

Less invasive left ventricular assist device implantation—a match changer!

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Dr. Maltais manuscript (1) is a nice overview touching every major aspect regarding the strategy and the most important steps of less invasive left ventricular assist device (LVAD) implantation. This work gives an answer to the question why centers with very good results following LVAD implantation through a conventional sternotomy approach should adopt less invasive strategies when implanting second and third generation continuous flow devices as outlined in the Vanderbilt paper.

Mitral and/or tricuspid valve surgery are among the most common cardiac procedures which are increasingly performed through less invasive thoracotomy incisions to avoid sternotomy. Several randomized controlled studies have demonstrated excellent results that equal those of “larger incision” methods. Less invasive approaches for valve reconstruction and replacement surgery prove to be beneficial for several perioperative factors including bleeding, blood transfusion, ventilation time and hospital stay. Nonetheless open chest procedures remain the gold standard for valve surgery and no randomized study has yet been able to show a benefit of less invasive approaches for early mortality (2).

If one looks at the introduction of less invasive surgery for LVAD implantation, one may appreciate that the overall approach and development of the technique is quite similar to that used for mitral valve surgery: “How to do papers”, reports about single cases and small non-randomized studies have been published about initial experiences, showing that less invasive approaches for LVAD implantation are feasible and can be effectively implemented to become a standard procedure. These articles were followed by papers reporting on small cohorts that showed a reduced incidence

of bleeding, less need for blood transfusion, less respiratory morbidity and right ventricular failure (RVF) (3). Following all these reports, randomized studies are yet necessary to confirm that it is the less invasive approach itself that contributed to these favourable results. Benefits of this approach will need formal evaluation of efficacy and require controlled studies, preferably randomized.

Even though similar at the first glance, the second analysis of these two fields of application reveals significant differences. Although some clinical benefits are substantial, the main driving force behind less invasive approaches in cardiac valve surgery is still cosmetic issues, costs, and the aim to compete with percutaneous approaches feasible for interventional cardiology treatment. Sometimes, patients are reluctant to undergo a sternotomy while still being asymptomatic (4,5).

However, all these thoughts and factors have absolutely nothing to do with LVAD surgery: patients who need an assist device are terminal heart failure patients and therefore extremely symptomatic. They usually just want to survive and will never ask for smaller incisions. In addition there are no percutaneous alternatives and patients are not afraid of sternotomy: they will rarely demand for cosmetically sound solutions, as their only alternative is death.

Among multiple potential problems, three of them represent real challenges for every VAD team because they are strong predictors of outcome and survival: RVF, cerebrovascular accident and the need for reoperation. Although the authors have already roughly covered these areas, we would like to shortly add a few comments as we believe that by beneficially influencing these aspects, the less invasive approach in VAD surgery has the potential to

become a match-changer, when not a match-winner.

Right ventricular failure (RVF)

Newer generation continuous-flow LVADs have contributed to improve outcomes with lower incidence of immediate and mid-term RVF when compared with the pulsatile devices. Yet, RVF still occurs in 9% to 40% of LVAD recipients. Postoperative RVF is associated with poor outcomes, end-organ dysfunction, high mortality and reduced survival to transplant (6).

Less invasive approach may lead to less RV dysfunction. Several experimental and clinical studies show that an intact pericardium preserves the right ventricular function. Once the pericardium is incised right ventricular contractility has been shown to decrease and the physiologic response to changes in afterload and preload decreases.

Keeping the pericardium closed, the minimal invasive approach seems to protect the right ventricle from postoperative dilatation. Less bleeding and subsequent need for transfusion may further protect the right ventricle and the lungs (7,8). On the other side, if RVF occurs in the setting of less invasive LVAD implantation, access to the right heart is not possible and percutaneous ECMO would be the only solution.

Cerebrovascular accidents

Despite improved technology and different anti-coagulation strategies, stroke remains a significant complication following LVAD implantation. In the original randomized controlled trial of continuous flow-LVADs, the incidence of stroke (hemorrhagic and ischemic) was 18% at 2 years of follow-up. The Fifth Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) annual report had a nearly identical incidence with 17% stroke at 2 years (9,10). In this context Maltais *et al.* mention different sites for implantation of the outflow graft especially in patients with porcelain aorta and in those with proximal bypass graft anastomoses. Very recent reports from Riebandt *et al.* show that routine implantation of the outflow graft into the subclavian artery can reduce the rate of embolization into the carotid arteries. This approach may reduce the overall ischemic cerebrovascular event rate, as the first two aortic branches are protected from the ascension of possible thrombotic material into cerebral vessels. Furthermore, technical advantages are the relative ease of surgical exposure of the subclavian artery and the

fact that it is usually free from atherosclerosis.

Concerns about this technique are the compression of the outflow graft by the surrounding structures, excessive blood flow to the arm as well as flow disturbances on extensive elevation of the arm. Banding of the subclavian artery is mandatory if there is a mean pressure difference of more than 20 mmHg to avoid excessive blood flow to the arm (11).

Reoperations

Patients who receive LVAD as a bridge to transplantation will need reoperation for transplantation. Every surgeon who has performed transplantation in patients with previously implanted LVAD knows that pericardial adhesions and re-sternotomy is challenging and may increase morbidity and mortality of the second intervention. This observation has already been confirmed for redo valve surgery (12).

When initial surgery is performed through right mini-thoracotomy or small left subcostal incision, opening the sternum is considerably facilitated and the technical challenges of the second procedure are reduced: there is minimal to absent danger of heart injury, there are less adhesions, which means less postoperative bleeding and therefore less need for postoperative transfusion. This again positively influences the lung function and the recovery of the right ventricle of the transplanted heart.

Even patients that are not scheduled for subsequent transplantation may benefit from the reduced trauma due to a less invasive intervention. Should pump failure happen or drive line damage which is more likely to occur in patients on support for several years, the less invasive approach through thoracotomy will facilitate straightforward pump exchange in case of pump thrombus formation or driveline fractures. This means that the less invasive implantation technique may also be attractive in destination patients.

There are two additional aspects that we would like to add to this discussion and which should be considered as words of caution. A strategy to perform less invasive LVAD implantation should not compromise the completeness of therapy and safety. This concerns the requirement for concomitant coronary circulation tricuspid and mitral valve repair (MVR) and off-pump surgery.

The function of the right ventricle is one of the limiting factors in long-term survival of destination patients. Many patients require LVAD support for longer periods of time

(prolonged waiting time until transplantation and increasing application of destination therapy) and the presence of severe tricuspid valve regurgitation has been demonstrated to be likely associated with increased midterm morbidity and mortality. We favor, even in the absence of evidence-based data, reconstruction of the tricuspid valve with ring annuloplasty as soon as regurgitation is moderate to severe. There are at least theoretical short- and long-term benefits when tricuspid valve regurgitation is addressed. Elimination of tricuspid regurgitation may lead to improvement rather than worsening of the RV function and reducing venous congestion may improve hepatic and renal perfusion (13,14).

In patients bridged to transplantation, there are reports that concomitant MVR during implantation of continuous-flow LVAD may further decrease pulmonary vascular resistance more than after LVAD implantation alone. This may permit certain patients found to be ineligible for transplantation to become candidates after a certain period of LVAD support (15).

As concomitant valve procedures to LVAD implantation usually require full sternotomy, the threshold for addressing the valves should not change!

Secondly, we do not support the concept of implanting LVADs off-pump. Even in patients undergoing assist device implantation under full sternotomy we would refrain from off-pump procedures. Short period of asystole with the help of adenosine as reported in the Vanderbilt strategy (1) or rapid pacing during outflow graft connection may lead to passive dilation of the right ventricle which may be deleterious in patients with borderline preoperative RV-function. Sutures can also easily tear through thin myocardium when the sewing ring is attached to a beating and volume-loaded heart. In general, operation through a limited incision leaves fewer margins for error and options to deal with problems and complications are less comfortable when LVAD implantation is performed off-pump.

To benefit from the versatility of cardiopulmonary bypass and to reduce surface trauma, the use of an ECMO system may be beneficial.

We congratulate Dr. Maltais and his team for their work. The Vanderbilt strategy clearly shows the need for refining and further developing minimal and alternative approaches. This is of actual interest with the upcoming generation of smaller devices. Although less invasive LVAD implantation may have the potential to develop into a gold standard, initial steps should be cautious and never compromise results of a good working LVAD program.

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