Perioperative management of a patient with left ventricular failure

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INTRODUCTION
Congestive heart failure (CHF) is a complex clinical syndrome where the heart is unable to pump blood at a rate that is commensurate with the requirements of the metabolising tissues or is able to do so only at an elevated ventricular filling pressure. The estimated lifetime risk for developing CHF is 1 in 5. Heart failure is the commonest reason for hospital admission among adults over 65 years of age. Congestive heart failure presents the clinical anaesthesiologist with a unique set of challenges. Thorough knowledge of the clinical features and medical management of CHF, and the potential effects of anaesthetics on cardiac function, will help to guide the patient safely through the perioperative period.

CHF is characterised by impaired ventricular performance, exercise intolerance, a high incidence of ventricular arrhythmias and a shortened life expectancy. Coronary artery disease and hypertension are the two major risk factors for the development of heart failure in the elderly. Other risk factors include the male gender, diabetes mellitus and advancing age. Heart failure is the final common pathway of a variety of cardiovascular disease entities. Early stages of heart failure can benefit from medical management while end-stage congestive heart failure is amenable only to cardiac transplantation. As cardiac organ donors are limited in numbers, ventricular assist devices have become popular as bridge-therapies for patients awaiting cardiac transplantation.

Heart failure can be broadly subdivided into two distinct forms termed as diastolic dysfunction and systolic dysfunction. Diastolic dysfunction or diastolic heart failure is caused by inadequate ventricular relaxation preventing adequate end-diastolic filling of the ventricles. This type of heart failure primarily affects the left ventricle. Systolic dysfunction or systolic heart failure is caused by inadequate force generation resulting in inadequate ejection of blood from the ventricles. This type of failure can affect either ventricle, though failure of the left ventricle is more common.
PATHOPHYSIOLOGY OF HEART FAILURE

Congestive heart failure is associated with enlargement of the chambers of the heart with increased ventricular wall thickness and stiffness. These morphological changes lead to important functional changes that affect both the ability of the ventricles to relax (diastolic dysfunction) and contract (systolic dysfunction).

Diastolic filling of the ventricle happens in 3 phases; isovolumetric relaxation phase, passive ventricular filling and atrial contraction. At the start of ventricular diastole, the ventricular muscle relaxes without any change in dimension (isovolumetric relaxation phase). This is an active ATP-dependent process resulting in sequestration of calcium within the sarcoplasmic reticulum. In heart failure, this process breaks down, resulting in a ventricle that fails to relax and therefore becomes stiff and less compliant. In the normal heart, passive ventricular filling accounts for 75% of ventricular filling (preload), with the last 25% of ventricular filling being brought about by atrial contraction. However, the poorly compliant ventricle seen with diastolic dysfunction depends more on atrial contraction for building up adequate preload. Patients with diastolic dysfunction need close attention to optimise their preload as they do not tolerate hypovolaemia well.

Systole is divided into 2 phases; an isovolumetric contraction phase which ends with the opening of the aortic valve and an ejection phase where blood is ejected into the aorta (ending with closure of the aortic valve). Both these are ATP-dependent active processes involving interaction between actin and myosin. Systolic dysfunction is said to exist when the heart fails to generate sufficient force to eject blood from the ventricle.

CLINICAL PRESENTATION

The clinical presentation of a patient with CHF is relatively straightforward as it includes a constellation of symptoms and signs that are pathognomonic of heart failure. Preoperative evaluation of heart failure includes eliciting a thorough history, detecting pertinent physical findings, and obtaining selected laboratory and specialised diagnostic tests.

One of the earliest symptoms of CHF is the presence of dyspnoea on exertion or shortness of breath. This sensation of difficult, laboured, and uncomfortable breathing is related to pulmonary congestion which decreases lung compliance and in turn increases work of breathing. Orthopnoea is a feeling of breathlessness on assuming the supine position. Intrathoracic blood volume increases and raises the left ventricular filling pressure. This results in the patient developing laboured breathing when lying flat. The
Dyspnoea gets relieved with the assumption of the upright position. Paroxysmal nocturnal dyspnoea is a form of orthopnoea in which the patient wakes up suddenly feeling suffocated a few hours after falling asleep. Though simple orthopnoea may be relieved by sitting the patient upright at the side of the bed with the legs hanging down, a patient with paroxysmal nocturnal dyspnoea may experience coughing and wheezing that often persists even with the assumption of the upright position, taking up to 30 to 60 minutes to resolve.

Cough often accompanies dyspnoea and is considered a “dyspnoea equivalent”. It is characteristically non-productive and is brought on by exertion or recumbent position. Cough is secondary to bronchiolar congestion resulting in excessive mucous production. Drugs such as angiotensin converting enzyme inhibitors can produce a dry, hacking and forceful cough as a side effect that can confound the symptoms of heart failure.

Anginal pain can be a presenting symptom of CHF and is a manifestation of increasing myocardial oxygen demand brought about by increasing ventricular wall thickness. Nocturnal diuresis is seen with redistribution of blood flow and an increase of renal perfusion brought about by recumbency. Decreased cardiac output results in easy fatigueability. Decrease in cerebral blood flow may be manifested as alteration in mental acuity, confusion, disorientation or memory impairment.

**MEDICAL AND SURGICAL MANAGEMENT OF CONGESTIVE HEART FAILURE**

Treatment of CHF begins with attention to associated conditions such as hypertension, ischaemic heart disease or valvular heart disease. If symptoms do not get controlled despite adequate attention to the above co-existing conditions, the physician introduces the three cornerstones of pharmacological treatment which include digitalis, diuretics and vasodilators. Digitalis and diuretics are usually used for initial control of CHF and vasodilators added to optimise cardiac function by reducing afterload.

Surgical management of heart failure is the new dimension that has now been added in the management of end-stage heart failure. The spectrum of surgical procedures range from **coronary artery bypass grafting** to **heart transplantation**. However, the availability of donor hearts far outnumbers the number of potential recipients who have been placed on a heart transplant list. To tide over this waiting period, several surgical options that have become available include placement of a left ventricular assist device or partial left ventriculectomy.
ANAESTHETIC CONSIDERATIONS

Patients with CHF are not good candidates for elective surgery. Presence of CHF has often been described as the single most important factor for predicting postoperative cardiac morbidity. The clinical condition of a patient with heart disease can be classified using the New York Heart Association (NYHA) classification.

Class I  No limitation and ordinary physical activity does not cause symptoms
Class II Slight limitation of physical activity with ordinary activity resulting in symptoms
Class III Marked limitation of physical activity with less than ordinary activity resulting in symptoms
Class IV Inability to carry on any activity without symptoms and symptoms are present even at rest

Those who are in NYHA Classes I and II can often be managed safely at most centres by exercising adequate precaution. Patients belonging to Class III and IV often need intensive haemodynamic monitoring intraoperatively and care in an intensive care unit following all but the most minor surgery. Irrespective of the NYHA Class to which they belong, patients need to be evaluated and optimised with medical management prior to surgery. The patient population that is likely to be offered surgical management for CHF include those belonging to NYHA Class IV, a predicted life expectancy of less than six to twelve months and an ejection fraction less than 20% on maximal medical therapy.

A complete cardiology workup including a 12-lead ECG and an echocardiography to evaluate ejection fraction and wall motion abnormalities is essential before scheduling for elective surgery. Any drug therapy that the patient is on should be noted and those on diuretics such as spironolactone (more than 25 mg/day) should have their potassium levels carefully monitored as there is a risk of hyperkalaemia. Patients receiving ACE inhibitors often have significant blood pressure changes perioperatively. The anaesthesiologist should be vigilant and ready with vasopressors, intravenous fluids and other drugs to treat haemodynamic instability during the perioperative period.

Both general anaesthesia as well as regional anaesthesia have been used successfully in patients with CHF undergoing noncardiac surgery. When general anaesthesia is chosen, the effects of intravenous and inhalational anaesthetics on cardiovascular function should be borne in mind. Opioids, benzodiazepines and etomidate are acceptable options for anaesthetic induction as these drugs have little or no direct myocardial depression. One must bear in mind that the addition of nitrous oxide to opioids, or a combination of
Benzodiazepines and opioids can be associated with significant depression of the cardiac output and blood pressure. On the other hand, the addition of nitrous oxide to diazepam is known to retain cardiovascular stability. In the presence of severe CHF, the use of opioids alone as the only drug for induction and maintenance of anaesthesia is justified as opioids are known for their cardiostability. While ketamine may be used for anaesthetic induction, propofol is known to produce an unacceptable drop in both cardiac output as well as blood pressure. Muscle relaxants such as pancuronium, as also other drugs with sympathomimetic activity, can precipitate cardiac dysrhythmias in patients on concomitant digitalis therapy.

The spectrum of surgical procedures done for CHF range from traditional coronary artery bypass grafting to cardiac transplantation. However, due to a critical shortage donor hearts, cardiac transplants centres offer interim measures such as placement of a left ventricular assist device or partial left ventriculectomy until a donor heart becomes available.

Anaesthetic management of the cardiac donor is critical. Mean arterial blood pressure must be maintained between 80 to 90 mmHg with a combination of vasodilators, vasopressors or inotropes. The urine output should be be maintained between 100 to 200 mL/hour. Volume resuscitation and diuresis may be indicated. Adequate oxygenation and ventilation should be maintained with appropriate ventilatory support. Anaesthetic management of the recipient should begin with a review of current laboratory data. Invasive haemodynamic monitoring in the form of pulmonary artery catheters that allow mixed venous oxygen saturation monitoring and/or intermittent cardiac output monitoring. High-dose narcotics or benzodiazepines titrated with cardiostable muscle relaxants (vecuronium or cisatracurium) and 100% oxygen are commonly used during induction. The anaesthesiologist should be prepared to use inotropic and vasoactive drugs to maintain haemodynamic stability. Though the denervated implanted heart responds to circulating catecholamines, one may need to use isoprenaline infusions for adequate chronotropy. Intensive care should continue into the postoperative period for a successful outcome following cardiac transplantation.

Left ventricular assist devices can be classified as short-term support devices such as intraaortic balloon pump or long-term support devices such as total artificial hearts. Partial left ventriculectomy (PLV) is another interim surgical procedure that is particularly useful in dilated cardiomyopathy. Anaesthetic management of a patient undergoing PLV is very similar to that of the patient receiving cardiac transplant or left ventricular assist device insertion. To prevent excessive stress on the ventriculectomy suture site, mean arterial pressure should be maintained between 60 to 70 mmHg and volume overload avoided.
CONCLUSION

Congestive heart failure is one of the commonest reasons for admission to hospital in patients over the age of 65 years. While medical management with digitalis, diuretics and vasodilators constitutes the mainstay of management, surgical options are now being offered to patients with end-stage heart disease (NYHA Class IV). Partial left ventriculectomy is now becoming a popular bridge therapy while awaiting heart transplantation. Other options available are short-term and long-term ventricular assist devices and heart transplantation. The modern-day anaesthesiologist is therefore likely to come across patients in CHF both in the operating room and in the intensive care unit. Thorough knowledge of the pathophysiology of CHF and the impact of pharmacological therapy on anaesthetic management will help in the safe perioperative management of these patients.