Case Reports

Successful Management of a Left Ventricular Assist Device Malfunction in an Outpatient Setting

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Abstract: Heart disease kills as many people as nearly all other causes of death combined. Chronic, progressive, end-stage heart failure results in substantial health care costs and immeasurable suffering for both individuals in particular and society in general. Ventricular assist devices are having an increasing role in supporting patients with severe circulatory compromise. These devices provide support and make it possible for patients to be discharged from the hospital and returned to their communities. System failures and device malfunctions do occur and are the most common cause of death for patients on device support. We present a device malfunction involving a HeartMate XVE Bridge to Transplant that occurred while the patient was at his home, >100 mi. from our center. The patient was placed on a HeartMate after a re-operative coronary artery bypass surgery. He was discharged to his home on day 43 after device implant. On the 447th post-operative day, two “Red Heart” alarms occurred. After initiating hand pumping of the device, the patient’s companion contacted our center, and the local Emergency Medical Service was activated. The patient was transported by helicopter to the Maine Medical Center, where he was placed on a backup pneumatic console and subsequently transferred to a Boston transplant center. The patient subsequently underwent cardiac transplantation. It is imperative to have a definitive strategy and clear support plan to address device malfunctions and system failures. Considering the growing number of ventricular assist device patients discharged home, these occurrences will be more common outside of the hospital setting. Education of clinicians, patients, and their companions, as well as local rescue teams and community hospitals, is essential for successful outcomes and continued quality of life. Keywords: ventricular assist device, heart failure, HeartMate, cardiac transplantation. JECT. 2007;39:49–52

Heart disease kills more individuals than all other causes of death combined (1). Chronic and progressive end-stage heart failure results in substantial health care costs and causes immeasurable suffering for individuals and society. The first clinical implant of a ventricular assist device (VAD) was performed in 1963 by Hall et al. (2) in a patient that developed cardiogenic shock after undergoing an aortic valve replacement.

Although the pump worked well, the patient had suffered a neurologic injury before implantation that did not improve despite adequate support. Circulatory assistance was terminated after 4 days (2). The device was a Dacron-made intrathoracic left ventricular bypass pump placed between the left atrium and the descending thoracic aorta. VAD technology has continuously improved over the last 45 years in terms of portability, power source management, and patient manageability. Today, VADs have an increasing role in supporting patients with severe circulatory compromise. Patients with devices are often discharged to their homes. Many return to work in their communities and enjoy an improved quality of life.

In the United States alone, there are currently >1400 patients on VADs, with a projected increase to 4600 patients by 2010 (3).

Device malfunctions and system failures do occur and are the most common cause of death for patients on support (4). The device evaluation committee from the Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart failure (REMATCH) trial evaluated device malfunctions and system failures.

Device malfunctions were defined as an instance when any component of the system failed to perform its in-
tended function. This may include a loss of display; inability to operate the batteries; and/or temporary loss of life support caused by the device.

System failures were defined as the inability of the device system (including redundant backup components) to maintain adequate circulatory support that qualified with two or more of the following conditions: acute reduction in cognitive function, hemodynamic instability defined as a sustained blood pressure of <80 mmHg and a heart rate >120 beat/min, and acute oliguria (urine output <30 mL/h) (5).

CASE REPORT

We present a 54-year-old man, status post-redo coronary artery bypass grafting (CABG) ×1, with a history of cerebral vascular accident, borderline diabetes mellitus, perioperative myocardial infarction, and ischemic cardiomyopathy. Before implant, a transesophageal echo exam showed a hypokinetic lateral wall and an estimated left ventricular ejection fraction of 20%. Because of the progressive heart failure despite intra-aortic balloon pump (IABP) and inotropic support, a HeartMate XVE (Thoratec Corporation, Pleasanton, CA) was implanted on the fourth post-operative day. The patient was transferred to our Intermediate Care Unit on post-operative day (POD) 14. The assist device team, including a cardiac surgeon, perfusionists, nursing, occupational therapy, physical therapy, nutrition, and social work, met weekly to discuss patient progress and a plan for discharge.

Discharge planning included various levels of VAD education for the patient and companion; family and friends; community hospital; visiting nurses; local cardiologists; and emergency medical technicians (EMTs) and other first responders such as police and fire departments. Preparations for discharge included patient and caregiver education and addressing psychosocial needs. Escorted outings, day trips, and overnight stays were also arranged. A thorough home inspection was performed including contacting the local electric company to arrange for pri-
ority power and having an emergency generator available. The patient was discharged on POD 43 to his home, which was >100 mi. from our hospital. Field support was provided including, but not limited to, emergency contact numbers, biweekly to monthly clinic visits, pump analysis as needed, snow removal, and telephone check-ins. The patient was able to go on vacation that summer, taking a ferry from Maine to Nova Scotia, Canada, traveling >600 mi.

On POD 442, a potential device malfunction occurred involving a “Red Heart” alarm. Red heart alarms occur when the HeartMate XVE stops pumping because of a mechanical or electrical problem. The patient’s companion paged the perfusionist on call and was encouraged to call the local emergency medical service (EMS). The patient was transferred to our center and was admitted to the assist device service. The HeartMate system controller was changed out by the perfusionists. Pump analysis was performed through waveform and vent filter testing. The patient was discharged with analysis pending.

On POD 447, the patient experienced two “Red Heart” alarms with the pump stopping. His companion began to handpump the device and proceeded to change out the system controller, with no resultant actuation of the HeartMate. Handpumping was continued, and the EMS was called. The patient was air lifted to Maine Medical Center and was placed on the pneumatic console by the perfusionists. He was immediately transferred to the transplant center in Boston and was subsequently transplanted on POD 468.

DISCUSSION

Data card analysis provides a “snapshot” of device performance that measures the amperage and runtime data of a single pump cycle. Increases in amperage could mean an increase in afterload. An increase in pump afterload could be caused by hypertension, an occluded vent filter, fluid in air vent line, kink in the outflow graft, or occluded inflow or outflow valve. Extended periods of increased pump afterload may lead to premature bearing wear within the pump motor.

Vent filter analysis measures elements that are captured on the foam of the filter. Calcium, potassium, salts, copper, and titanium are measured by way of weight percent. Increases in calcium, potassium, and salts indicate fluid ingress, whereas an increase in copper and titanium could be indicative of bearing wear. The results from our analysis taken on POD 442 (5 days before device malfunction) were sent to us by Thoratec within 6 weeks.

The data card analysis “did not reveal any abnormal pump function.”; 1.63 A were measured (concern is gen-

![Figure 2. Example of high current waveform analysis.](image-url)
erally >1.50 A, with a peak of 2.20 A; Figures 1 and 2). This slight increase in amperage was not of great concern to the engineers at Thoratec.

Vent filter analysis revealed the presence of titanium, with a measurement of 1.3 weight percent (reference range, 0.5–1.3 weight percent). This would indicate the beginning stages of main bearing wear.

In conclusion, device malfunctions and system failures do occur and often without warning. Therefore, it's imperative to have a definitive strategy and clear support plan to address these clinical scenarios. The Cardiac Services Assist Device Program at Maine Medical Center uses a collaborative partnership between the patients, their family, and our multidisciplinary team.

Considering the growing number of VAD patients being discharged home, these types of occurrences will become more common outside of the hospital setting.

Education of patients and their companions, as well as local rescue teams and community hospitals, is essential for successful outcomes and continued quality of life.

REFERENCES