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Development of de novo aortic valve incompetence in patients with the continuous-flow HeartWare ventricular assist device

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BACKGROUND: In this study we investigated the development of aortic incompetence (AI) and change in aortic root and left ventricular dimensions after implantation of the continuous-flow HeartWare ventricular assist device (HVAD) in our adult patient cohort.

METHODS: A retrospective analysis of serial echocardiograms was performed on patients implanted with an HVAD between July 2009 and July 2013. Data from echocardiograms performed before and at 1 and 2 years (±3 months) were analyzed. Patients with native aortic valves (AoVs) with no previous intervention and HVAD in situ for ≥6 months were included.

RESULTS: A total of 73 HVADs in 71 patients with a mean duration of support of 624 ± 359 days were included in our study. One patient developed moderate AI at 1 year (1.9%). Mild or greater AI was more likely in those with a closed or intermittently opening AoV at 1 year ($p = 0.005$). Aortic annulus dimensions increased significantly at 1 and 2 years, regardless of extent of AI. At 2 years, in those with mild or worse AI, the sinuses of Valsalva were also larger ($p = 0.002$). Left ventricular end-diastolic dimension (LVEDD) was significantly reduced in those with no or trace AI at 1 and 2 years ($p = 0.012$ and $p = 0.008$, respectively), but remained unchanged in those with AI at both time-points.

CONCLUSIONS: The development of more than mild AI is rare in HVAD patients at our center. When encountered, it is more common with a closed AoV. Dilation of the aortic annulus, and root dilation in those with mild or more AI, is seen with HVAD support over time.

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Worldwide, continuous-flow left ventricular assist devices (cfLVADs) comprise >95% of implants.[1] Long-term left ventricular assist devices (LVADs) are frequently used as destination therapy (DT).[2] Currently in the UK, LVADs are licensed only as bridge-to-transplant (BTT) therapy for patients with refractory heart failure (HF).[3] In an era of seemingly declining numbers of available organs, these devices provide an important means of prolonging survival and improving patient symptoms and quality of life while awaiting organ transplantation. In the UK, the rate of BTT at 12 months is approximately 10%.[4]

De novo aortic incompetence (AI) in patients with cfLVADs results in the development of a wasteful

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recirculation circuit, which, if significant, over the course of time can result in adverse hemodynamics. This is due to reduced effective pump flow, increasing pump work and reduced systemic perfusion.[5] Pathologic changes in the native valve have been thought to be causative in the development of de novo AI. The aortic valve (AoV) in patients with LVADs has been found to be thinner, with partial fusion of leaflets along with leaflet shortening secondary to curling seen on pathologic examination.[6–8] The commissural fusion has been to shown to be secondary to a non-inflammatory process.[9]

The HeartWare LVAD (HVAD; HeartWare, Framingham, MA) is a third-generation cfLVAD that has been commercially available in Europe (CE approval in 2009) and Australia (TGA approval 2011) before being approved in November 2012 by the Food and Drug Administration for use in the USA. The published literature to date on the development of new AI in patients supported with cfLVADs has been based predominantly on data from experience with the HeartMate XVE (HM-XVE; Thoratec Corporation, Pleasanton, CA) and HeartMate II (HMII; Thoratec) cfLVADs.[10–16] The number of patients with HVADs has been limited in previous studies.

The HVAD software for the European market has the facility to enable or disable the Lavare cycle. This feature is not available in North America. The Lavare cycle occurs at 60-second intervals and lasts for 3 seconds (Figures 1 and 2). During this cycle, the pump speed is lowered by 200 rpm below baseline for 2 seconds, then increased by 200 rpm above baseline before returning to baseline (refer to instructions for use of the HeartWare VAD, Rev0208/13 EN). This may have an impact on the long-term development of AoV pathology.

We have implanted HVADs at our institution since 2009 and now have a growing cohort of patients with longer term devices. This has provided a unique opportunity to study the development of de novo AI. The aim of this study was to examine the development of new AI after implantation of the HVAD in our adult patients and, using echocardiography, document changes in the aortic root and left ventricular dimensions over time.

Methods

A retrospective review of echocardiograms was performed in patients who had an HVAD implanted at our institution between July 1, 2009 and July 31, 2013. Patients were excluded if they had previous AoV surgery, or if surgery on the AoV was carried out at the time of HVAD implant. Only those who had an HVAD in situ for at least 6 months were included in the subsequent analysis.

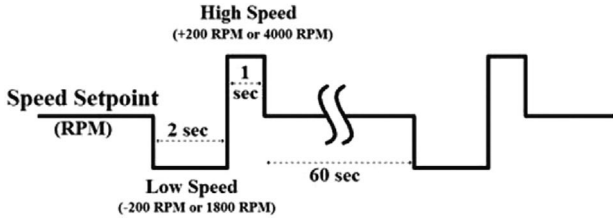

Figure 1 LAVARE™ Cycle. Reprinted with permission from HeartWare, Inc.

Surgical implantation technique

Implantation of the HVAD was carried out via median sternotomy on cardiopulmonary bypass using cannulation of the ascending aorta, and a 2-stage venous cannula via the right atrium (RA) or selective cannulation of the superior and inferior vena cava, respectively. Device implantation was carried out according to a standard technique recommended by the manufacturer. The outflow graft was attached to the right side of the middle part of the ascending aorta using a side-biting clamp. A simple 10-mm aortotomy was performed and the anastomosis was carried out end-to-side using a 5-0 Prolene continuous suture line. The length of the outflow graft was adjusted according to the size of the right ventricle (RV) and RA; that is, particular care was taken to ensure sufficient length to allow positioning of the graft entirely at the lowest level of the pericardium around the RV and the RA. Therefore, at the time of chest closure, the graft was visible only in the area of the anastomosis to ascending aorta. All patients had the Lavare cycle enabled before discharge from hospital. This was not disabled at any time-point, even if the patient was re-admitted with suspected HVAD thrombus.

Echocardiographic analysis

Echocardiograms performed within 3 months of implant were considered baseline. Thereafter, echocardiograms performed at 12, 24 and 36 months (± 3 months) post-implant were reviewed. These were performed by experienced cardiac sonographers and reported according to standards of the British Society of Echocardiography. The echocardiograms were further reviewed by the authors (S.B. and C.B.) for the purposes of this study. AI was assessed visually in the parasternal long- and short-axis views. A graded scale was used to report the grade of severity of AI as follows: none; trace; mild; mild–moderate; moderate; or worse. Opening of the AoV was assessed visually over a 3-beat cycle. The aortic annulus, the sinus of Valsalva (SoV) and the left ventricular end-diastolic dimension (LVEDD) and end-systolic dimension (LVESD) were all measured using the parasternal long-axis window.

Statistical analysis

SIGMAPLOT for Windows version 11.0 (Systat Software, Inc., San Jose, CA) and Microsoft EXCEL 2007 were used for data analysis. With normally distributed data, results are presented as mean ± standard deviation of the mean (SD). If data were not normally distributed, median and interquartile ranges (IQRs) are reported. Groups were compared using Fisher's exact test for categorical variables and Student's *t*-test or the Mann–Whitney rank sum test for numerical variables. To evaluate trends in results over time using matched data, repeated-measures analysis of variance (ANOVA) on ranks or Friedman's repeated-measures ANOVA was employed. $p < 0.05$ was considered statistically significant.

This study adhered to the terms of the UK Data and Protection Act and Freedom of Information Act, and was approved to obtain confidential information by the local Caldicott Guardian.