In case of an isolated graft to the arch vessel, one should ensure sufficient space to inflate the endoclamp without compromising cerebral perfusion. If uncertain, one should consider cannulating the brachial or axillary artery to perfuse the brain during the endoclamp inflation.

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Ventricular assist device use for the treatment of acute viral myocarditis

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Acute viral myocarditis is a rare condition and associated with high mortality due to the rapid development of heart failure. Ventricular assist devices (VADs) have become a life-saving approach for patients with acute viral myocarditis who are otherwise refractory to the aggressive medical therapy.[1,2] We reviewed our institutional experience to evaluate the use of VADs as a treatment option for viral myocarditis.

Patients and Methods

From January 1995 to March 2005, 11 patients underwent VAD implantation (left VAD [LVAD] in 10, biventricular assist device [BIVAD] in 1) for acute viral myocarditis at Columbia-Presbyterian Medical Center. Patients were evaluated with regards to demographics, presenting symptoms, histological manifestations, and electrocardiographic findings. Outcome variables included bridge-to-transplantation rate and long-term survival. Data was collected by retrospective chart review.

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Received for publication July 26, 2005; accepted for publication Aug 3, 2005.

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J Thorac Cardiovasc Surg 2006;131:1190-1

0022-5223/$32.00

doi:10.1016/j.jtcvs.2005.08.073

Results

The mean age of the population was 33.8 ± 14.2 years. None of the patients had a previous history of cardiac disease. Prodromal symptoms preceding the onset of myocarditis included flulike symptoms, chest pain, syncope, and varicella syndrome (Table 1). All patients were transferred from outside institutions with diagnoses of decompensated heart failure complicating acute viral myocarditis. The diagnosis of viral myocarditis was primarily based on clinical presentation and histologic findings and supported by viral serology and culture. Viral pathogens were isolated only in 6 of the 11 patients (Table 2). Histologic evidence of acute myocarditis using the Dallas Criteria was present in 8 patients (72.7%); only cellular infiltrate was found in the remaining patients.[3] At the time of admission to our center, 4 patients were temporarily supported by either intra-aortic balloon pump (n = 3) or extracorporeal membrane oxygenation (ECMO; n = 1). All patients had electrocardiographic abnormalities including sinus tachycardia, diffuse nonspecific repolarization abnormalities, and bundle branch block.

LVAD was used as the sole support system in 8 patients with left ventricular failure. BIVAD was temporarily implanted in 2 patients with biventricular failure and was switched to LVAD after recovery of right ventricular function. One patient was bridged to transplant using BIVAD alone without the necessity for LVAD.

There were no operative mortalities (0.0%). Nine patients had postoperative complications including acute renal failure, right heart failure, reoperation for bleeding, pericardiocentesis for cardiac tamponade, and sepsis (Table 1). The mean duration of VAD support was 58.4 ± 91.7 days (range 5-324 days). Four patients (36.4%) died in-hospital on VAD support with a mean survival of 12 ± 6 postoperative days. Causes of death for these patients included right heart failure (n = 2), sepsis (n = 1), and multiorgan failure (n = 1). The mean preoperative LVAD score was significantly higher in patients who died compared with those who survived (6.3 ± 1.3 vs 3.5 ± 1.9, $P = .034$).[4] Of the 7 surviving

TABLE 1. Clinical characteristics of patients with acute viral myocarditis

Patient no.	Age	Sex	Initial symptoms	Preoperative support	LVAD score*	Complications	Outcome
1	31	M	Varicella	—	2	Reop	Explant
2	36	F	Flulike, chest pain	IABP	1	—	Transplant
3	36	M	Flulike	IABP	5	—	Transplant
4	29	F	Syncope	—	6	RHF	Expired
5	50	M	Chest pain	—	5	Reop	Expired
6	49	F	—	—	6	ARF, RHF	Expired
7	12	M	Flulike, chest pain	BIVAD	8	ARF, Sepsis, Reop	Expired
8	20	M	Flulike	—	6	Reop	Transplant
9	40	F	Flulike	—	4	RHF	Transplant
10	54	F	—	IABP, BIVAD	3	Reop	Explant
11	16	F	Flulike	ECMO	BIVAD	Pericardiocentesis	Transplant

LVAD, Left ventricular assist device; *IABP*, intra-aortic balloon pump; *RHF*, right heart failure; *Reop*, reoperation for bleeding; *ARF*, acute renal failure; *BIVAD*, biventricular assist device. *LVAD score out of 10 possible points, directly proportional to postoperative mortality rate.

TABLE 2. Viral pathogens and histology of endomyocardial biopsies

	No. of patients	Percentage (%)
Viral pathogens		
Epstein-Barr virus	2	18.2
Varicella zoster virus	1	9.1
Influenza virus	1	9.1
Coxsackie virus	1	9.1
Cytomegalovirus	1	9.1
Histology (Dallas criteria)		
Myocyte necrosis and cellular infiltrate	8	72.7
Cellular infiltrate	3	27.3

patients, 5 were successfully bridged to cardiac transplantation and are still alive with a mean posttransplantation survival of 6.5 ± 4.3 years. The remaining 2 patients underwent LVAD explantation following myocardial recovery.

Discussion

Viral infection of the myocardium occurs not uncommonly, and in most cases, is of little clinical consequence. However, in rare instances, it can lead to acute heart failure, followed by severe hemodynamic compromise and cardiogenic shock. Temporary mechanical support by way of ECMO, LVAD, or BIVAD has been shown to improve survival in these patients either by bridge to transplantation or bridge to recovery.

The choice of device for mechanical support in these patients remains controversial. The Thoratec HeartMate (Thoratec Corp, Pleasanton, CA) LVAD is suitable for explantation in candidates for myocardial recovery, yet also convenient for long-term support until a cardiac allograft becomes available. In select patients then, LVAD alone seems sufficient. In cases of fulminant viral myocarditis with severe left and right ventricular dysfunction, however, BIVAD may be the more appropriate option. ECMO remains a suitable alternative, especially in pediatric patients with viral myocarditis-induced acute heart failure. However, it is not ideal for extended periods of support.[5]

To our knowledge, this report is the largest series to date of patients undergoing VAD insertion for the treatment of acute heart failure secondary to viral myocarditis. These patients represent a high-risk group as evidenced by high VAD scores. At the time of admission, 8 patients were ventilator-dependent and 5 patients were on mechanical support. Moreover, LVAD score was found to be a significant predictor of mortality.

In summary, we believe that VAD implantation is an effective therapy in patients with viral myocarditis complicated by acute heart failure with uni- or biventricular support determined by severity of illness at presentation. Preoperative risk assessment is crucial to predict mortality in these patients. Development of new devices may decrease postoperative complications, facilitate earlier implantation, and improve overall survival in this population.

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