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Percutaneous biventricular mechanical assistance as a bridge to heart transplant

Asistencia mecánica biventricular percutánea como puente a trasplante cardiaco

To the Editor,

The best therapeutic alternative for end-stage heart failure remains heart transplantation (HTx). Nonetheless, because of the severity of the disease and the presence of temporary contraindications, many patients are unsuitable for elective HTx and therefore require short- or long-term circulatory support as a bridge to HTx. Particularly in patients with biventricular heart failure, the circulatory support options before HTx have long been limited to extracorporeal membrane oxygenation (ECMO) and surgical assist devices such as EXCOR (Berlin Heart AG, Germany) and CentriMag (Thoratec Corporation, United States), all of which are associated with a high risk of peritransplant mortality.[1,2] Therefore, in recent years, simpler devices have been developed thatvia percutaneous or minimally invasive approaches, can provide temporary circulatory support for the left ventricle or even both ventricles with reduced risk.

The Impella device (Abiomed, United States) is a catheter-based microaxial ventricular assist device. This pump is used in coronary interventions, as well as for cardiogenic shock and as a bridge to HTx.[3] Various models are available, such as the Impella 5.0, CP, and 5.5 for left ventricular support and the Impella RP for right ventricular support. The latter is disadvantaged by an exclusively femoral venous access, which impedes patient mobility during extended support periods. This limitation is resolved by the CentriMag device, which can be implanted using a ProtekDuo dual-lumen cannula (LivaNova Plc, United Kingdom) that can be placed via the jugular vein. Here, we describe our initial experience with percutaneous biventricular assist devices (BiVADs) that combine an Impella device and the ProtekDuo cannula in 2 patients with biventricular dysfunction as a bridge to urgent HTx.

The first case concerns a 60-year-old man on the HTx waiting list due to ischemic dilated cardiomyopathy with severe biventricular dysfunction who experienced decompensation with limiting dyspnea and congestion requiring dobutamine and intense diuretic therapy. The patient exhibited elevated liver and kidney function biomarkers. Despite an initial improvement, he experienced a rebound in liver transaminases and creatinine at 10 days. We decided to implant a BiVAD as a bridge to urgent HTx (figure 1).

The second case involves a 53-year-old woman with anthracycline-induced dilated cardiomyopathy under treatment with twice-weekly levosimendan who was also on the waiting list for HTx. The patient experienced a sudden deterioration in functional class with hypoperfusion requiring treatment with biogenic amines, diuretic therapy, and ultrafiltration. Given the severe biventricular dysfunction and impossibility of weaning from the applied treatments, we decided to implant a BiVAD (figure 2).

Both patients showed evidence of multiorgan failure and severe right ventricular dysfunction that prevented implantation of a long-term left ventricular assist device as a bridge to HTx. In both patients, a similar procedure including fluoroscopy guidance and transesophageal echocardiography was followed for BiVAD implantation in a hybrid operating room. First, we used a minimally invasive procedure to implant the Impella 5.0 device for left ventricular support via the axillary artery, applying an 8-mm Dacron graft for anastomosis (right artery in patient 1 and left in patient 2). This required prior study of the artery diameter because it could have been a limiting factor for the implantation. Next, the ProtekDuo cannula was implanted via percutaneous puncture of the right jugular vein and placed in the distal lumen of the pulmonary artery for right ventricular support with a CentriMag device. Both patients were extubated a few hours later and began rehabilitation in a sitting position. No complications occurred. The patients were placed on the waiting list for an urgent

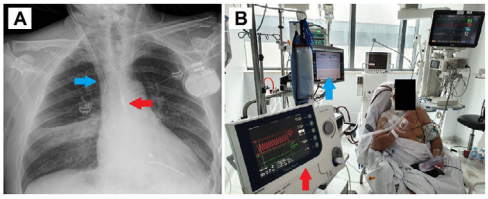

Figure 1. A: chest radiograph showing the Impella left ventricular assist device implanted via the right axillary artery (red arrow) and the ProtekDuo cannula and CentriMag right ventricular device implanted via the right jugular vein (blue arrow). B: extubated patient with both support devices performing rehabilitation while on the heart transplant waiting list.

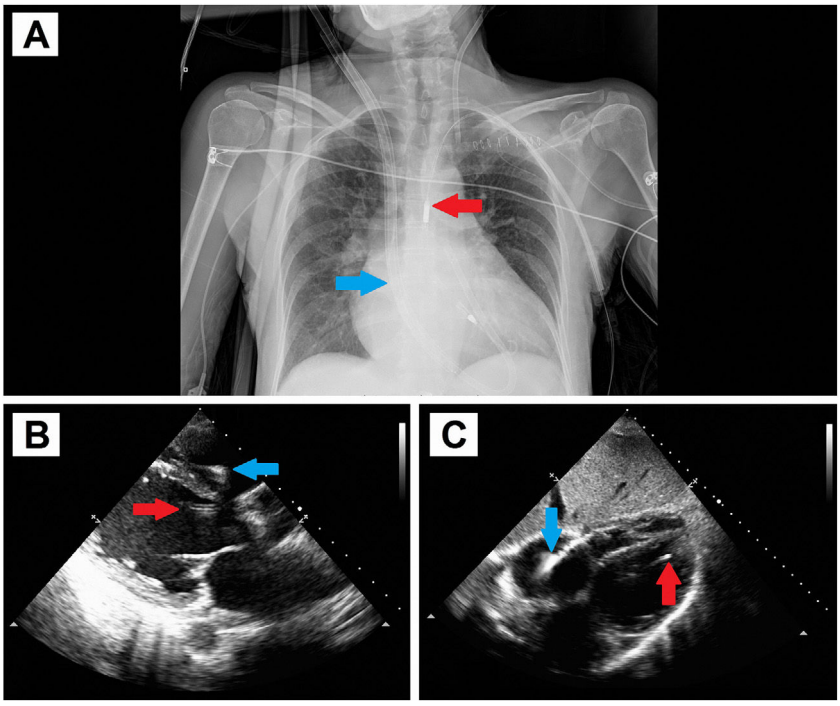

Figure 2. A: chest radiograph showing the Impella left ventricular assist device implanted via the left axillary artery (red arrow) and the ProtekDuo cannula and CentriMag right ventricular device implanted via the right jugular vein (blue arrow). B and C: transthoracic echocardiography with parasternal and subcostal planes for confirming the correct position of the implanted devices.

HTx once the multiorgan failure had resolved (notably, the creatinine levels of the first patient normalized, reaching 3.3 mg/dL). Htx was successfully performed after 21 and 15 days of support, respectively.

In 2019, the first case was reported of percutaneous BiVAD involving the Impella CP and the ProtekDuo cannula in a patient with viral myocarditis.[4] This strategy has multiple advantages due to the minimal invasivity of the procedure compared with other devices requiring median sternotomy, which results in fewer transfusions, early extubation, and a more rapid recovery vs other strategies, including minimally invasive implantation techniques involving thoracotomy.[5]

Another advantage is that a sitting position is possible and even ambulation, which makes this approach the most effective rehabilitation for patients awaiting a HTx. Nonetheless, multiple complications are associated with the devices, particularly due to the vascular access and hemolysis. In our center, before the ProtekDuo cannula became available, double femoral-jugular vein cannulation was performed for right heart support.[6] However, the jugular vein access used for the ProtekDuo cannula obviates the need for femoral vein cannulation and facilitates rehabilitation.

In conclusion, BiVAD implantation combining an Impella device implanted through the axillary artery via a minimally invasive approach and the ProtekDuo cannula percutaneously implanted through the jugular vein is a viable option that facilitates the optimal rehabilitation of patients on the HTx waiting list. This approach is associated with a lower incidence of bleeding and infectious complications and less aggressive surgery and could be an alternative in critically ill patients awaiting a HTx.

The present study was approved by the Drug Research Ethics Committee of La Fe University and Polytechnic Hospital. Informed consent was not required because no human experiments were performed and no patient-identifying data are reported. The study complies with current legislation, and this is stated in the favorable report issued by the Drug Research Ethics Committee of La Fe University and Polytechnic Hospital.

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All authors have contributed to the manuscript conception and design, have drafted the article or critically reviewed its content, have approved the final version for publication, and assume responsibility for all aspects of the article.

CONFLICTS OF INTEREST

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Agreement between 3D volumetric and strain parameters to assess left atrial function

Concordancia entre las mediciones 3D de volumen y de deformación para evaluar la función de la aurícula izquierda

To the Editor,

Atrial cardiomyopathy is a consequence of several pathophysiological processes with dysfunction and fibrosis of the left atrium (LA). This condition is often diagnosed in advanced stages due to incidental atrial fibrillation (AF), thromboembolic complications, or heart failure.[1] Image based biomarkers can be considered as surrogates of the status of this atrial substrate as they are currently able to precisely quantify LA size, function and, potentially, geometry and tissue composition. A widely available, noninvasive, and inexpensive imaging technique such as transthoracic echocardiography (TTE) could be easily applied in large cohorts of at-risk patients and would be readily applicable if shown to be useful in the early detection of at-risk patients.

Moreover, in recent years, LA function has shown prognostic yield in various clinical settings (eg, diastolic dysfunction, heart failure, AF, etc).[2] Analysis of LA function may demonstrate abnormal performance of the atrium prior to changes in LA size. Volumetric quantification of the LA and myocardial strain parameters allow detailed description of each LA contribution (reservoir, conduit, and contractile)[3] and both can be adequately obtained with TTE.

While strain assessment provides detailed information on regional myocardial deformation and can detect subtle changes in atrial function, it is influenced by cavity size, yielding less accuracy in patients with significant atrial remodeling. On the other hand, 3-dimensional (3D) volume assessment offers a comprehensive evaluation of atrial morphology and function, without geometric assumptions, accommodating complex shapes, and facilitating detailed analysis of remodeling and changes in atrial size, but reflects volumetric changes that may be only reflected in more advanced stages of myocardial dysfunction. Both techniques require adequate image quality.

Although these 2 methods can study all these LA contributions, the relationship between them is poorly understood and limits understanding and standardization of evaluation of LA function. Given the potential differences between 2-dimensional (2D) strain and 3D volume assessment in evaluating atrial function, understanding their relationship is crucial to further explore the potential contributions they can offer. Therefore, we sought to analyze the agreement in assessing LA function with 2 modalities, phasic 3D volumetric assessment and strain imaging, using TTE in a large population cohort of patients at epidemiological risk of AF.

In this prospective observational study, we analyzed LA function in 483 patients (mean age 51.6 ± 7.2 years; female sex, 29.8%). All patients were in sinus rhythm and at epidemiological risk of AF (high intensity endurance athletes [n = 277, 57.35%], chronic hypertension [n = 178, 36.85%], and mitral regurgitation [n = 28, 5.80%]). Informed consent was obtained from all study participants.

We obtained 3D TTE images with a dedicated commercially available echographic system (Vivid 9 and E95, General Electric, United States) and 3D LA volumes as well as LA strain were determined using a commercially available dedicated software package (Echo Pac, General Electric, United States). LA function was assessed based on phasic LA volumes and speckle tracking echocardiography derived myocardial deformation. Indexed 2D and 3D phasic LA volumes (ie, minimal [Vmin], maximal [Vmax], and the volume before atrial contraction at the beginning of the *P* wave [VpreP]) were used to calculate indices of LA function and total ejection fraction (related to LA reservoir function), as well as active (LA contractile function) and passive (LA conduit function) emptying fractions.[4,5]

We calculated the Pearson correlation coefficient between each pair of continuous quantitative variables. Inter- and intraobserver variability in measuring LA contractile strain were 0.3% (95% confidence interval [95%CI], − 6.1 to 6.7) and 0.7% (95%CI, − 1.39 to 2.85), while inter- and intraobserver variability in LA conduit strain were 0.9% (95%CI, − 3.9 to 5.8) and 0.9% (95%CI, − 3.7 to 5.6), respectively. The intra- and interobserver variability in the calculation of the maximum 3D LA volume were 0.7 ± 5.2 mL and 0.9 ± 7.4 mL, respectively.

Mean left ventricular ejection fraction was 61.2 ± 6.6% and indexed 3D LA volume was 37.4 ± 10.8 mL/m^2. Mean total 3D LA emptying fraction was 55.4 ± 7.2% and global LA strain was 31.7 ± 6.3% (reservoir function), while mean passive 3D emptying fraction was 34.2 ± 9.1% and passive LA strain was 17.1 ± 5.1% (conduit function). Finally, mean 3D LA active emptying fraction was 32 ± 8.4% and peak atrial contraction strain was 15.6 ± 2.8% (contractile function) (figure 1). Pearson correlation coefficients between each pair of variables assessing LA reservoir, conduit and pump function were 0.48 ($P < .001$), 0.48 ($P < .001$) and 0.38 ($P < .001$), respectively. Scatter plot graphics representing each LA function measured by the different modalities are shown in figure 2.

Our data show a moderate lineal and positive correlation between 3D volume and strain values assessing reservoir, conduit, and pump LA function. The correlation was higher between parameters evaluating reservoir and conduit function than contractile function. Theoretically, 2D strain may exhibit earlier changes than 3D volume assessment when evaluating atrial function, allowing detection of atrial dysfunction at an earlier stage, which could be one of the reasons for the modest correlation