Chapter 39

Failing Cardiac Transplant

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Case Scenario

A 12-year-old male weighing 40 kg with a history of congenital aortic stenosis for which he underwent cardiac transplantation in infancy has been posted for cardiac catheterization to assess hemodynamics, obtain myocardial biopsies, and perform coronary angiography. He was clinically well until the previous several weeks but has recently developed decreased exercise tolerance and is no longer keeping up with his peers. At his last cardiology visit 6 months ago there were no concerns, and an echocardiogram at that time showed normal biventricular function. In the holding area, he is quiet and reserved. He is tachypneic and has a heart rate of 130 beats/minute.

Key Objectives

- Understand preoperative assessment goals for cardiac transplant patients.
- Describe the risks and benefits of anesthesia for cardiac transplant patients.
- Describe team preparation for patient management to optimize patient outcomes.
- Discuss commonly seen complications in patients with heart failure undergoing an anesthetic.

Pathophysiology

What is the epidemiology of pediatric cardiac transplantation?

Cardiac transplantation is a life-saving procedure for children with heart failure unresponsive to medical management. In 2015 alone 684 pediatric heart transplants were performed, representing approximately 12% of all heart transplants [1]. Congenital heart disease (CHD) remains the most common indication for recipients under 1 year of age. Dilated cardiomyopathy, the most common etiology for transplantation in older children, is increasingly a reason for heart transplantation in patients less than 1 year of age.

What are the outcomes for patients who undergo pediatric cardiac transplantation?

Recent data from the International Society of Heart and Lung Transplant (ISHLT) registry demonstrate an impressive 1-year survival of 83% for all pediatric age groups. The best outcomes occur in the youngest patients, with a median survival of 22.3 years for patients <1 year of age compared to 13.1 years for those transplanted at >11 years of age [1]. From a survival standpoint, cardiomyopathy patients fare better in the early post-transplant years compared to their CHD counterparts. In the subgroup of patients with CHD, patients with single ventricle physiology who have undergone surgical palliation(s) have the least favorable outcomes. Not surprisingly, patients requiring extracorporeal membrane oxygenation (ECMO) support who undergo transplantation do less well than those who do not require mechanical support. Patients supported with ECMO also do less well than those supported by a ventricular assist device (VAD) prior to transplantation.

Clinical Pearl

Patients transplanted for cardiomyopathy have lower early mortality than patients transplanted for CHD, but the long-term transplant survival is comparable for both groups.

What are the early and late complications of cardiac transplantation?

In the early post-transplant period complications of cardiac transplantation include acute rejection, anastomotic related issues with the transplanted heart, and postoperative infection. Given the interval of time that has passed since this patient's heart transplant (>10 years), chronic complications are the more likely cause of his new symptoms; these include rejection, infection, and cardiac allograft vasculopathy. Graft survival is also compromised by poor compliance with immunosuppressant and other post-transplant medications.

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Post-transplant lymphoproliferative disease is the most frequent malignancy in heart transplant patients.

Anesthetic Implications

What questions should the family be asked to better understand the patient's condition?

Patients and their guardians should be asked the baseline preoperative questions germane to all patients undergoing an anesthetic. These include medication regimen and adherence, allergy history, fasting status, the presence of coexisting illnesses or organ dysfunction, and any history of recent acute illnesses or problems with previous anesthetics. In post-menarche patients pregnancy status should be ascertained. As these patients and their families have great experience and frequent contact with the medical system, reviewing the chart prior to the preoperative interview can save the family from the frustration of repeating what is already documented and spare the interviewer from appearing unprepared. Any new symptoms, such as exercise intolerance, should be explored for duration and rapidity of onset. Often patients will deny exercise intolerance or significantly underestimate their actual disability if specific questions are not asked.

Clinical Pearl

During the preoperative patient and family interview, it is imperative to explicitly ask if new symptoms have arisen. Bear in mind that patients may underestimate changes in functional status or exercise tolerance.

What information should be gathered from the medical record?

At a minimum, the results of recent electrocardiograms (ECG) and echocardiograms should be reviewed in the medical record; ideally, the actual studies should be reviewed. Changes from previous exams should be noted. Is there an arrhythmia, prolonged QT interval, or a new bundle branch block? Has there been a change in the qualitative cardiac function? Is there any new valvular insufficiency or stenosis? The most recent chest radiograph should be reviewed for pulmonary edema, pleural effusions, and/or cardiomegaly. Previous anesthesia records should be examined for notes regarding airway management, any vital sign instability, and/or use of emergency medications. Laboratory data may give clues to the patient's volume status, overall nutritional status, and degree of heart failure.

What physical examination findings are important?

Prior to any patient receiving an anesthetic, a focused physical examination should assess the patient's general physical status, the airway, cardiac and pulmonary systems, and general cognitive state. In addition, for this previously transplanted child with heart failure, his cardiac examination should investigate whether he has any jugular venous distension, a murmur, gallop, or dysrhythmia. On pulmonary examination, does he have tachypnea, dyspnea, rales, or wheezing? Is there any hepatosplenomegaly, abdominal distension, or abdominal tenderness? How is the perfusion to his extremities? Does he have dependent edema? Is his mentation normal or is he lethargic? And does he appear ill or is he otherwise well appearing? Children with heart failure do not always appear ill despite compromised cardiac function, and supportive data such as the echocardiogram should be incorporated to provide a global assessment.

Clinical Pearl

Children in heart failure do not always appear ill. Therefore, it is important to factor in supportive data such as echocardiographic findings into the patient assessment.

What preoperative tests should be ordered prior to anesthetizing this patient?

Routine bloodwork is generally not necessary prior to cardiac catheterization, even in children with poor cardiac function. However, the impact of this patient's chronic immunosuppression and chronically decreased cardiac output would render some lab studies useful. A basic metabolic panel will provide information regarding electrolytes, blood urea nitrogen, and creatinine; this will be useful as the patient is likely to receive a contrast load if he undergoes coronary angiography and has a ventriculogram performed. Although not absolutely necessary to guide anesthetic management, a blood natriuretic peptide level would provide some insight into the degree of his heart failure. A recent echocardiogram, as mentioned earlier, will provide useful information about overall cardiac function. This patient is undergoing a diagnostic catheterization procedure; however, if interventions were proposed, a baseline hemoglobin and hematocrit as well as a type and crossmatch of red blood cells might be indicated.

Given this patient's recent change in functional status, a new echocardiogram should be completed and read by a cardiologist prior to induction of anesthesia. In this

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structurally normal heart, the most important considerations are biventricular systolic and diastolic function.

Clinical Pearl

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Can anything be done to optimize this patient prior to his procedure?

This case is time sensitive. Obtaining myocardial biopsies for evaluation is crucial for initiation of appropriate therapy. Based on clinical examination, a gentle bolus (5–10 mL/kg) of a balanced salt solution may combat potential hypotension caused by anesthetic agents; however, a patient with a failing heart may not tolerate a fluid load. If the patient is ill appearing, or supportive data indicates markedly depressed cardiac function, one should consider either initiating a low dose inotropic infusion (epinephrine 0.03 mcg/kg/minute) prior to anesthesia induction, or having such an infusion readily available.

Why and when should ECMO be considered in such a patient?

Extracorporeal membrane oxygenation is a lifesaving therapy that can stabilize a decompensating patient and provide an opportunity for further evaluation and management. It does not guarantee an excellent outcome; indeed, a large percentage of such patients will succumb to their disease despite ECMO support. One of the key concepts of successfully utilizing ECMO as rescue from cardiac decompensation or cardiopulmonary resuscitation is early activation, which typically cannot occur unless there have been discussions with the ECMO team beforehand. This includes the surgeon who will place the cannulae, the nurses who will assist the surgeon, the perfusionist who will prime and manage the pump, and intensivists who will receive the patient should they survive. If ECMO is being contemplated as a possible therapeutic intervention option, this should be discussed with the family, ideally prior to the procedure.

What risks should be discussed with the family before proceeding to the catheterization lab?

The child with a remote heart transplant presenting with acute heart failure for cardiac catherization has a high risk of cardiac arrest. This patient should be considered high-risk, given his new complaint of poor exercise tolerance and the clinical presentation of tachycardia and tachypnea. Physical exam findings of jugular venous distension, poor peripheral perfusion, abdominal distension from ascites, hepatomegaly, and hypotension would add to the level of concern.

Hemodynamic decompensation can occur upon anesthetic induction or during the catheterization procedure itself. In addition to the routine discussion regarding the anesthetic risks, the parents or guardian should be made aware of this reality. The potential need for ECMO support should be discussed and the family's wishes documented. As these patients span the age range of infants to young adults, the amount of information discussed with them should be guided by their developmental stage and their ability to provide assent or consent to the anesthetic.

What monitoring should be utilized?

Standard recommended American Society of Anesthesiologists monitoring, including 5-lead ECG, should be used, even for cases where no sedation is planned. End-tidal carbon dioxide should be monitored for all cases. The placement of an arterial line should be considered, depending on the hemodynamic status of the patient. During many cases, a femoral arterial line is placed by the interventional cardiologist and can be used for monitoring during the majority of the procedure. For this patient, while a preinduction arterial line might not be placed it would be a consideration post-procedure if continued inotropic support was required.

How should a safe and appropriate anesthetic for this patient be provided?

Depending on the age of the patient and his or her ability to cooperate, numerous sedative and anesthetic options exist for patients undergoing cardiac catheterization. Many mature patients can be managed like adults with sedation alone. In cases where the risk of hemodynamic complications outweighs the benefits of being anesthetized, the best option is generally monitored anesthesia care, reassurance, and no medications. Clearly these are not options for very young, uncooperative, or developmentally delayed patients who would not tolerate light sedation alone.

Conscious sedation can be achieved with many different agents and in many different combinations. Propofol, ketamine, midazolam, fentanyl, and dexmedetomidine have all been used for procedural sedation in this patient population. Judicious dosing of propofol is necessary to account for the potential for both respiratory depression and hypotension related to the decrease in systemic vascular resistance (SVR). While the sympathomimetic effects of

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ketamine are favored for maintaining cardiovascular stability, in patients who have exhausted their catecholamine reserve the negative inotropic effects of ketamine become unopposed and can precipitate cardiovascular collapse. The risk of respiratory depression is higher when midazolam, fentanyl, and/or propofol are used in combination. Although dexmedetomidine is generally well-tolerated in transplant patients [2]. it should be used with caution in patients with acute cellular rejection as there is a potential risk for cardiac arrest [3].

For this patient, the option for procedural sedation would depend on the maturity level of the patient and skill of the interventional cardiologist. A 12-year-old patient who underwent transplantation in infancy will be very familiar with catheterization procedures from annual surveillance catheterizations. His feelings could range from being well adjusted, even familiar with undergoing the procedure with light sedation, to having high anxiety as a chronic medical patient. It is also important to know if the patient can lie flat for the procedure. Mentation must be intact. If proceeding with sedation, midazolam, fentanyl, and/or very low dose propofol (20 mcg/kg/minute) could be utilized if required. The drawback to this method is that if the patient becomes unstable, the airway must first be secured. In this particular scenario, the initiation of preemptive inotropes is likely not necessary, unless of course the baseline blood pressures are already very low.

Do pediatric patients undergoing anesthesia for cardiac catheterization require endotracheal intubation?

As noted previously, cardiac catheterization procedures do not require general anesthesia (GA) for all patients, so a natural away with supplemental oxygen provided by nasal cannula is adequate for patients undergoing sedation. A laryngeal mask airway (LMA) is acceptable for patients undergoing GA, although if one is concerned that a significant risk of cardiac arrest exists, securing the airway with an endotracheal tube is prudent.

How should anesthetic induction proceed?

Induction of anesthesia is the period of greatest risk for patients with decreased cardiac function. With severe cardiac dysfunction, one must be optimally prepared and maximally vigilant. When cardiac function is compromised, the rate of intravenous (IV) administration of drugs for induction should be slow to account for delayed onset of medications. In this 12-year-old patient, an IV induction is strongly preferred; the risk of an inhalation induction with no IV access in a patient with symptoms of heart failure is simply excessive and has the potential to quickly result in deterioration. Inhalation or mask induction should be considered only infrequently for routine diagnostic studies in nonfailing patients. Having emergency medications immediately available is a must and these should include epinephrine, phenylephrine, and calcium. As mentioned previously, initiation of a low-dose inotropic infusion prior to induction may help to minimize the potential hypotension experienced with anesthetics. The ideal induction agent would maintain SVR and have no effect on cardiac function. Judicious use of induction agents is required.

For this patient, etomidate, along with a small amount of fentanyl (less than 1 mcg/kg) and rocuronium are good induction choices. Prior to induction, an epinephrine infusion at 0.03–0.05 mcg/kg/minute could be initiated. Since this patient is at higher risk for clinical decompensation, use of an endotracheal tube would be preferred over an LMA. There is a greater likelihood of hypotension with a general anesthetic, so one must be prepared to readily treat this; both epinephrine boluses (both 1 mcg/kg spritzers and 10 mcg/kg code doses), volume, phenylephrine (bolus dose 1 mcg/kg), and calcium (chloride formulation dose 10 mg/kg, gluconate formulation dose 30 mg/kg) should be available to administer if needed.

Clinical Pearl

Inhalation or mask induction should be considered only for routine diagnostic studies in nonfailing patients. Having emergency medications immediately available is a must and these should include epinephrine, phenylephrine, and calcium.

What complications can occur and how should one be ready to treat them?

Hypotension, arrhythmias, low cardiac output syndrome, and coronary vasospasm are potential complications. As discussed previously, hypotension is very common after the induction of anesthesia, more so with GA than with monitored sedation. A decline in ventricular function of 6%–10% can be expected in patients with transplanted hearts undergoing GA [4]. Phenylephrine and epinephrine should be ready to administer. Antiarrhythmic medications such as adenosine and lidocaine should be available, and most importantly, a defibrillator with appropriately sized paddles and settings should be present in the room. Low cardiac output syndrome can be treated with a variety of inotropes. Typically, epinephrine is selected, as it provides both chronotropic and inotropic support. Coronary vasospasm can be induced during selective coronary angiography and is often first noticed by the interventional cardiologist when the contrast does not clear normally from the coronary artery. A quick response with

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nitroglycerin injected into the coronary artery catheter may prevent cardiovascular collapse.

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Hypotension is the most common complication, but be wary of arrhythmias, low cardiac output syndrome, and coronary vasospasm in the catheterization laboratory. Vasospasm can occur during selective coronary angiography and may first be noticed by the cardiologist when the contrast does not clear normally.

Where should the patient recover after this procedure?

A patient with an uncomplicated anesthetic course can safely be recovered in the post-anesthesia care unit (PACU). Even patients who required a low dose inotropic infusion during the case may often be weaned successfully at the end of the procedure and be taken to the PACU. Intensive care unit (ICU) admission is required for patients with an ongoing need for inotropic support; a change in neurologic status; cardiac, respiratory, or airway concerns that require advanced care and continuous monitoring; and newly diagnosed arrhythmias.

When should intensive care unit admission be considered necessary?

The ICU should be notified that this patient is being anesthetized and they should be prepared to accept him post-procedure. If there are no available ICU beds, that would be an indication to delay the procedure until a bed is available. If the procedure occurs uneventfully, and the catheterization did not reveal new information mandating ICU admission, it is possible to manage such a patient on the pediatric cardiac floor post-procedure.

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Suggested Reading

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