Kugler, J. (2012). The effects of clinical pathways on professional practice, patient outcomes, length of stay, and hospital costs: Cochrane systematic review and meta-analysis. *Evaluation & the Health Professions, 35*(1), 3-27. https://doi.org/10.1177/0163278711407313

Seawright, A. H., & Taylor, L. (2011). A systematic approach to postoperative management of deceased donor kidney transplant patients with a clinical pathway. *Progress in Transplantation (Aliso Viejo, Calif.), 21*(1), 43-52. https://doi.org/10.1177/152692481102100106

Shabaninejad, H., Alidoost, S., & Delgoshaei, B. (2018). Identifying and classifying indicators affected by performing clinical pathways in hospitals: A scoping review. *International Journal of Evidence-Based Healthcare, 16*(1), 3-24. https://doi.org/10.1097/XEB.0000000000000126

Snell, G. I., Yusen, R. D., Weill, D., Strueber, M., Garrity, E., Reed, A., Pelaez, A., Whelan, T. P., Perch, M., Bag, R., Budev, M., Corris, P. A., Crespo, M. M., Witt, C., Cantu, E., & Christie, J. D. (2017). Report of the ISHLT working group on primary lung graft dysfunction, part I: Definition and grading—A 2016 consensus group statement of the international society for heart and lung transplantation. *The Journal of Heart and Lung Transplantation*, 36(10), 1097-1103. https://doi.org/10.1016/j.healun.2017.07.021

Soetanto, V., Grewal, U. S., Mehta, A. C., Shah, P., Varma, M., Garg, D., Majumdar, T., Dangayach, N. S., & Grewal, H. S. (2021). Early postoperative complications in lung transplant recipients. *Indian Journal of Thoracic and Cardiovascular Surgery,* 1-11. https://doi.org/10.1007/s12055-021-01178-1

Syrett, A. J., & Huang, A. (2020). Transfusion and primary graft dysfunction after lung transplantation: All about the ratio? *Journal of Cardiothoracic and Vascular Anesthesia, 34*(11), 3033-3035. https://doi.org/10.1053/j.jvca.2020.07.012

Thakuria, L., Davey, R., Romano, R., Carby, M. R., Kaul, S., Griffiths, M. J., Simon, A. R., Reed, A. K., & Marczin, N. (2016). Mechanical ventilation after lung transplantation. *Journal of Critical Care, 31*(1), 110-118. https://doi.org/10.1016/j.jcrc.2015.09.021

University of Washington Medicine (2017, August 22). *Lung Transplant Clinical Care Pathway.* https://www.uwmedicine.org/provider-resource/information/lung-transplant-clinical-care-pathway

Van der Mark, S. C., Hoek, R., & Hellemons, M. E. (2020). Developments in lung transplantation over the past decade. *European Respiratory Review, 29*(157), 190132. https://doi.org/10.1183/16000617.0132-2019

Venuta, F., & Van Raemdonck, D. (2017). History of lung transplantation. *Journal of Thoracic Disease, 9* (12), 5458-5471. doi:10.21037/jtd.2017.11.84

Von Dossow, V., Costa, J., D'Ovidio, F., & Marczin, N. (2017). Worldwide trends in heart and lung transplantation: Guarding the most precious gift ever. *Best Practice & Research. Clinical Anaesthesiology, 31*(2), 141-152. https://doi.org/10.1016/j.bpa.2017.08.001

Weill, D., Benden, C., Corris, P. A., Dark, J. H., Davis, R. D., Keshavjee, S., . . . Glanville, Allan R. (2015). A consensus document for the selection of lung transplant candidates: 2014—An update from the pulmonary transplantation council of the international society for heart and lung transplantation. *Journal of Heart and Lung Transplantation, 34*(1), 1-15. doi:10.1016/j.healun.2014.06.014