FLEX CEUs

Organ Transplantation - Role of Physical Therapy

Introduction

Around forty thousand people in the United States undergo organ transplantation of some type annually. Due to the progressive loss of function that precedes and follows organ transplantation, many healthcare providers are involved. Rehabilitation professionals have a role to improve the physical capacity of patients who undergo organ transplantation both before and after surgery. This course will include information on different organ types most common for transplantation, organ transplantation procedures, complications, epidemiology, and evidence-based assessment items and protocols for rehabilitation professionals. This course will help rehabilitation professionals including physical therapists, physical therapist assistants, and occupational therapists prepare to work with patients who have undergone organ transplantation, whether employed in acute care or other settings.

Background on Organ Transplantation [1]

Organ transplantation (OT) is a life-saving treatment for those with organ failure and end-stage diseases. OT involves an interdisciplinary team involving primary and specialty physicians, rehabilitation professionals, pharmacists, and other health care providers. The most common organ transplants occur in the kidney, the liver, the lungs, and the heart. This section will overview the physiology, disease progression, complications, and pathoanatomy of organ transplantation. These are important concepts for rehabilitation professionals to know in providing patient-centered care to their patients who have undergone organ transplantation.

The History of Organ Transplantation [1]

The idea and practice of organ transplantation began in the times of ancient Greek, Rome, Chinese, and Indian mythology. This involved bone, skin, teeth, extremities, and hearts. In the 1500s, Gasparo Tagliacozzi performed one of the first recorded skin transplants, and his patient had complications of the recipient rejecting the donor skin. In the 1700s, animal models were developed to research OT. Doctor Alexis Carrel from France worked to develop a new method for vascular anastomoses, kidney transplants, vessel reconstruction, and cold graft preservation. He won a Nobel Prize in 1912 for this work. After all of this progress, the first human transplantation occurred in 1933 in the Soviet Union by U.U. Voronoy. The donor and recipient died, as little was known about

the immune response to transplantation at the time. Peter Brian Medawar was a British biologist who specialized in immunology. He worked on skin homograft transplantation in the Burn Unit of Glasgow hospital during World War II and documented the concept of graft rejection and acquired immune tolerance. He was awarded the Nobel Prize for Physiology or Medicine in 1960 and made OT possible. After many trials of OT, the first successful kidney transplant was performed in the 1950s by Dr. Thomas Murray. Dr. James Hardy performed the first lung transplant and this patient survived a little over two weeks with no rejection signs. The first successful liver transplant was performed by Dr. Thomas Starzl in 1967 at the University of Colorado. The first successful heart transplant was also performed in 1967, by Dr. Christiaan Barnard. During these times, immunosuppression and poor surgical anastomoses healing prevented good outcomes. In 1984, cyclosporine was introduced to the practice and increased the survival of organ transplant recipients drastically as it was the first effective immunosuppressant to prevent rejection. In 1984, the United Network of Organ Sharing (UNOS) was created to manage organ transplantation activity in the United States. UNOS has lists for every type of organ transplantation, collects important data, and keeps records of educational information.

It is important to understand the process of how organ transplantation became standard medical practice. Some of the issues that plagued early transplantations still exist today – the issue of organ rejection and organ availability. Today, many societies exist, such as the International Liver Transplantation Society (ILTS) to create international standards and medical collaboration on transplantation concepts.

Epidemiology [2–4]

On a population level, it is crucial to understand just how many patients and families are affected by organ transplantation each year. Physical therapists and other rehabilitation professionals may interact with OT patients in an acute care setting, subacute settings, or outpatient settings after they recover from transplantation.

The number of organ transplantations in the United States continues to rise, besides in 2020 in response to the COVID-19 pandemic. In 2021, physicians in the United States performed around 41,000 total transplants. Of these, 24,669 were kidney transplants, 9,236 were liver transplants, and 3,817 were heart transplants. According to UNOS organ transplantation waiting lists in 2021, there were around 90,000 people on the kidney donation waiting list, 12,000 on the liver waiting list, 3,500 on the heart waiting list, and 1,050 on the lung waiting list.

Patients who need an organ transplantation are placed on the UNOS waiting list and prioritized based on medical necessity and predicted outcomes, size of the patient, patient blood type, and geography. OT has better outcomes the shorter distance that the organ must be transported. For a kidney transplant, the factors of receiving an organ depend on waiting time, immune system compatibility, distance from the donor hospital, survival benefit, and the prioritization of children. For the lung, factors are survival benefit, medical urgency, waiting time, distance from a donor hospital, and pediatric status. For the liver and heart, medical urgency, distance from donor hospitals, and pediatric status are factors in the time it takes to receive an organ from the UNOS list.

Etiology [1]

The etiology or cause of organ transplantation is usually due to end-stage disease. For kidney transplants, it is an end-stage renal disease which can happen from things like complications of diabetes and hypertension, and kidney injury. For liver transplants, cirrhosis, liver infection, and alcoholism are major causes of end-stage liver disease. For lungs, conditions that restrict breathing over time, like chronic obstructive pulmonary disease (COPD) are often to blame. For the heart, congestive heart failure from myocardial infarction, coronary artery occlusion, and other causes create severe heart failure. The remainder of this course will discuss how these etiologies and other personal factors affect someone's eligibility and outcomes from OT.

COVID-19 Impact [5]

The COVID-19 pandemic had a large impact on organ transplantation. First of all, in 2020 there were sixteen percent fewer organ transplants performed than in other years. This impacted kidney transplantation the most. The largest reason for the reduction was a risk versus benefit analysis in recipients due to the probability that immunosuppressed patients post-transplantation would contract COVID-19 and have poor outcomes. Patients who had undergone organ transplantation had a twenty-five percent mortality rate in 2020, which in 2022 fell to around ten percent. Transplant programs across the country closed down in response to the pandemic and the reduced number of transplants. Of course, the impact on donors and recipients was large. There was a thirty percent reduction in organ donations from deceased donors, due to the reduced capacity of hospital staff to fit in the organ donation evaluation. Living donations decreased by forty percent globally as well. Organs were allocated to only severe and

complex patient presentations, meaning that the remaining people on the UNOS donation list experienced more significant disease and death. Donors for lung transplantation who died of COVID could not donate lungs, but if they had RNA from signs of past COVID, they could donate.

The pandemic diverted many hospital resources across the globe to fight it, leaving other lifesaving procedures like organ transplantation less emergent. At the end of 2022, transplantations were trending back toward pre-pandemic activity.

Section 1 Key Words

United Network of Organ Sharing (UNOS) – a system created to manage organ transplantation activity in the United States that collects data on transplant availability and allocation

End-stage organ disease – the leading cause of organ transplantation of all types including kidney, liver, lung, and heart

Section 1 Summary

The history around the success of organ transplantation is relatively recent. The system of organ transplantation has developed into successful organ allocation, donation, surgeries, post-operative management, and rehabilitation. The number of organ transplants continues to rise with the exception being the year 2020 due to the COVID-19 pandemic.

Transplantation Types – Indications and Complications

Physical therapists should understand the procedure, indications, and complications that people undergoing organ transplantation procedures endure. PTs and other rehabilitation professionals will treat patients who are in the same hospital stay as the surgery. Therefore, it is crucial to understand the process of recovery from a surgical and rehabilitative standpoint. This section will detail the medical procedures and complications that the most common types of organ transplantation recipients face.

All organ transplantation takes an interdisciplinary approach and a great support system. Patients will do better with psychosocial support, including from family and psychology professionals. Patients who have fewer socioeconomic resources may face barriers in

aftercare and management after transplantation, especially because they will not be able to work for a while. Patient-centered care is crucial for the management of the entire person behind the transplant, not just their organ.

Kidney Transplantation [6,7]

Kidney transplants are the most common type of organ transplantation in the world. This is because of the extensive list of causes of kidney failure. Kidneys are wider in availability than other organs because of living donors and deceased donors. It is crucial for healthcare professionals who work with kidney transplantation recipients to have adequate background knowledge of the procedure and complications.

Why Transplantation?

Several conditions lead to the necessity of a kidney (renal) transplant. These include any condition that leads to end-stage kidney disease. Some of these conditions are acquired at birth and some develop over time from lifestyle and environmental factors. Common diseases that lead to end-stage renal disease are diabetes mellitus, pyelonephritis, polycystic kidney disease, and chronic kidney disease. Diabetes mellitus and high blood pressure occurring comorbidly account for around two-thirds of chronic kidney disease cases, which ultimately lead to kidney failure. Pyelonephritis, or kidney infection, if not treated immediately can lead to kidney failure due to permanent damage. This is typically caused by a type of gram-negative bacteria, such as Escherichia coli (E Coli). Polycystic kidney disease is a genetic disorder where kidneys begin to weaken and lose function over time due to clusters of cysts forming on them. A genetic mutation in the PKD gene causes this disorder. Other causes that lead to kidney transplantation include but are not limited to interstitial nephritis, chemical nephrotoxicity, renal artery emboli, and congenital urinary tract abnormalities. Interstitial nephritis is swelling between the tubules of the kidneys, impairing function. Chemical nephrotoxicity occurs when toxic chemicals and medications collect in the kidneys. These chemicals include certain types of mold, cisplatin (a chemotherapy agent), antibiotics, and heavy metals. Renal artery embolism blocks blood flow to the kidney. Congenital anomalies in the urinary system include renal hypodysplasia (underdevelopment of a kidney), congenital multicystic dysplastic kidneys with cysts formed at birth, extra ureters, and hydronephrosis or the collection of urine in the kidney. All of these disease processes and others lead to the development of poor kidney functioning and the potential for end-stage renal disease.

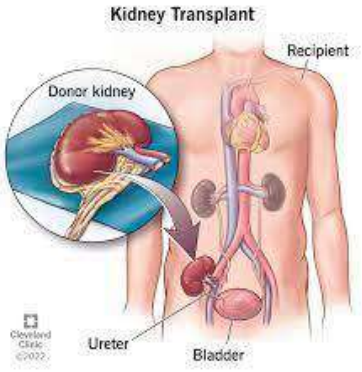
Contraindications and Alternative Treatments

Certain factors would exclude a person from being medically cleared for transplantation. These include advanced age, severe heart disease, active or recently active cancer, dementia, highly symptomatic mental illness, alcohol or drug use, or any factor that would impair a person from safely undergoing the procedure and taking immunosuppressants after. If someone does not qualify for transplantation, they will likely require hemodialysis for the rest of their lives. Hemodialysis filters the blood like the kidneys and is an option to extend life after developing end-stage renal disease. The average life expectancy on hemodialysis is five to ten years, but some have lived up to thirty years. Dialysis takes an average of three to five hours per session and three times per week in an outpatient setting. It can be shortened for home sessions to two hours each for six or seven days.

The Procedure

Once a patient's disease process has advanced enough to need a kidney transplant, they will be placed on the UNOS kidney transplant list by their physicians. Extensive testing is completed before being placed on this list. This includes mental health evaluation, social health considerations, multiple blood tests to find the correct donor, and diagnostic tests to determine overall health and the ability to recover after the transplant. If a person has a relative that is a match and willing to donate, the procedure will take place at a planned time. If not, the patient will be on the UNOS list with instructions to immediately report to the hospital if and when there is a match.

During the kidney transplantation procedure, a patient is monitored continuously as the surgeon operates and is dosed with the appropriate sedatives by an anesthesiologist. The donor's kidney is placed into the lower abdomen, not reattached to the normal anatomical region of the kidney. The donor kidney renal artery and vein are sewn to the external iliac artery and vein. The original kidneys stay in place as long as they are not causing health problems. The donor ureter is then attached to the bladder and the surgical team ensures adequate blood circulation and function before closing the operation wound.



https://my.clevelandclinic.org/health/treatments/22537-kidney-transplant

After the Procedure

Right after surgery, a kidney transplantation recipient will need to stay four to five days in the hospital to monitor output and recovery from the donated kidney. Some patients may need temporary hemodialysis until their kidney starts working and at times the kidney will work right away. Depending on their functional capacity, a kidney transplant recipient may be able to discharge home or go to an extended care facility like a skilled nursing facility. A patient may need home health care or continued outpatient check-ups to ensure adequate healing and kidney function. Transplanted kidneys last on average for ten years.

Precautions

A recipient of a donated kidney will need to recover for about eight weeks before returning to normal activities. Recipients should be educated to avoid strenuous physical work and lifting for eight weeks (no more than twenty pounds for three months, and no more than forty pounds for six months). Patients should avoid driving for six weeks and should focus on exercise to improve aerobic and functional capacity like jogging, walking, bicycling, golf, and swimming. Recipients need to stay well hydrated, limit caffeine, avoid undercooked foods due to the risk of food poisoning, eat adequate protein, avoid nonsteroidal anti-inflammatory drugs, and avoid certain herbal supplements. It's important for kidney transplant recipients to clear dietary questions with their dietitian or physician to ensure optimal healing and to avoid interaction with immunosuppressants.

Complications

There are a few complications unique to kidney transplantation that one should be aware of. First of all, there is a risk for blood clots and bleeding from the surgery. There is a risk of the donated kidney spreading infection or cancer to the recipient. There is also

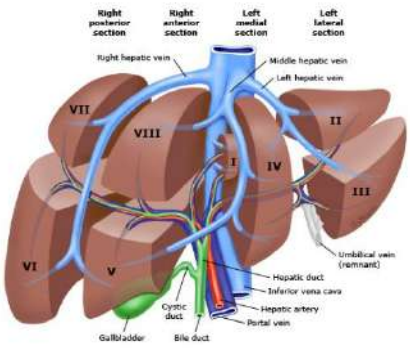
the risk of leaking from the ureter, infection, cardiac arrest, and cerebrovascular accident. Another large risk is rejection or failure of the donated kidney. There are side effects of the antirejection (immunosuppressant) medications that a recipient will take as well. Side effects include bone thinning, diabetes, excessive hair growth or loss, hypertension, elevated cholesterol, infection, puffiness, weight gain, increased cancer risk, and acne.

Liver Transplantation [8]

Liver transplantation is the second most common OT in the United States. It is the best treatment for end-stage liver disease when every other treatment has been attempted. When it is truly end-stage liver disease, there is no alternative like dialysis while waiting for a kidney transplant to extend life. Liver transplants extend their lifespan by fifteen years.

Why Transplantation? [9]

The most common need for liver transplantation is due to cirrhosis and decompensated liver disease. Survival rates are ninety percent at one year and seventy-seven percent at five years. The liver is the largest organ in humans and consists of four lobes (right, left, quadrate, and caudate) with two functional lobes. The functional lobes are the right and left lobes divided by the Cantile line. The liver has two blood supplies from systemic and hepatic portal circulation. It is important to be knowledgeable of liver anatomy as it applies to transplantation.



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Liver transplantation is indicated for patients who have acute or chronic end-stage liver disease where medication and other forms of medical management have failed. Hepatic decompensation from cirrhosis, hepatic encephalopathy, variceal hemorrhage, and

ascites are serious forms of serious liver disease. Decompensated liver disease is synonymous with decompensated cirrhosis. Cirrhosis is a chronic liver disease where the liver, usually as a result of prolonged alcohol use or hepatitis, develops inflammation, degeneration, and thickening of fibrous tissue. This happens to around 200,000 people per year in the United States. There are four stages to cirrhosis. Stage one involves inflammation of the bile duct or liver and is called steatosis. Stage two is called fibrosis where scarring and inflammation begins to damage the source of circulation in the liver. Stage three is called cirrhosis and is marked by scar tissue taking over normal liver tissue. The liver becomes bumpy and hard rather than pliable tissue as normal. Stage four is liver failure or advanced liver disease and is marked by the liver not functioning anymore. At stage one, the disease process is reversible and patients do not have many symptoms. At stage two, people may recover with the correct treatment. By stages three and four, cirrhosis is typically irreversible and patients will feel weak, lose appetite and weight, be jaundiced, and have abdomen bloating. The most common indication for liver transplantation as of 2022 was alcohol-related liver disease. Before surgery, patients must undergo psychological and psychiatric treatment to have six months or more of no alcohol use. If they do not comply with this, they are taken off the waiting list.

Hepatic encephalopathy, variceal hemorrhage, ascites, and jaundice are all effects of end-stage liver disease and cirrhosis. Hepatic encephalopathy is marked by confusion and is a loss in brain function as a result of the liver's inability to remove toxins from the blood. Variceal hemorrhage occurs when dilated blood vessels (varices) in the portal vein burst. This is a medical emergency and can lead to extensive liver damage. Ascites refers to the collection of fluid containing high protein content in the abdominal cavity. Jaundice occurs when there is too much bilirubin, a yellowish pigment in the body that is not processed by the liver. The result is a yellowish tint in the eyes and skin.

The scoring system Model of End-Stage Liver Disease (MELD) is a widely used tool to determine survival, and therefore organ prioritization, for liver transplantation. It assesses the three-month mortality rate concerning creatinine, bilirubin, and INR measures. A score of fifteen or greater with severe symptoms of cirrhosis (jaundice, ascites, hepatic encephalopathy) is a strong indication for urgent liver transplantation.

Contraindications and Alternative Treatments

There are many reasons that a person will not receive a liver transplantation although they have end-stage liver disease. Contraindications are in place to protect people that undergo liver transplantation and allocate livers to the people that have the best predicted outcomes. Absolute contraindications mean there is no way a person could

get a liver transplant and relative contraindications mean there are considerations against undergoing a liver transplantation. Absolute contraindications include having a MELD score of lower than 15, an advanced heart or lung disease, acquired immunodeficiency syndrome (AIDS), alcohol or substance abuse, hepatocellular carcinoma, HCC or perihilar cholangiocarcinoma with metastatic spread, untreated septic shock or sepsis, an intrahepatic cholangiocarcinoma, severe pulmonary hypertension, hemangiosarcoma, and extra-hepatic malignancy. Patients with HIV alone are considered for transplantation, but not if their condition has progressed to AIDS. HCCs are hepatocellular carcinomas and develop from hepatocytes becoming malignant. Perihilar cholangiocarcinoma is liver cancer that occurs within the bile duct. Intrahepatic cholangiocarcinoma is also bile duct cancer and hemangiosarcoma is malignant cancer from blood vessel cells in the liver. Relative contraindications for liver transplantations include debility, weakness, non-compliance, advanced age, prior involved abdominal surgery, or thrombosis in the portal or mesenteric vessels.

Chronic hepatitis C before 2015 was the top indication for liver transplantation. However, advances in antiviral agents allowed the eradication of hepatitis C before and after liver transplantation. This allowed patients battling hepatitis C to have good outcomes post transplantation. Patients with hepatitis B used to need transplantation due to the resulting end-stage liver disease. However, immunoglobulins and antiviral treatment have prevented many transplantations. Another treatment option instead of or while waiting for transplantation is a transjugular intrahepatic porto-systemic shunt (TIPSS) which allows blood to avoid passing through the liver to the rest of the body. Many medications exist to manage the symptoms of cirrhosis when patients do not qualify for transplantation or when they are waiting for a transplant. These include diuretics to reduce systemic swelling, hypertensive medication to reduce portal hypertension, and antivirals if cirrhosis is from viral hepatitis. In addition, patients will be educated to take nutritional supplements to ensure adequate nutritional intake, to avoid salt, and to get mild aerobic exercise.

The Procedure

There are many steps to ensure a safe and adequate procedure. First of all, pre-liver transplantation evaluation and treatment generally addresses many health concerns that would put a new liver and patient at risk. The evaluation will screen for relative and absolute contraindications, including organ health, habitual health, and psychological health. Liver transplantation will either be performed as a deceased donor liver transplantation (DDLT) or as a living donor liver transplantation (LDLT). A DDLT involves

transplantation of the whole liver with anastomoses of the liver vasculature and the bile duct is reconstructed. The LDLT is used in children and adults and is much more complex than a DDLT. It is a partial liver transplant where the graft of vessels is also smaller and uses either the left or right lobe of the liver.

After the Procedure

Patients are monitored in the acute hospital for around a week to ten days to ensure adequate blood work and post-transplant liver testing. Once a person is stable and the liver is performing well without signs of complications, they will either be sent home or to a subacute care facility (skilled nursing facility) for further recovery. They will then receive rehabilitative care typically in home health, skilled nursing, or outpatient care.

Precautions

Patients who have undergone liver transplantation are vulnerable to viruses and bacteria due to immunosuppressants that prevent rejection. Healthcare workers need to be wary of this when seeing patients in acute recovery or for other future care when working with patients on immunosuppressants.

Complications

Liver transplantation is a major surgery that can have severe complications. There are early complications that a person can undergo while staying in the hospital. One of these is when the liver allograft does not function properly. This results in producing inadequate bile or clear bile. A person will need to undergo a new graft immediately to survive this due to the production of liver enzymes and bilirubin. Another complication is hepatic artery thrombosis which can happen early or late in the recovery process. It can lead to liver ischemia and tissue death. If not caught right away, a person will need a new liver transplant. Another early complication is acute cell rejection which is common, at a rate of one in two post-transplant patients. At follow up appointments, acute cell rejection markers are measured and patients are prescribed corticosteroids to combat this. When managed with the correct medication, cell rejection is well managed. Biliary complications can happen when the biliary anastomosis is constricted. This is combated with dilating, stenting, or surgically widening the anastomosis. Lastly, infection is an early complication of a liver transplant. The necessary immunosuppressants that are given to patients post-transplant are to prevent rejection. However, this weakens the immune system to viral and fungal infections, which can lead to organ-specific or systemic infection.

Late complications involve problems around immunosuppression, persistent liver disease after transplant, and de novo malignancy. Immunosuppressants predispose patients to chronic kidney disease, hypertension, and diabetes as a side effect. In addition, long-term corticosteroid use can weak bones and connective tissues. Patients may sustain liver disease after transplantation such as hepatitis B or C. Malignancy is a risk to the new liver due to the risk factors of older age, viral infection, and alcohol and cigarette use.

Due to these early and late complications, patients post-liver transplantation should be prepared to work with many physicians and specialists before and after transplantation.

Lung Transplantation [10]

Lung transplantation is the optimal treatment for patients with severe and terminal lung disease. Lung transplantation is an arduous procedure but provides a chance for extending quality of life and length of life for people with various end-stage lung diseases. Lung transplantation has a survival rate of eighty-five percent at one year, just shy of seventy percent at three years, and fifty-five percent at five years.

Why transplantation?

Transplantation is indicated for a variety of conditions. These include but are not limited to chronic obstructive pulmonary disease (COPD), idiopathic pulmonary fibrosis (IPF), cystic fibrosis, and other diseases.

COPD qualifies for a lung transplant if the patient has a BODE index of greater or equal to seven, forced respiratory volume (FEV) of less than fifteen to twenty percent, three or more severe exacerbations in the past twelve months, or one severe exacerbation with hypercapnic respiratory failure. The BODE index stands for body-mass index, airflow obstruction, dyspnea, and exercise and is predictive of long-term quality of life for people with COPD.

Cystic fibrosis that is accompanied by frequent hospital stays, rapid decline in function, pulmonary hypertension, chronic respiratory failure, hypoxia, hypercapnia, and long-term ventilation is an indication for lung transplantation.

Interstitial lung disease accompanied by alpha-1 deficiency, hospitalization because of respiratory function, pulmonary hypertension, oxygen desaturation to less than 88 percent on a six minute walk test, and a decline in forced vital capacity are indications for listing a patient on the UNOS lung transplantation list.

Other indications are pulmonary vascular disease, pulmonary arterial hypertension, bronchiectasis, and sarcoidosis. These conditions must have a certain functional debility to be considered severe enough to qualify for transplantation.

Contraindications and Alternative Treatments

There are a few lifestyle and disease factors that are contraindications for lung transplantation. These include a recent malignancy, active tuberculosis infection, class two or three obesity, noncompliance with medication management, severe atherosclerosis if another organ system is in severe condition, certain psychiatric conditions, and medical acuity (sepsis or liver failure). Patients older than sixty-five, with a BMI between thirty and thirty-five, with extensive malnutrition, with extensive osteoporosis, with prior severe chest surgery, or with HIV or other certain infections will be carefully considered for their eligibility for a lung transplant.

The Procedure

A lung transplant is an involved procedure done on either one or two lungs at a time. It typically takes anywhere from four to twelve hours from start to finish. During the procedure, patients will go under general anesthesia, be connected to ECMO support, and have a Swan Ganz catheter to monitor pressures. For a single lung transplant, surgeons will perform an anterolateral thoracotomy and for a bilateral transplant, surgeons will use a clamshell incision with sternal splitting. With bilateral transplants, the more diseased lung is transplanted first. The pulmonary ligament is detached and the pulmonary artery and vein are detached leaving enough to graft the donor lung to the remaining vessels. The donor's lung is inserted and attached to the bronchus first, then the pulmonary artery and the vein. At that point, ventilation is gradually increased to allow the lungs to begin functioning and to check for adequate circulation. After adequate ventilation and circulation, the team places three chest tubes for drainage and closes the chest.

After the Procedure

Immediately after the surgery, each patient transfers to the critical care unit of the hospital. They stay on ventilation until they wake from surgery and lung function is adequate to begin tapering off of ventilation. Patients are on antirejection and pain management medications at this stage. The critical care team monitors fluid intake and hemodynamics carefully. Immunosuppressants at this point include steroids, a cell cycle, and a calcineurin inhibitor. While in the hospital, the transplant team and aftercare team monitor for early rejection signs. Once the team deems the patient stable, they can

transfer to the cardiothoracic floor of the hospital. This is where early rehabilitation happens. The total length of stay for a person post-lung transplantation is around two weeks if there are no complications. From there, depending on their functional capacity, strength, and endurance, they could transfer from the hospital to a subacute rehab center or home with home care.

Precautions

Patients who have had lung transplants who are in the cardiothoracic unit and ready for rehabilitation will have chest tubes, and supplemental oxygen, and will have weakened immune systems due to immunosuppressants for anti-rejection. This means that any healthcare professionals working with post-lung transplantation should be careful to manage chest tubes, oxygen, and safety around sternal precautions as well. This means having a lifting restriction of five pounds, avoiding pushing and pulling, and avoiding reaching posteriorly, laterally, and superiorly.

Complications

Immediate complications are associated with a rejection reaction or a poorly matched lung for the recipient. Early complications are post-operative excess bleeding, primary graft dysfunction, kidney injury, and dysfunction of the pleural membrane. Such could lead to effusion, hemothorax, pneumothorax, or air leaking from the lung(s). Rejection is a life-long complication, making long-term immunosuppressant therapy imperative. Problems such as stenosis or blockages within the pulmonary artery or vein may occur. Additional complications include pulmonary embolism, lung infection, bronchogenic carcinoma or exposure to the same disease that necessitated the original transplant. Rehabilitation professionals should be aware of the signs and symptoms of complications in the form of reduced functional capacity, problems with respiration, and abnormal vital signs when working with post-lung transplant patients. PTs and OTs should alert the patient's transplantation care team or emergency medical services depending on the patient's presentation.

Heart Transplantation [11,12]

Heart failure (HF) is very common, affecting around six million adults in the United States per year annually. Advanced heart failure is end-stage heart disease. Around three thousand patients per year receive a heart transplant and three thousand five hundred are on the UNOS waiting list for a transplant.

Why Transplantation? [13]

Patients with advanced heart disease will benefit from a heart transplant to extend their life if they qualify. Advanced HF is defined in a few ways. The New York Heart Association defines functional class four as advanced HF which means symptoms of breathlessness and chest pain at rest and with activity. The American Heart Association defines stage D heart failure as needing extensive intervention to reduce symptoms despite using the full potential of medical therapy. The Interagency Registry for Mechanically Assisted Circulation also categorizes patients to determine how urgent intervention should be, ranging from critical cardiogenic shock to Advanced NYHA Class three. These three systems are used together as a way to determine the necessity and urgency of transplant or other interventions. Heart disease typically starts with high blood pressure, myocardial infarction, arrhythmias, congenital heart defects, valvular disease, cardiomyopathy, or lung disease.

A person may be put on the UNOS waiting list for a heart transplant if several conditions are met. They must have end-stage heart disease that will not respond to other treatments, a VO2 maximum measurement of fewer than 10 ml/kg/min, ischemia that limits activity and will not respond to bypass surgery, and/or ventricular arrhythmia that is persistent and not responding to therapy. Before transplantation, patients will undergo extensive evaluation, as shown in the table below.

Evaluation of the Heart Transplant Candidate:
• Clinical History and Physical Examination • Laboratory Evaluation: Complete Blood Count, Basic Metabolic Panel, Liver Function Tests, Urinalysis, Coagulation Studies, Thyroid Evaluation, Urine Drug Screen, Alcohol Level, HIV Testing, Hepatitis Testing, Tuberculosis Screening, CMV IgG and IgM, RPR/VDRL, Panel Reactive Antibodies, ABO and Rh Blood Type, Lipids, Hemoglobin A1c • Chest X-Ray, Pulmonary Function Testing • EKG • Right and left heart catheterization • Cardiopulmonary exercise testing • Age appropriate malignancy screening • Psychosocial evaluation (including substance abuse history, mental health, and social support) • Financial Screening

Indications for Heart Transplantation from UNOS:

Contraindications and Alternative Treatments

Tier	
1.	i. VA ECMO (up to 7 days) ii. Non-Dischargeable BIVAD iii. Mechanical circulatory support with life threatening ventricular arrhythmia
2.	i. Intra-aortic balloon pump (up to 14 days) ii. Acute percutaneous endovascular circulatory support (up to 14 days of support) iii. Ventricular tachycardia / Ventricular Fibrillation, mechanical circulatory support not required iv. Mechanical circulatory support with device malfunction / device failure v. Total Artificial Heart vi. Dischargeable BIVAD or RVAD
3.	i. LVAD for up to 30 days ii. Multiple Inotropes of Single High-Dose Inotrope With Continuous Hemodynamic Monitoring iii. Mechanical Circulatory Support with Device Infection iv. Mechanical Circulatory Support with Thromboembolism v. Mechanical Circulatory Support with Device Related Complications Other Than Infection, Thromboembolism, Device Malfunction/Failure, and Life Threatening Ventricular Arrhythmias
4.	i. Diagnosis of Congenital Heart Disease (CHD) with: a. Unrepaired/incompletely repaired complex CHD, usually with cyanosis b. Repaired CHD with two ventricles c. Single ventricle repaired with Fontan or modifications ii. Diagnosis of ischemic heart disease with intractable angina iii. Diagnosis of hypertrophic cardiomyopathy iv. Diagnosis of restrictive cardiomyopathy v. Stable LVAD patient after 30 days vi. Inotropes without hemodynamic monitoring vii. Diagnosis of amyloidosis viii. Retransplant
5.	i. Approved combined organ-transplants: heart-lung, heart-liver, heart-kidney
6.	i. All remaining active candidates
7.	i. Inactive / Not Transplantable

The progression of heart disease often means that a patient's other organ systems may be unhealthy or that their potential for survival of the transplant surgery is low. Definite contraindications for transplantation are a major systemic disease, seventy years or older, cancer in the last five years, less than six months since quitting smoking, substance abuse, HIV, infection, and major neurological or psychiatric deficits.

Before transplantation, patients undergo the maximum medical effort through medication, surgery, or other treatments to try and reverse heart failure. Patients will likely be on beta-blockers, angiotensin and aldosterone antagonists, and other inhibitory medications to achieve a balance in heart function. Patients may undergo coronary artery bypass grafting, catheterization, or pacemaker placement before being considered for a heart transplant.

The Procedure

For those that qualify, heart transplantation is one of the only long-term solutions for end-stage heart disease. Greater than ninety percent of patients are alive one year after transplantation and on average, patients survive just over ten years after transplantation.

The procedure itself is extensive. Orthotopic heart transplantation involves the removal of every part of the recipient's heart besides the cuffs of the atria. The donor's heart is

attached from the atria to the cuffs of the recipient's heart, to the aorta, the pulmonary artery and the vena cava. The recipient is put on cardiopulmonary bypass while the donor's heart is being transplanted. After the attachment of the new heart and vessels, the team repursues the heart with circulation and gradually lowers the bypass. The team places two chest tubes and the patient is taken out of the operating room.

After the Procedure

Intimal recovery will occur in the intensive care unit and the ICU team will monitor vitals and electrocardiogram readings. A typical length of hospital stay is around two weeks with no complications. After a stay and stability in the ICU, patients will be sent to the cardiothoracic unit to recover further. Rehabilitation either begins in the ICU or the cardiothoracic unit depending on the stability of the patient, their vital signs, and functional capacity.

Precautions

Patients will have sternal precautions and immunosuppressive precautions. They will have two chest tubes with drains and may be on supplemental oxygen.

Complications

Complications are mostly related to rejection, as with other organ transplants. Patients will need immunosuppressants balanced appropriately to prevent their immune systems from recognizing the transplanted heart. Systemic infection is another complication because recipients of organ transplantation have a low ability to fight infections from immunosuppressive therapy. Another complication is a return of the original disease and ischemia or tissue death within the new heart. Primary graft dysfunction or failure of the circulation graft is the most common complication in early transplant. Around ten percent of patients will develop a malignancy within five years of the heart transplant. Cardiac allograph vasculopathy is a narrowing of the coronary arteries and is a major cause of mortality long after transplantation.

Section 2 Key Words

Cirrhosis – a chronic liver disease where the liver develops inflammation, degeneration, and thickening of fibrous tissue and a major cause of end-stage liver disease

Chronic Obstructive Pulmonary Disease (COPD) – lung disease ranging from mild to severe that is a common reason for lung transplantation; marked by emphysema and chronic bronchitis, and difficulty breathing

Advanced Heart Failure – represented by stages of progressive decline in cardiac function to the most severe form where there are symptoms of dyspnea and chest pain at rest

Section 2 Summary

Kidney, liver, lung, and heart transplantation are the main organ transplantation surgeries across the world. Although these surgeries come with many complications and are extensive procedures, they are the best method to extend life in terminally ill patients. Common comorbidities and reasons for the development of organ disease include diabetes, obesity, poor diet, substance and alcohol abuse, and many other things. Patients usually have a few weeks under recovery in the hospital or subacute locations before returning home. Physical therapists have a role in this recovery process by helping patients return functional strength and capacity.

Physical Therapy Assessment

Physical therapists have a role before and after organ transplantation in evaluating and treating patients to improve their functional recovery after transplantation. Many patients have to wait months to years from being listed on the UNOS waiting list for OT to the time they receive a transplant. There is potential to maintain strength and functioning before and early after transplantation, which has a huge impact on the overall recovery outcomes. This section will detail pre-transplant and post-transplant assessment considerations to prepare PTs to comprehensively evaluate patients going through OT.

Pre-Transplant Assessment [14]

The physical therapist assessment for each organ system varies in pre-transplant. There is a general assessment and specific considerations for kidney, liver, lung, and heart transplants. This assessment will capture vitals, strength, range of motion, exercise capacity, performance at activities of daily living, and functional capacity. The point of

pre-transplantation assessment and physical therapy treatment is to preserve functional strength and safety to prepare for the upcoming transplant.

Observation

Observation of patients with organ transplantation is crucial. Patients waiting for liver transplantation may have jaundice or ascites, which can show the severity of the need for a transplant. With patients waiting for lung transplantation, signs to show severity of their condition include overactive accessory muscles of respiration and skin color. Patients may have overactive scalenes and sternocleidomastoid muscles, indicating they use less diaphragmatic, effortless breathing and overuse muscles that are not meant for respiration out of necessity. Patients may have cyanotic or bluish tint on the skin of their faces or fingers, indicating lower levels of oxygen in their bodies. For heart transplantation, patients with severe heart failure may have a collection of edema in their lower extremities (especially ankles and feet), which is important to measure and track throughout a course of PT evaluation and treatment. Patients awaiting all transplantation types may have muscle atrophy from weakness, fatigue, and lack of activity tolerance. It is important to characterize these observations and track them over time before transplant (and after).

Vitals

Vitals are incredibly important to track at evaluation because they are a screen for the functioning of the heart and lungs. Blood pressure, heart rate, and oxygen saturation should always be taken. Normal blood pressure is less than 120/70, normal heart rate for adults is 60-100 beats per minute, and normal oxygen saturation is above 90 percent on a SpO2 monitor. However, these values may be skewed especially if patients are awaiting a lung or heart transplant. PTs should always consult with their patient's physician who listed them for transplant to determine a safe range of vitals at rest and with activity and concerning medications. For example, someone awaiting a heart transplant may have a heart rate of 50 and low blood pressure but their physician may have prescribed beta-blockers or other heart medications to manage the reserve in their heart's function.

Table 1. **Vital signs: normal values in adults**	
Temperature	37°C
Heart rate	60-99 beats per minute
Pulse	60-99 beats per minute
Blood pressure	120/80mmHg
Respiratory rate	12-16 breaths per minute
Oxygen saturation	95-100%
pH	7.3-7.5

Frailty

Many patients facing OT are frail. Frailty is measured by a few characteristics: unintentional weight loss of ten or more pounds in the last twelve months, reported exhaustion over half of the week, grip strength in the 20th percentile or lower, gait speed of fewer than 0.8 meters per second, and an activity level of sitting or laying most of the week (around 300 calories of active energy expenditure per week). The Fried Frailty Index can be a useful tool in understanding how much reserve a patient has and is predictive of mortality waiting for a transplant.

Traditional Definition of Frailty: Fried Model

(Criteria for Frailty as a Clinical Syndrome as proposed by Fried et al 2001)

- Frail: a person meets **≥ 3** of the criteria
- Prefrail: a person meets **1 or 2** of the criteria

(Score 1 point for each of the following true statements)

1. Unintentional weight loss of 10 lb or more in the past year
2. Self-reported exhaustion (person states they are exhausted 3 or more days per week)
3. Muscle Weakness (grip strength in lowest 20%: < 23 lb for women; < 32 lb for men)
4. Walking speed in the lowest 20% (< 0.8 m/sec)
5. Low level of activity (kcal/week - lowest 20%: 270 kcal/wk for women; 383 kcal/wk for men = equivalent to sitting quietly and/or lying down for the vast majority of the day)

Total points: _____

Gait and Balance Assessment

PTs should note gait quality by breaking down the cycle and balance on their assessment as part of a safety analysis for household and community ambulation. The Timed Up and Go (TUG) is a good assessment tool for gait speed and can be performed with or without an assistive device (should document the device used). Normal TUG scores are less than ten seconds, which predicts a low risk of falling. The Berg Balance Scale (BBS) tests fall risk and balance in patients, statically and dynamically. The Berg is a safer option to capture balance measures in patients who need assistance to ambulate. The Berg is out of 56 points and scoring less than 41 indicates the patient is walking with some type of assistance. The dynamic gait index and functional gait assessment are also good balance

measures to indicate on an examination. PTs should assess patients on their safety with different assistive devices if they are unsteady and a fall risk per gait and balance screening.

Strength [15,16]

Manual muscle testing is appropriate when a PT notices specific muscle weaknesses when performing functional activities. Strength is more effectively captured by tests of functional strength like the 30-second chair rise test or the five-time sit to stand test. These should be measured at evaluation and remeasured for progress and discharge as well. The chair stand test is predictive of functional strength in adults. In men from age sixty to sixty-four, a score under fourteen stands in thirty seconds is predictive of falls and functional decline, and in women that number is less than twelve stands. For ages sixty-five to sixty-nine, under twelve stands in men and under eleven in women is predictive of falls and debility. From seventy to seventy-four, under twelve for men and under ten stands for women is predictive of functional decline and falls. The five-time sit to stand test is predictive of falls and hospitalizations in people of all ages. Patients who complete five sit-to-stands in greater than seventeen seconds have a thirty percent higher rate of hospitalization and older adults who score greater than fifteen seconds have a high fall risk.

Range of Motion

PTs should take a range of motion measurement at joints that look abnormal on the gait assessment. Common joints that affect ambulation in patients with debility due to organ failure may include the ankle (edema from heart failure), the hips, low back, and the knees. Patients awaiting OT may have underlying orthopedic issues in their joints that should also be noted because they affect mobility and quality of life too.

Functional Mobility and Capacity [17]

Functional mobility should be measured by how much assistance patients need to ambulate and to transfer from sit to stand, stand to sit, pivot to a chair, sit to supine, and supine to sit. Functional capacity can be measured through the standardized six-minute walk test, which involves recording the distance in meters that someone can walk in six minutes. Healthy adults can walk between four hundred and seven hundred meters. Any amount under four hundred meters indicates debility, and the clinically important difference is fifty-four meters.

Levels of Assistance in Functional Mobility:

Term	FIM Score	Patient performed	Helper/PTA performed
Independent	7	100% of the physical task with no helper, no equipment/devices safely and within a reasonable time	A helper was not required
Modified Independent	6	100% of the physical task without the need of another person at all; used an assistive device, brace or other equipment or took extra time for the task	A helper was not required
Supervision or Stand By Assist	5	100% of the physical task; needed another person there for things like verbal cuing or to watch for safety	0% of the physical task; needed another person there for things like verbal cuing or to watch for safety
Contact Guard Assist	4	Basically 100%.. needed "light touching"	Basically 0%.. other than "light touching"
Minimal Assistance		75% or >	25% or less
Moderate Assistance	3	50%-74%	24%-50%
Maximum Assistance	2	25%-49%	51%-75%
Total Assistance/ Complete	1	<25%	>75%

Post-Transplant Assessment [14]

Post-transplantation assessment for physical therapists involves different measures and focuses depending on which setting of rehabilitation the patient is in. The tests and measures for post-transplant are often the same as pre-transplant and are more involved when patients are more functional. Settings where PTs will evaluate patients after organ transplantation are the intensive care unit, general hospital recovery, subacute recovery, home health, and outpatient settings. Each evaluation should begin with a thorough history taking including information on what a patient's daily life is like any comorbidities, ADL status, mobility status, capturing any functional decline in the past months to a year, and what adaptive equipment the patient has.

Intensive Care Unit and Hospital

In the ICU, physical therapists need to work within their hospital and organ transplant interdisciplinary team protocol. Early mobilization is very helpful for reducing debility after an organ transplant but needs to be safe for each patient. PTs should monitor vitals closely throughout every interaction. The assessment focus should be on observation, functional mobility, range of motion/strength, and activity tolerance.

Observation

PTs first need to speak with the patient's physician or follow protocol for appropriate mobility and vitals at rest and activity. They should orient themselves to every line and

tube and the necessary equipment to help the patient with mobility. The patient should be alert and oriented to their name, time, and location to participate in an evaluation.

Functional Mobility 18,19

When appropriate and typically with assistance from another qualified healthcare worker to manage lines and tubes, the PT should instruct and assess the patient's ability to roll, move from supine to sit, sit to stand, short ambulation, and sit to supine. The PT should document vitals, levels of assistance, and observation with every movement and keep exertion and vital levels within appropriate ranges. A helpful standardized tool is the AM-PAC "Six-Clicks" which helps to predict functional mobility and discharge recommendations in acute care settings. The test is based on functional mobility tasks of turning in bed, supine to sit, a bed to chair transfer, sit-to-stand, walking, and negotiating three to five stairs with a railing. The scoring is out of twenty-four total points (higher is more independent) and is scored based on the amount of assistance needed for those mobility tasks. In this scoring system, scores under eighteen indicate that someone may need subacute rehabilitation after a hospital stay. The AM-PAC is a great tool for discharge prediction and for progress in functional mobility tasks. Another measure of function is called the Barthel Scale/Index which measures functioning in activities of daily living. The index measures a patient's independence with bowels, bladder, grooming, toileting, feeding, transfers, mobility, dressing, stairs, and bathing. Higher scores indicate better function and the total is out of 100 points. Scores from twenty-one to sixty point out severe dependency, scores from sixty-one to ninety point out moderate dependency, and scores of ninety to ninety-nine indicate slight dependency. Occupational therapists commonly use the Barthel Index, but PTs can contribute to the scoring with mobility, transfers, and stair function.

Range of Motion/Strength

It is crucial to assess range of motion because patients are at risk for hypomobile joints and contractures when immobile for long periods. Common joint ranges of motion to assess include ankle dorsiflexion, knee flexion/extension, hip flexion and rotation, wrist, and shoulder mobility. Strength testing in the supine and sitting position for the lower extremity and upper extremities is also helpful to document progression or regression.

Activity Tolerance

PTs should examine activity tolerance in some way based on the patient's ability. This could be the amount of time a patient can sit at the edge of bed or stand and what the

patient's vital response is. It could be ambulation distance and vital response for either patients in the ICU or general hospital floors.

Gait/Balance

When a patient in the ICU or hospital floor is ready for ambulation medically, PTs should assess gait and fall risk. PTs should document the level of assistance needed, the appropriate assistive device, balance strategies, near falls, gait disturbances, gait speed, and distance ambulated. A patient will likely need an assistive device at this stage of recovery, such as an EVA walker (cardiac walker used after surgeries where the chest was opened), a walker, or a cane.

Subacute and Home Health Evaluation

For the settings of skilled nursing and long-term acute care hospitals (LTACHs), the rehabilitation evaluation is typically a bit more involved than in the hospital because patients are further in their recovery and more functional.

Observation

PTs should observe their patient, documenting things like perceived or stated motivation, any lines and tubes a patient is connected to, any incisions and their healing state, and pallor or yellowish skin tint.

Functional Mobility

Functional mobility measures should be appropriately matched to the patient's functional status and should be able to measure improvement. This includes the level of assistance needed for transfers, ambulation, and bed mobility, functional measures like the AM-PAC, and scoring systems like the Patient Driven Payment Model to measure outcomes. The PPS Model helps Medicare decide what services are necessary for patients in rehabilitative care. The OASIS model from Medicare will need to be used for patients in home health.

Range of Motion/Strength

PTs should record range of motion and strength measures where they notice deficits in their patients. This is especially important with muscle and joint stiffness that are common with debility due to organ disease before transplantation. Manual muscle tests, goniometer measurements for range of motion, the five-time sit to stand, and the chair stand test are all great examination items.

Activity Tolerance

1 - 10 Borg Rating of Perceived Exertion Scale	
0	Rest
1	Really Easy
2	Easy
3	Moderate
4	Sort of Hard
5	Hard
6	
7	Really Hard
8	
9	Really, Really, Hard
10	Maximal: Just like my hardest race

In subacute and home health settings, the 6MWT is a great indicator of functional progress, just like the pre-transplantation evaluation. The FSS is a good measure of self-reported fatigue. Physical therapists should also ask for Borg's Rating of Perceived Exertion to understand how difficult tasks are for patients.

Gait and Balance

In the subacute, home health, and outpatient settings, it is important to use effective gait and balance measures, assess appropriate assistive device use, and recommend assistive device use. Common measures are the Dynamic Gait Index, the Functional Gait Assessment, the Berg, TUG, and tandem or single leg balance assessment. As patients make progress, they should be reassessed with more difficult gait and balance measures. It is important after organ transplantation to ensure that patients are at low fall risk. This means assessing their gait with the least restrictive assistive device for them. Patients may need a walker, cane, or EVA support walker after heart or lung transplantation.

Section 3 Key Words

Frailty – defined by unintentional weight loss, reported exhaustion, weak grip strength, slow gait speed, and sedentary lifestyle due to a combination of factors

AM-PAC Six Clicks – a mobility assessment tool that allows the documentation of bed mobility, transfers, ambulation, and stair negotiation

Section 3 Summary

In order to help improve the functional status of both patients pre-transplantation and post-transplantation, physical therapists should evaluate each patient according to their functional level. This is crucial to discover progression or regression, which should be communicated with the medical team. The evaluation should always be setting and

patient specific and PTs in best practice should communicate well with the transplantation team to provide excellent interdisciplinary care.

Physical Therapy Intervention

Physical therapy intervention and plan of care are shifting focus to early mobility protocols to help patients recover the most effectively and efficiently from organ transplantation. This means that the best practice is to mobilize patients as early as medically able to reduce complications due to debility. Of course, vitals and response to mobility are always monitored.

Rehabilitation in Critical Care/ICU [20,21]

Physical therapy in the ICU focuses on all mobility tasks that the patient can tolerate and within the limits of vital signs that the transplant physician and medical team deem safe to avoid overexertion and negative effects. Patients should be alert and oriented to name, place, and time to participate in most cases and treatment should be coordinated with nursing staff depending on the hospital. PTs should ask for an RPE (Rating of Perceived Exertion) throughout treatment and monitor and record vital responses to all treatments.

A general protocol is as follows for all transplantations. Considerations for each type of transplant are as follows.

Post Operative Days 0-2

Mobility

Functional mobility is arguably the most important part of rehabilitation after OT. The main goal of rehab at this stage is to leave the hospital once the patient is stable and recovering well, including with mobility status. After the examination, physical therapists should progressively challenge mobility whether that is rolling, supine to sit, sit to stand, transfers, or ambulation. Depending on functional status and vital response, this could be very limited or progressive. PTs should have the extra assistance of qualified staff if needed to optimize mobility safety.

Range of Motion/Strength

This is critical in preventing contractures and beginning to challenge the muscular system to prevent deconditioning. Sessions may include exercises to range the ankles, knees, hips, and shoulders, all to optimize mobility. PTs should repeat range of motion exercises throughout the range of motion for three sets of fifteen repetitions and train nursing staff or support staff as able. Strength exercises include activation of the lower extremity muscles (abdominal or chest sparing depending on the surgery site) to prepare for transfers and ambulation. Examples are straight leg raises, ankle pumps, heel slides, and seated marches. It is ideal to leave exercises with the patient to be completed three to four times per day at ten repetitions or so each.

Positioning/Posture

PTs have a crucial role in pressure relieving techniques in the ICU for the prevention of pressure injuries. This means implementing appropriate position changes, especially for patients who spend the majority of their day in bed and have been unable to mobilize. Patients who have not mobilized on post-op day 0 should be rotated in bed with the assistance of staff every two hours. Wedge cushions are helpful to maintain a new position for two hours. PTs should also reinforce boots to float the heels and prevent pressure injury there too. Posture is important to work on in sitting and standing to work towards normal muscle function. In sitting, PTs should encourage a tall posture supporting the appropriate spinal curvature. In standing, PTs should promote good spinal position and deep breathing to optimize lung and heart function.

Activity Tolerance

Activity tolerance is crucial during the early stages of rehabilitation. PTs should always document a patient's tolerance to activity, whether in mode, intensity, or RPE score. Activity tolerance should be challenged in every part of a PT session in the ICU. The PT should focus on challenging the patient with respect to fatigue and vital response. By

day two, patients should be able to sit at the edge of the bed for multiple minutes, stand, and transfer from bed to chair in most cases.

Post-Operative Day 3 and Until Hospital Discharge

Mobility

By hospital discharge, PTs should progress patients from dangling at the edge of the bed to transfers, ambulation, and stair negotiation if possible. Mobility goals should focus on the tasks that patients need to do at home if home is the discharge goal. PTs should recommend assistive devices, typically walkers, to patients to use until they are at a low fall risk.

Strength

Strength exercises after a patient has mobilized include ankle pumps, seated marches, long arc quads, sit to stands, and other ways to challenge the lower extremities. Patients should be working on a home exercise program in the hospital to ensure they keep their muscles active throughout the day and prepare for activity at home or at subacute rehabilitation.

Activity Tolerance

Activity tolerance needs to be progressive in terms of goals for the home as well. By hospital discharge, patients should be able to stand or sit for as long as their activities of daily living take and negotiate all stairs and gait distances required for the home. PTs need to challenge activity tolerance each day to build muscular and cardiovascular endurance. This can take many forms such as standing exercises, ambulation for distance, seated exercises, and daily activities.

For renal transplantation, an early mobility protocol involves rolling in bed on post operative day one, moving from supine to sit on day two, and sitting for any desired activities on day three after surgery. This level of mobility is then followed by progressive transfers and ambulation, based on the patient's response to the intervention and vital signs. This early mobility protocol improved bowel activity profoundly and reduced hospital length of stay significantly. Patients also have higher ratings of satisfaction after an early mobility experience, likely because they return to independence more quickly. Mobility precautions include lifting no more than ten pounds and surgical site sparing movements. Patients post kidney transplants may have difficulty with blood glucose levels, more easily develop cardiovascular disease, osteoporosis, and an increased amount of tendon injuries.

For liver transplantation, patients will need to move with an abdominal sparing technique. PT's should teach their patients the "log roll" which involves rolling without flexing the spine or abdomen. PT's should monitor their patient's cognition, abdominal tenderness, fatigue, and color. Patients post liver transplant can also have reduced pulmonary function from the proximity of the liver to the right lung.

For lung and heart transplantations, early mobility and weaning from the ventilator and supplemental oxygen is the focus. Therapists should be wary of airway clearance techniques and perform this if respiratory therapy is not. They should assist patients in any breathing re-training activities such as using an incentive spirometer. In best practice, PT's contribute to this process through progressive mobility beginning with bed mobility and progressing to ambulation. PT's should educate and ensure that patients do not break their sternal precautions throughout all mobility and that vitals are within a safe range per the surgeon's recommendations.

Rehabilitation in Subacute Settings and Home Health

Intervention in subacute settings, such as skilled nursing or LTACH, involves building activity tolerance and strength for independence. Areas that should be intervened on are safety and function with mobility, activity tolerance, balance, strength, and range of motion. Just like with therapy in the hospital, patients post transplantation rehabilitating in subacute settings are striving to discharge home and should have PT goals in accordance with that.

Mobility and Activity Tolerance

PT sessions in subacute care and home health can last anywhere from one half hour to an hour. Mobility and activity tolerance are crucial for a home discharge, or for becoming more functional at home. PTs should spend time transfer training, gait training, and stair training with goals of the patient achieving these tasks with independence. PTs should work on gait speed and distance for ambulatory patients. Good outcome measures for this are gait speed and the 6 minute walk test. PTs should help patients achieve faster than 0.6 meters per second for gait speed and 400 to 700 meters on the 6MWT to have a good indication of functional recovery.

Balance [22]

PT intervention should focus on sitting, standing, static, and dynamic balance to promote patient safety in their home. A good protocol to use is the progression of balance tasks

like righting against perturbations and balancing with eyes closed and changing the task. If patients are not safe ambulating, PTs should challenge sitting balance, such as tasks for sixty seconds of balance while eyes are closed, against perturbations, or reaching activities. Standing balance should be challenged in the same ways, to simulate reaching while standing in the kitchen or bathroom. Dynamic balance can be challenged by gait activities like weaving, stepping over objects, and stepping on uneven ground. Generally, to train balance, a patient should fail around fifty to sixty percent of the time. For static tasks, balance training should be completed in several rounds of sixty seconds trying to achieve the failure rate. For dynamic tasks, patients should be challenged to fatigue and given rest breaks if they begin to lose their balance quite often. All balance training should be done with a gait belt for safety.

Strength/Range of Motion [23]

Exercises in home health and subacute rehabilitation settings should be focused on gaining strength. Many patients have profound weakness after organ transplantation because of the nature of rest and debility that preceded and followed their surgery. To gain strength and muscle hypertrophy, the lower extremity muscle groups (quadriceps, hamstrings, gluteal, and gastrocnemius/soleus) should be challenged at two to three sets of eight to twelve repetitions every session. Of course, PTs should follow precautions from the organ transplant as long as they are in place. This could mean no lifting over ten pounds and sternal precautions. Range of motion deficits are important to work on as patients gain mobility. PTs should intervene on any lower extremity short muscles or stiff joints so patients can move as efficiently as possible. Three sets of sixty seconds for stretches of the calves, hamstrings, and quadriceps two to three times per day are appropriate to gain muscle length.

Rehabilitation in Outpatient

Chronic rehabilitation for patients post transplantation has the goal of helping patients return to activities they enjoy doing. This could be hiking, biking, playing golf, or playing with their grandchildren. Outpatient therapy post transplantation looks a little bit different per transplantation surgery. PTs may see patients with a history of transplantation for a different reason too, such as an ankle injury or a rotator cuff tear. They should be mindful about how the history of an organ transplant can affect the rest of the body while treating the patient for their injury. Immunosuppressants and steroids weaken tendons and muscle tissue and predispose patients to sickness.

Patients no matter the transplant type may need balance training, which can take many forms in outpatient rehabilitation. Depending on the goals and ability of the patient, static and dynamic balance training are appropriate. Standing balance can be challenged by perturbations, differing bases of support, closing the eyes, and standing on an unstable surface such as foam. Dynamic balance training can involve weaving, stepping over objects, and is effective when combined with tasks that gain strength as well (lunges, step ups on foam surface, etc.).

Heart [24]

One of the best forms of outpatient therapy after heart transplantation is called cardiac rehabilitation. Physical therapists either work directly in these programs or they can refer to the programs. Cardiac rehabilitation involves strategies to change the lifestyle around patients with complicated heart disease, including post myocardial infarction, post bypass surgery, and post heart transplant. Patients in cardiac rehabilitation will receive multidisciplinary care including lifestyle education, psychological assessment to support behavior change, and exercise therapy. Both resistance and aerobic training are tolerated well in patients post transplantation because the autonomic nervous system control of the heart improves with exercise. High intensity interval training is a great intervention as it challenges the cardiovascular system for short bouts while improving endurance and muscular strength.

Intensity and frequency of exercise in a cardiac rehab program gradually increases until a peak of exertion. The programs can last two months to a year, typically are performed three to five times per week, achieve around 90% of the maximal heart rate, 70% of VO2 max, a Borg rating of 4-7/10 (moderate to hard), and sessions last on average for forty minutes. Exercise types vary and include high intensity interval training, aerobic (walking, running, cycling), and strength training. The goal is to challenge extremity muscles, the heart, the lungs, and achieve excellent functional outcomes, like meaningful change on the 6MWT and the Chair Stand Test.

Lung [25]

After lung transplantation, outpatient therapy should begin within one month after surgery. The goal of outpatient rehab post lung transplantation is to achieve normal function in gait (walking without an assistive device with low fall risk), wean from supplemental oxygen, and return muscle strength to normal (before the transplant and associated weakness). The 6MWT is an excellent tool to determine functional capacity and endurance post transplantation. This exercise can take many forms but should

involve a few types: aerobic, resistance, and flexibility. Aerobic exercise should be performed three to five times per week for thirty minute sessions. Parameters are within 50 to 80% of maximum heart rate, 4 on the Borg RPE scale (moderate/hard), and may be walking or cycling. After three months, a patient can do the elliptical or arm ergometry because the chest healing is adequate. After six weeks from the transplant, patients can progress up to sixty minutes of aerobic exercise if it is tolerated. Resistance training should be performed three days per week and at around seventy percent of a one rep maximum per exercise. For three months, there is no lifting greater than ten pounds from sternal precautions and no exercises should challenge the core. Exercises include anything to challenge the lower extremities such as squats, lunges, calf raises, and targeting the quadriceps, gluteal, gastrocnemius, hamstrings, and hip abductors/ adductors. Sets and repetitions should be two to three and eight to twelve, respectively. Flexibility training should be targeted to taut and short muscles all over the body, most commonly the calves, hamstrings, shoulders, and quadriceps. PTs should direct patients to perform specific stretches for two to three repetitions of thirty seconds each daily.

Kidney [7]

Kidney transplantation outpatient rehabilitation should focus on strength, aerobic endurance, and flexibility. Appropriate exercise dosing should work on muscle hypertrophy for strength training, and be dosed at two to three sets of eight to twelve repetitions to form failure, three times per week. Aerobic exercise should be done three to five times per week at thirty to sixty minute sessions and cycling, walking, or the elliptical are good forms. Patients may swim as well once cleared for incision healing. Flexibility training and balance training should be performed if there are deficits in short muscles or gait instability.

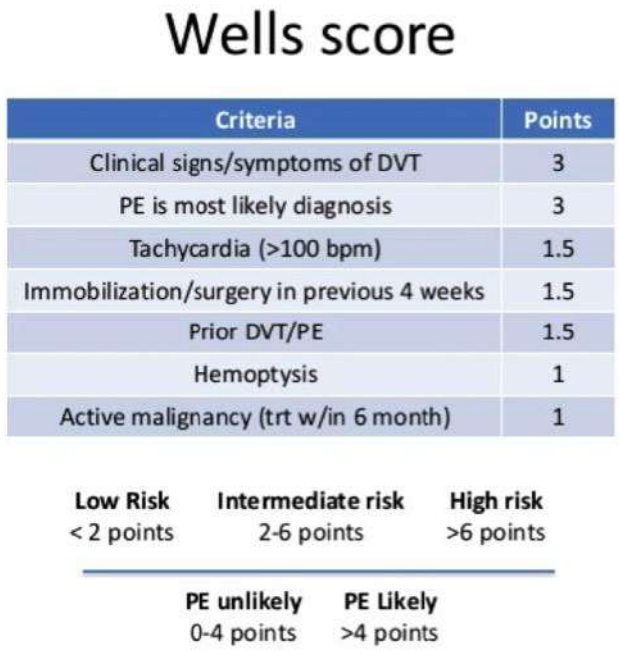
Liver [14]

Liver transplant rehabilitation may progress as tolerated and ensure that patients return to their highest level of functional strength. PTs should follow abdominal precautions and no core exercises for three months. Strength training should be performed at two to three sets of eight to twelve repetitions to form failure, two to three times per week. Aerobic exercise should be performed three to five times per week for thirty to sixty minute sessions and cycling, walking, or the elliptical. Patients may swim around three months from surgery when the core and incision has healed enough. Flexibility training and balance training should be performed if there are deficits in short muscles or gait instability.

Signs of Complications per Transplant [20]

As stated throughout this course, complications are a major concern after transplantation. Acute rejection and infection are among the most serious. Signs of infection for all transplants would be fever, elevated white blood cell count, malaise, poor endurance, hypertension, and increased heart rate. Each patient with immobilization for a period of time are at risk of deep vein thrombosis and pulmonary embolism, which are depicted in clinical risk in the charts below.

Clinical Feature	Points
Active cancer (on treatment, treated in the last 6 months or palliative)	1
Paralysis, paresis or plaster immobilisation of the lower limb	1
Bedridden for 3 days or more, or major surgery in the past 12 weeks requiring general or regional anaesthesia	1
Localised tenderness along the distribution of the deep venous system	1
Entire leg swollen	1
Calf Swelling 3 cm larger than the symptomatic side	1
Pitting oedema confined to the symptomatic leg	1
Collateral superficial veins (non-varicose)	1
Previous DVT	1
Alternative diagnosis is at least as likely as DVT	-2
Clinical probability simplified score	Points
DVT likely	2 points or more
DVT unlikely	1 point or less



Signs of complications for kidney transplants include anorexia, hypertension, leukocytosis, and high BUN level, an enlarged and painful kidney. Anorexia indicates the body is malnourished, leukocytosis is an immune response to an infection with elevated white blood cell count, and a high BUN level indicates a poor ability for the kidneys to excrete urea (renal failure).

Signs of complications when working with patients post liver transplant are poor exercise tolerance, fatigue, jaundice, stool or urine color changes, and declining cognition. Patients are at risk of hepatic encephalopathy, or a buildup of toxins from poor liver function, causing confusion and poor cognition. Jaundice and color changes of stool may indicate poor liver function as well.

Heart [24]

There is evidence that nearly forty percent of patients who have had a heart transplant are hospitalized within one year and sixty percent are hospitalized within four years. The most common reasons are rejection and infection. Rejection, despite medication, occurs in one quarter to half of heart transplant patients within five years of surgery. In addition, there could be an infection in the sternal opening from the surgery, marked by skin tenderness, redness, and warmth.

For patients post lung transplant, around half of patients within five years face chronic rejection. Signs of this are malaise, fever, increased respiratory rate, decreased SpO2 readings, and increased labor of breathing. If PTs notice signs of distress in chronic stages, it is important to act immediately and with the urgency the situation demands. Patients should be referred back to their transplant surgeon for evaluation or sent to the emergency room if they are in acute distress.

Coordination of Care and Family [1]

Organ transplantation is an involved process that takes family support and an interdisciplinary team. Physical therapists should always refer to any healthcare professional depending on the patient's need. Helpful referrals may include dietitians for nutrition recommendations, specialist physicians, occupational therapists, speech therapists, respiratory therapists, psychologists, and many more.

A large part of success for patients after organ transplantation depends on family and community support. Physical therapists will need to educate families on how to help their loved one with mobility, how to perform exercises (home health and outpatient), the benefits of exercise, signs of complications, and any patient-specific education that is necessary. It truly takes a village to recover most effectively from organ transplantation.

Section 4 Key Words

RPE – Rating of perceived exertion; a subjective report measure used to determine how difficult a patient thinks a specific task is

Positioning Wedge – wedges used for patients to rotate in bed every two hours; used for patients who are immobile to prevent pressure injury

Section 4 Summary

Physical therapy intervention after transplantation takes many forms from exercise, education, and monitoring for complications. Physical therapists are a crucial member of the healthcare team to achieve best outcomes for patients post transplantation. PT is an opportunity for patients to achieve function again after the progressive debility they experienced both waiting for a transplant and after having surgery.

Case Study

Debra, a PT working her first week in the ICU, is evaluating and treating a patient, John, who is on post operative day 1 from a unilateral lung transplant. He is on supplemental oxygen at five liters, has a resting heart rate of 79, an SpO2 reading of 91%, and a respiratory rate of 23 when Debra enters the room to evaluate. John has not been mobilized yet and is alert and oriented and appropriate for physical therapy evaluation and treatment.

Reflection Questions

1. What evaluation items should Debra focus on with her patient John?
2. What precautions should Debra follow when beginning mobility with John?
3. What may a fever, high blood pressure, and high respiratory rate indicate?
4. Debra returns on John's fourth day, where he is on the hospital floor as he was stable to transfer out of the ICU. What should Debra focus on in treatment if John's goal is to discharge home in a week?
5. Paul, a physical therapist in an outpatient setting sees John six weeks after his transplant. What is a sign that he should be referred back to his medical team?

Responses

1. Debra needs to capture functional mobility, strength, range of motion, and vital and fatigue response to these items. This should be based on how John tolerates the activity and stay within safe vital ranges throughout. Appropriate mobility tasks include rolling, supine to sit, and potentially standing if John tolerates it.

2. Debra should ensure that John follows sternal precautions to protect his chest when moving. To do this, the log roll and hugging a sternal/chest pillow are good techniques. Debra should ensure that vitals are within expected limits, including heart rate, respiratory rate, SpO2, and blood pressure. SpO2 should not fall below around 88%, whether on supplemental oxygen or not.
3. This could indicate signs of infection or acute rejection and should be communicated promptly to the medical team for testing.
4. Debra should focus on every mobility task that John needs to be at home safely. This includes transfers, prolonged standing, ambulation, and stairs if he has them. Each interaction with John, Debra needs to monitor vitals, RPE, and for signs of complications.
5. John should be referred back for signs of chronic rejection, such as a fever, poor tolerance to exercise, poor oxygenation, or elevated or low blood pressure or heart rate.

Conclusion

Patients who undergo kidney, liver, lung, and heart transplantation face extensive disease prior to the transplant, extensive surgery, and a long rehabilitative journey. However difficult, transplantation is the ultimate long-term solution for end-stage organ disease. This course detailed the involvement of rehabilitation professionals in the functional assessment, intervention, and detection of complications in patients with a history of organ transplantation. Physical therapists and other rehabilitation professionals play a vital role in helping these patients build functional capacity to participate in their lives again. PTs will see patients post organ transplantation in virtually every setting - the ICU, other hospital floors, subacute settings, home health, and outpatient. A patient-centered, evidence-based approach detailed in this course is key in achieving successful outcomes in the rehabilitation of patients post organ transplantation.

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