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ABSTRACT

Left ventricular assist device (LVAD) insertion in patients with advanced heart failure with deteriorating clinical status is life saving, and LVADs are now being inserted into an increasing number of patients with advanced heart failure. They were initially inserted as a bridge to transplantation, and the decreased availability of donor hearts means that an increasing number of patients are requiring LVAD support for survival when their clinical status deteriorates. There is strong evidence that with LVAD unloading, particularly when combined with pharmacological treatment, the patients’ myocardial function can also recover, allowing device removal and avoiding the need for transplantation, immunosuppression and its associated complications. This indication, known as “bridge to recovery” is a newer and expanding indication. The future use of LVADs, particularly as survival continues to increase, is extending to their wider use as destination therapy, when the device is inserted lifelong as an alternative to transplantation, and this role is likely to increase further. LVAD technology is evolving quickly, survival is improving, the incidence of complications is decreasing and durability of the devices is improving.

Medical treatment together with resynchronisation therapy has improved the survival of many with heart failure, but there remain a large group of patients who, despite optimal medical treatment, are in New York Heart Association (NYHA) class III/IV heart failure with a very poor prognosis. Unfortunately, the number of usable donor hearts available for heart transplantation for these patients has significantly decreased over recent years and now across the UK only about 125 heart transplants are performed each year, a number totally inadequate for the need. Furthermore, the UK has an urgent listing system whereby a patient generally on inotropic or intra-aortic balloon pump support is a priority for the next available heart provided that that centre “pays back” their next heart into the country’s pool. The proportion of heart transplants that are used for urgent recipients in the UK has been increasing over the past few years, reflecting the desire to use available hearts in those patients who will benefit most (fig 1).

Left ventricular assist devices (LVADs), which are artificial hearts that assist the circulation, are rapidly evolving and are increasingly used to treat patients with advanced heart failure. LVAD technology itself is also evolving quickly. They were initially inserted as a bridge to transplantation in patients with advanced heart failure with deteriorating clinical status who were unable to wait any longer for heart transplantation. These patients had deteriorating NYHA class IV heart failure despite inotropic ± intra-aortic balloon pump support, usually with end-organ dysfunction. LVADs are life saving in these patients with a deteriorating condition who would otherwise die before a donor heart became available, and also improve secondary organ function for transplantation, reduce pulmonary hypertension and allow for improvement of nutritional status. The decrease in donors means that an increasing number of patients are requiring LVAD support for survival when their clinical status deteriorates.

There is now compelling evidence that with LVAD unloading, recovery of the patients myocardial function can also occur. This allows device removal and avoids the need for transplantation, immunosuppression and its associated complications and leaves the patient with an excellent quality of life. This also means that the precious resource of a donor organ can be used for another needy person. This indication, known as “bridge to recovery” is a newer and expanding indication.

The future use of LVADs, particularly as survival continues to increase, is likely to be as destination therapy—that is, when the device is inserted lifelong as an alternative to transplantation; this has already started in the USA and parts of Europe. Early referral of the deteriorating patient and insertion of the LVAD before the onset of severe end-organ dysfunction is extremely important.

Factors affecting early survival and reversal of organ dysfunction include chronicity of disease, intrinsic end-organ functional reserve, comorbid conditions and age. Early intervention improves outcome—the stress of surgery superimposed on a fragile patient with advanced disease contributes to poor outcomes in the short and long term.

The role of the cardiologist in the care of these patients is likely to increase, most importantly by recognising that patients need an LVAD and by referring them early enough for a successful outcome. Cardiologists will also need to assess the patients before implantation and also assess myocardial recovery while the patient is on the device and use adjuvant treatment to promote myocardial recovery.

HISTORY

The advent of cardiopulmonary bypass (CPB) paved the way for early mechanical support systems and the inability to wean some patients from CPB stimulated interest in more prolonged mechanical support. In 1971, De Bakey reported the first successful clinical application of a true VAD which was a pneumatically driven diaphragm pump—a 57-year-old woman could not be weaned from CPB following valve replacements and was supported for 10 days with a paracorporeal circuit from left atrium to right axillary artery, she was then weaned successfully and subsequently...
discharged from hospital. The total artificial heart (TAH) was used first as a temporary support device until transplantation was possible by Cooley et al in 1969 in a 47-year-old man who could not be weaned from bypass following repair of a left ventricular aneurysm. This TAH had been developed by Liotta and the De Bakey Baylor-Rice research team and it provided 64 h of support until transplantation could be performed. The world’s first permanent TAH implant occurred in 1982 with the Jarvik-7 in Dr Barney Clark, a 61-year-old retired dentist with advanced dilated cardiomyopathy who survived 112 days of support. Copeland performed the first planned TAH implant as a bridge to transplantation in 1985.

In 1978 Norman et al reported a case of bridging to transplantation using an intracorporeal pneumatic device for 5 days, the patient survived the support but died after transplantation. In the early 1980s cardiac transplantation became widely applied, but it was clear that the need for hearts was greater than donor availability and there was a strong incentive to develop better assist devices. In 1984 Portner and colleagues reported the first successful cardiac transplant following bridging with a Novacor LVAD at Stanford.

**Ventricular Assist Devices**

There have been important advances in VAD technology over the past decade. VADs can broadly be divided into first-, second- and third-generation devices. The first-generation VADs are pulsatile volume displacement pumps. The main ones are the Heartmate I, the Thoratec paracorporeal VAD (PVAD) and the Novacor. These pumps provide excellent haemodynamic support but have constraints, particularly their size (they are large hence needing extensive surgical dissection), the presence of a large diameter lead (which is more prone to infection), an audible pump, the need for medium–large body habitus and limited long-term durability as they were only designed for up to 1 year of support. The second-generation VADs are axial flow pumps that are smaller than first-generation VADs (principally through elimination of a blood sac or reservoir necessary for a pulsatile system). Surgical implantation requires less extensive dissection and therefore it is less traumatic for the patient. They are also easier to insert into patients with smaller body habitus. The smaller diameter drivelines appear to result in lower rates of driveline infection. These continuous-flow pumps are quiet and hence needing extensive surgical dissection), the presence of a large diameter lead (which is more prone to infection), an audible pump, the need for medium–large body habitus and limited long-term durability as they were only designed for up to 1 year of support. The second-generation VADs are axial flow pumps that are smaller than first-generation VADs (principally through elimination of a blood sac or reservoir necessary for a pulsatile system). Surgical implantation requires less extensive dissection and therefore it is less traumatic for the patient. They are also easier to insert into patients with smaller body habitus. The smaller diameter drivelines appear to result in lower rates of driveline infection. 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PVAD is positioned on the anterior abdominal wall with cannulas crossing into the chest wall. Warfarin (international normalisation ratio = 2.5–3.5) and aspirin antiocoagulation are required for this pump. There is also now an implantable version of this pump—the IVAD.

The Novacor LVAD has been implanted in over 1600 patients for durations up to 6.1 years. It has a pump drive unit which is implanted in the left upper quadrant of the abdomen and incorporates a dual pusher plate 70 ml stroke volume, sac-type blood pump with a smooth blood-contacting surface, coupled to a pulsed-solenoid energy converter drive. The pump drive unit is implanted in a pocket in the left upper quadrant of the abdomen, the inflow cannula is inserted through the diaphragm into the left ventricular (LV) apex and the outflow graft anastomosed to the ascending aorta. Pump flow is maintained through the pumping cycle, in contrast to the typical diaphragm pusher-plate pump. The early version of this pump had some thromboembolic problems but modification of the materials drastically reduced this problem.9

Second-generation devices
Second-generation axial flow pump devices are being increasingly used. These are continuous-flow rotary pumps that have only one moving part, the rotor, unlike the the first-generation devices, and hence are expected to be more durable. The Heartmate II device is a continuous-flow axial blood pump (fig 3A) with an internal rotor with helical blades that curve around a central shaft. As the blood flows around the pump rotor, the spinning action of the pump rotor with its three curving blades introduces a radial or tangential velocity to the blood flow and imparts kinetic energy to the blood, which then flows past the outlet stator vanes. The twisted shape of the outlet stator vanes converts the radial velocity of the blood flow to an axial direction. The pump weighs 850 g, is approximately 7.0 cm in length and 4.0 cm at its largest diameter; the second-generation Heartmate II is one-seventh the size and one-quarter of the weight of the first-generation Heartmate I device. It can generate up to 10 l/min. The axial flow design and absence of blood sac eliminate the need for venting, currently required for the first-generation of implantable pumps, thus reducing the size of the percutaneous driveline and also eliminating the need for internal one-way valves. Over 3000 patients have had a Heartmate II implanted.

The Jarvik 2000 is an axial flow, continuous-flow pump which has an intraventricular position with the whole pump sitting within the LV cavity (fig 3B). The pump weighs 85 g, is 2.4 cm in diameter and 5.5 cm long. The single moving component is the impeller located in the centre of the titanium housing. A brushless direct-current motor, contained within the housing, creates the electromagnetic force necessary to rotate the impeller. Blood flow is directed through the outlet graft by stator blades located near the pump outlet and returns to either the ascending or descending aorta. The pump can generate up to 8 l/min. Pump implantation with the outlet graft in the descending aorta can result in stasis and clot formation in the aortic root, hence an intermittent low-speed controller can be used and many units, including our own10 anastomose the graft to the ascending not the descending aorta to reduce this complication. Because this pump has no pocket, serious pump infections are rare.

The Berlin Heart Incor is also an axial flow pump. As blood passes into the Incor it first passes the inducer that guides the laminar flow onto the actual impeller, which is suspended by a magnetic bearing and floats free of contact with other parts. The impeller operates between speeds of 5000 and 10 000 rotations per minute. The stationary diffuser behind the rotor has specially aligned blades which reduce the rotational effect of the blood flow and add additional pressure to assist the transport of blood in the outflow cannula to the aorta.

The MicroMed-De-Bakey VAD is another axial flow rotary pump. It has an elbow-shaped inflow cannula that inserts into the LV apex, a pump housing unit which houses the impeller (which is actuated by an electromagnet), a Dacron outflow conduit graft and an ultrasonic flow probe that encircles the outflow graft and provides direct, online measurements of pump flow.

Third-generation devices
Heartware (fig 4), VentAssist and Terumo are magnetic levitation third-generation pumps that are now being tested in clinical use. Heartware has no bearings and hence is likely to have a long durability, is much smaller than previous devices (fig 5) and easier to implant surgically than previous generation pumps.

CLINICAL ROLE
LVADs are being increasingly inserted into patients with advanced heart failure, initially mainly as a bridge to transplant, but now also as a bridge to recovery and increasingly, as destination therapy.

Bridge to transplantation
As a result of advances in the medical treatment of heart failure the death rates for patients with advanced heart failure on the waiting list of the United Network for Organ Sharing (UNOS) in the USA decreased from 45% in 1990 overall to 17% in 1999. For patients with advanced medical urgency status 1A in 1999 the death rate was 58% compared with 20% for medical urgency status 1B and 13% for regular urgency status 2.12 Between 1996 and 1998 (n = 11 542) for every 12 UNOS status 1 patients waiting 1 month for a heart transplant one died compared with one death for every 120 status 2 patients.13 14 Hence LVAD and inotrope-supported patients stand to gain most from transplantation. LVAD insertion as a bridge to transplantation is usually carried out either because of cardiogenic shock and deteriorating clinical status when it is felt the patient will not survive long enough to receive a donor organ or when the patient has developed secondary organ dysfunction such that transplantation becomes contraindicated.

In the multicentre evaluation of the Heartmate vented electric LVAD as a bridge to transplantation, 71% of 280 patients survived to transplantation or device removal, and in the Cleveland Clinic experience of 277 LVADs, 69% survived to transplantation.15 From 60% to 75% survival to transplantation has been reported in other series.16–18 However, these data are all from the first-generation pumps, which are associated with higher mortality. Data from the second-generation pumps, which would be expected to have a better outcome owing to their smaller size, easier surgical implantation etc, are now becoming available. Recently, Miller et al published a prospective multicentre study of 138 NYHA class IV patients on a transplant waiting list who underwent Heartmate II implantation as a bridge to transplantation.19 All were receiving inotropic support (except for 11% intolerant because of arrhythmia) and 41% were also in-aortic balloon pump dependent. After 180 days, 100 (75%) patients had reached the principal outcome of transplantation, recovery or survival on ongoing support.
with eligibility for transplantation. Patients on Heartmate II support improved NYHA class, 6 min walk functional status and quality of life. An additional five (4%) were alive and ongoing but not yet eligible for transplantation and another three (2%) were alive but had had a device replacement—that is, overall survival was 81% at 6 months. Interestingly, four patients removed themselves from the transplant waiting list as they preferred to continue mechanical support. The overall survival of patients who underwent transplantation, recovered their cardiac function or continued to receive mechanical circulatory support while remaining a candidate for transplantation was estimated to be 70% at 1 year.20

These 133 patients enrolled from March 2005 to May 2006 represented the “primary cohort”. Enrolment has continued and patients subsequently enrolled between May 2006 and March 2007 represent the continued access protocol cohort, which consists of a further 146 patients—an overall total 279 who have now reached 1 year after implantation. When 194 had reached 1 year after implantation an abstract showed that 1-year survival had improved, with 77% being alive at 1 year21 and
a Kaplan–Meier survival of 68±5% at 18 months. Now 279 have reached 1 year, survival has improved further (Miller L, personal communication) and survival has improved between the first 135 patients and the subsequent 146 patients. Furthermore, a high proportion of patients are now being discharged.

Data are beginning to emerge for the third-generation devices. VentrAssist have published data describing an implantation in 33 patients as a bridge to transplantation. The success rate was 82% at a follow-up point of 154 days with these results maintained at 365 days, with 82% either receiving a transplant (60.6%) or becoming eligible for transplantation (21.2%).

Significant improvements in quality of life occurred on the VentrAssist. Thirty-five patients have received the Durahert VAD with a Kaplan–Meier survival of 78% at 2 years, and 86% of 1 month survivors have been discharged home. Fifty patients have received the Heartware device with an 85% 1-year actuarial survival.

Support on the device allows renal function, nutritional status and pulmonary vascular resistance to improve before transplantation, which usually takes several weeks or months. Transplantation should only be considered once these improvements have occurred.

A recent study analysed a total of 3711 patients listed as UNOS status 1A candidates in the USA between January 2000 and December 2006, including 2208 (59%) who were initially treated medically and 1503 (41%) rescued with VADs as a bridge to transplant before the day of listing. Of the 2208 medically managed patients, 451 (20%) subsequently underwent VAD implant as a bridge to transplant. Patients were followed up until heart transplantation, death, removal from the waiting list or 1 September 2007. The use of VADs in medically managed status 1A candidates was associated with increased probability of survival and/or heart transplantation from 66.5% to 87.1% at 3 months (p<0.001). The authors concluded that elective VAD implantation as a bridge to transplant should be strongly considered in medically managed UNOS status 1A candidates at high risk of death and/or with an expected long waiting time to heart transplantation.

Bridge to recovery

A small number of patients supported with a LVAD have shown significantly improved myocardial function, and there is now compelling evidence that prolonged near-complete unloading of the left ventricle with the use of an LVAD is associated with structural reverse remodelling that can be accompanied by functional improvement. This can be sufficient in some cases to allow explantation of the device; however, the exact proportion of patients in which this is possible is unknown but has been reported to be only 5–24% in various series.

We have evolved a strategy which combines mechanical unloading using LVAD support with specific pharmacological interventions to first, maximise the incidence of recovery in patients with dilated cardiomyopathy and second, to improve the durability of recovery following explantation. Briefly, the pharmacological interventions are designed to act on component parts of the myocardium with the aim of reversing the pathological hypertrophy, remodelling and normalising cellular metabolic function. When maximal reverse remodelling, as judged by echocardiographic measurements of LV dimensions with the pump switched off, has been achieved, clenbuterol is given. This drug has been shown to induce physiological hypertrophy in several experimental models, including those with pressure overload hypertrophy. Using this strategy it has been possible to promote recovery and allow removal of the pump in approximately two-thirds of patients. Furthermore, these patients remain well 8 years later, suggesting this recovery is durable and they have a good quality of life.

The HARP (Harefield Recovery Study) trial is a multicentre study that has started in nine centres in the USA which is using the same protocol aiming to reproduce the results of this study.
prospective single-centre study on a larger scale. In these patients we have also observed reversal of many molecular changes seen at the time of LVAD implantation. Myocardial samples obtained at the time of device insertion and removal along with serum samples provide an ideal opportunity to explore the myocardial and circulating factors involved in the recovery of human heart failure.

Destination therapy

The future use of these devices, particularly as survival increases, is likely to be their wider use as destination therapy and this is already happening in the USA and some parts of Europe. Successful experience in the bridge-to-transplant patients, particularly among those with prolonged periods of implantation, justified evaluating these devices as long-term or destination therapy for chronic heart failure.

A randomised trial (REMATCH—the Randomised Evaluation of Mechanical Assistance for the Treatment of Congestive Heart failure) allocated 129 patients with advanced heart failure to 20 experienced cardiac transplant centres to receive either optimal medical treatment or a Heartmate I LVAD as permanent treatment. Patients were in NYHA class IV for at least 60 of 90 days despite maximal medical treatment and they were ineligible for cardiac transplantation (age >65 years, insulin-dependent diabetes with end-organ damage, chronic renal failure or significant irreversible comorbidity); median age was 69 years. One-year survival in the LVAD group was 52% compared with 25% in the group receiving optimal medical treatment and 2-year survival was 23% versus 8% in the optimal medical treatment group. Overall, all-cause mortality was reduced by 48%. Interestingly, 1-year survival for patients under 60 years was 74%. Both NYHA class and quality of life were better at follow up in the LVAD group. The survival benefit was particularly significant for those receiving inotropes (survival benefit p = 0.0014 for LVAD versus optimal medical treatment). There was a significant improvement in survival for LVAD patients enrolled during the second half of the trial (January 2000 to July 2001) compared with the first half (May 1998 to December 1999), reflecting improvements in patient management and device modifications even throughout the period of the trial. The 1-year survival in the second half of the trial was 59% versus 44% in the first half (p = 0.029) and the 2-year survival 38% versus 21%. The Minnesota Living with Heart Failure scores also improved significantly over the course of the trial. Terminal heart failure caused the majority of deaths in the medical treatment group, whereas the most common causes of death in the device group were sepsis (41% of deaths) and device failure (17% of deaths). The adverse event rate was also significantly lower as the trial progressed and the rates/patient-year of sepsis, renal failure and infection were significantly lower for those enrolled during the second half.43

A further study of patients implanted with the first-generation Heartmate I device at four high-volume centres following REMATCH from January 2003 to December 2004 showed improved 90% and 61% 30-day and 1-year survival, respectively.44 The death rates due to sepsis and device failure were 8.3 times and 2.2 times lower than REMATCH, respectively. Overall, patients were 2.1 times less likely to experience an adverse event and there was a reduction of 66%, 63%, 89% and 92% in neurological dysfunction, sepsis, site infection and for combined and suspected device failure respectively. The INTrEPID trial is a prospective non-randomised clinical trial comparing the Novacor first-generation pulsatile pump with medical treatment. Again the LVAD-treated patients had better survival rates at 6 months (46% vs 22%) and 12 months (27% vs 11%). Patients receiving medical treatment experienced no improvement in NYHA functional class, whereas 85% of the LVAD patients had either no symptoms or minimal heart failure symptoms at the last assessment. Quality-of-life measures improved in the LVAD group.9

Figure 5 Comparison of the size of a first-generation (Heartmate I), second-generation (Heartmate II) and third-generation (Heartware) device. Reproduced with permission.
Introduction of axial flow and centrifugal designs has improved LVAD survival further and reduced complications and many feel now there now needs to be a randomised trial of axial pumps versus optimal medical treatment. A trial is near completion randomising the pulsatile Heartmate I device against the Heartmate II continuous flow pump (fig 5).

The results of REMATCH led to FDA approval of the Heartmate VE for destination therapy in November 2002, and in October 2003 Medicare approved cover and reimbursement of LVADs for this indication in the USA.

Lietz et al divided 290 patients who underwent Heartmate XVE LVAD implantation between November 2001 and December 2005 as destination therapy into low-, medium-, high- and very high-risk groups (based on a composite risk score) who had 1-year survivals of 81%, 62%, 28% and 11%, respectively, showing that the very high-risk group significantly biases the overall results following VAD implantation. It is likely that to obtain good results after VAD implantation the very high-risk group should be “bridged to decision” with a short-term device to improve their clinical status first (see below).

Bridge to decision
Despite the improvements in the field of mechanical circulatory support seen in the past few years, the group of patients who present with severe heart failure in an extremely critical condition or “moribund” state are still a difficult group of patients to deal with usually because of the presence of end-stage organ failure and/or uncertain neurological status in a ventilated patient. The outcome remains poor in these very critically ill patients.

The Levitronix short-term extracorporeal VAD can be used as a “bridge to decision” in these extremely sick patients who have contraindications to the implantation of a long-term VAD or urgent transplantation at the time of presentation if these contraindications are considered acute and potentially reversible before deciding if a more expensive device or transplant should be used. Using short-term, low-cost devices such as the CentriMag in this setting is very effective in stabilising the haemodynamic state, improving the end-organ function, extubating the patient to assess neurological status and provides an opportunity to further assess their clinical condition.

Short-term, low-cost devices that can be inserted with minimal surgical invasiveness in such sick patients, often with coagulopathy, provide immediate haemodynamic stability and recovery for future assessment of these patients either for bridge to transplantation or bridge to recovery or as a long-term device. Short-term VADs are a fraction of the cost of longer-term VADs, and patients with a short-term VAD are easier to manage than patients with a long-term VAD. They can then be upgraded to a longer-term device when they are in a much better condition—usually extubated with normalised renal and liver function and with sepsis under control. Alternatively, some patients can be bridged straight to transplantation from the Levitronix device or straight to recovery, especially if they have a disease in which their myocardial function has the potential to recover in a short time—for example, myocarditis or after myocardial infarction.

Complications and problems with VADs
LVADs are not without complications as early on, perioperative haemorrhage and right heart failure can occur and later, infection, thromboembolism, haemolysis and device failure can be a problem. Earlier insertion of the LVAD before the development of multiorgan failure improves survival and reduces the risk of these complications. With evolving LVAD technology some of these complications are now improving.

Early complications following device insertion include perioperative haemorrhage, (which remains common but less of a problem with the newer continuous-flow pumps), abdominal complications and right ventricular failure. Often the underlying disease has a biventricular component and when the LVAD supports the left side of the heart and a normal cardiac output is returned to the right side, the right side can fail more and sometimes additional RVAD support is needed. Most commonly, this can be removed again after a short period. Abdominal complications caused by the device were common with the bulkier pulsatile devices, in particular the Heartmate I, which is inserted into the abdomen, and can lead to gastrointestinal obstruction, fistula and adhesions in some cases. However, abdominal complications are rare with the axial flow pumps and with devices that are not implanted into the abdomen, although gastrointestinal bleeding can occur.

Later complications include infection, thromboembolism, haemolysis and device failure. Infection can occur in the pump, in the pump pocket and around the driveline. The smaller surface area of foreign material of the axial flow pumps, the minimal movement of the device inside the body and the smaller driveline compared with the pulsatile pumps result in lower infection rates with the axial flow pump devices (0.31 vs 3.49 drive-line infections per patient year for the Heartmate II vs Heartmate I devices). Thromboembolism may take place—pump thrombosis is a complication that can occur causing obstruction of the pump, it usually manifests as an increased power consumption of the pump (seen as an increased wattage). Although it can be successfully treated with tirofiban/tissue plasminogen activator, it is associated with high mortality and can require a pump change. Thromboembolism is mainly avoided by the anticoagulation these patients require but stroke can still be a major problem. All devices except the Heartmate I require warfarin treatment and as these patients are anticoagulated, bleeding complications, such as intracerebral haemorrhage, can occur, hence the importance of controlling the blood pressure. Another recognised complication of continuous-flow pumps is bleeding from arteriovenous malformations of the intestine that are found incidentally in normal adults, this bleeding is worsened by the anticoagulation the patients require.

Device failure is another serious problem that can occur, particularly late after device insertion. Failure of the external components can take place, but these can usually be replaced, or of the internal components, which can be life-threatening. Device failure is more common with the pulsatile pumps as they have more moving parts and also have valves which can degenerate leading to valvular regurgitation. However, the pulsatile pumps do have a back-up system with a hand pump which can be manually operated by the patient or their carer (both of whom are trained in this procedure) and, consequently, device failure can be associated with low morbidity and mortality if appropriately managed. In the REMATCH trial, device failure was the second most common cause of death in patients with LVAD. Since then there have been many modifications to the Heartmate I device, which has significantly reduced the incidence of device failure. The second-generation axial flow pumps only have one moving part, the rotor, and hence are more durable and appear to have a lower rate of device failure. The third-generation magnetic levitation pumps have no bearings to wear out and are expected to be much more durable.
CURRENT SITUATION IN THE UK

In the UK, patients deemed to be deteriorating too fast to be able to wait for a suitable donor heart under the urgent scheme currently receive a VAD as a bridge to transplant or bridge to recovery. Current NCG (National Commissioning Group) recommendations support VAD use as bridge to transplant or bridge to recovery in patients who are appropriate candidates for cardiac transplantation or who will become appropriate for a transplant after a period of VAD support; or who have deteriorating heart function and clearly would not survive long enough to be transplant recipients despite the provision of an “urgent” category nationally. This service is currently provided by three centres (Harefield, Papworth and Newcastle) and is starting at Manchester, Birmingham and Glasgow. Survival in the UK following VAD implantation has significantly improved year after year over the past few years (unpublished data). Harefield Hospital started their VAD programme in 1986, Papworth in the mid-1990s and both are now well established and Newcastle started in 2003. Unfortunately, VAD implantation as chronic support or destination therapy is not yet funded in the UK.

CONCLUSIONS AND THE FUTURE

Insertion of VADs in patients with advanced heart failure with deteriorating clinical status is life saving, and they are being inserted into an increasing number of patients. Sustained reversal of severe heart failure (myocardial recovery) can be achieved with LVAD therapy, particularly when combined with pharmacological treatment. LVADs are rapidly evolving, which together with better patient management and selection is improving survival and lowering the rate of complications and is likely to lead to lower cost. The role of VADs as an alternative to transplantation—that is, destination therapy, is likely to increase in the future. It appears that as device design, patient selection and management and the promptness of referral continues to improve, the outcome for many patients with advanced heart failure will become much better.


