Catheter ablation is increasingly recognized as an important option for the treatment of ventricular tachycardia (VT) in the serious clinical settings of frequent implantable cardioverter defibrillator shocks, and arrhythmia storms, in a variety of structural heart diseases. The high incidence of VTs that are not hemodynamically tolerated forces challenges to the traditional approaches of using activation and entrainment mapping to localize the ablation target area, in favor of a strategy of substrate modification that can be performed during sinus rhythm. In some patients, however, a clear target cannot be detected during sinus rhythm; this frequently occurs in some forms of nonischemic cardiomyopathies. More recently, interest is growing in the possibility of making VT tolerable through cardiopulmonary support.

In this issue of Circulation: Arrhythmia and Electrophysiology, Ostadal et al provide experimental data on the different capabilities offered by 3 commercially available support systems. It should be kept in mind, however, that these systems are Food and Drug Administration–approved only to support temporary high-risk situations. The data offered in this study are limited in that they provide only information related to systemic arterial pressure in healthy animals and do not allow any evaluation of the different levels of perfusion attained at individual critical organs, ie, brain or kidney. The study does, however, offer a comparative evaluation of the performances of these different systems and offers the opportunity to discuss advantages and limitation of their use.

Percutaneous left ventricular assist devices (pLVAD) are increasingly used in few high-volume and skilled centers around the world in an attempt to achieve hemodynamic support during previously nontolerated ventricular arrhythmias to allow use of electrophysiological maneuvers to identify the critical isthmus of the circuit where an effective ablation will produce a permanent interruption of the VT. It is hoped that pLVAD will avoid excessive use of inotropic drugs, hemodynamic instability, and consequently worsening heart failure.

Historically, the first and most frequently used device, until recently, has been the intra-aortic balloon pump (IABP). As a result of its capability to increase diastolic pressure and therefore the coronary perfusion and to decrease left ventricle (LV) afterload, IABPs can produce significant changes in the circulatory physiology, including decreases in heart rate, systolic pressure, and pulmonary capillary wedge pressure and an increase in diastolic pressure and cardiac output, effects usually favorable in most patients in cardiogenic shock. Despite these beneficial effects, which are a function of mechanical and biological variables including aortic compliance and systemic vascular resistance, the IABP fails to show a significant effect in reducing mortality rate. In the recently published IABP-SHOCK II trial, the use of IABP in patients with cardiogenic shock complicating acute myocardial infarction in which an early percutaneous or surgical revascularization strategy was planned did not significantly reduce the 30-day mortality. The need for a more powerful hemodynamic support has led to the development of other circulatory systems, 3 of which are currently used in VT ablation procedures: the Impella 2.5 System (Abiomed Inc, Denver, MA), the TandemHeart system (Cardiac Assist, Inc, Pittsburgh, PA), and the extracorporeal membrane oxygenation (ECMO) system.

Each system has advantages and limitations. TandemHeart: To achieve full operational support with a cardiac output of 4 to 5 L/min, the system requires a 21F venous sheath to be placed transseptally (venous inflow) and a 17F arterial sheath. The size of the venous sheath requires a 2-staged procedure of transseptal puncture for the placement of the venous cannula in the left atrium with the high likelihood of residual left to right shunt that might potentially require subsequent correction. The size of the arterial cannula required for the maximum output (17F) may require surgical cut-down, thus making the procedure not easily performed by the average interventionalist. Furthermore, the transseptal approach to mapping and ablation of the LV is totally prevented by the presence of the big transseptal cannula, as acknowledged in the clinical experience by Bunch et al. Complications may include cardiac tamponade, bleeding, peripheral limb ischemia, sepsis, hemolysis, and stroke. Dislodgment of the transseptal cannula may add to the overall list of complications. The presence of aortic insufficiency or peripheral vascular disease is an absolute contraindication to use of this system.

Impella: This system requires only 1 femoral arterial access with a 13F sheath. The catheter is typically placed across the aortic valve using intracardiac echo and an over-the-wire technique. As a result of the smaller size and the need for 1 puncture only, the placement of the Impella requires less time compared with the placement of the TandemHeart (15 versus
45 minutes), and it is likely followed by fewer complications. This device is contraindicated in patients with peripheral vascular disease, moderate-to-severe aortic stenosis, aortic insufficiency, LV thrombus, or ventricular septal defect. Several trials have demonstrated the benefit of this type of support in specific clinical settings (acute heart failure, high-risk percutaneous coronary intervention)\(^{6-8}\) that are, however, substantially different from that proposed by Ostadal et al\(^{6}\) in hypotensive VT. The rate of complications related to the placement of the system may be potentially lower, but they are of similar type to those occurring with the TandemHeart.

The presence of the Impella catheter in the LV may hinder the movement of the ablation catheter and can cause mechanical irritation of the endocardium and incidental arrhythmias. In addition, the presence of rotor in the LV may produce electromagnetic interference with the electroanatomic mapping system, leading to displacement of the catheter position within the map and adding noise to the intracardiac electrogram recordings.

Both systems share the favorable feature of providing substantial diastolic unloading of the LV that ultimately may enhance coronary perfusion. This may provide some further protection against deterioration of cardiac function during sustained VTs.

Ostadal et al\(^{6}\) have compared the efficacy of these 3 systems under different hemodynamic conditions in a porcine model. Each support system was tested during pacing at 200 beats per minute, 300 beats per minute, and during ventricular fibrillation. All but one test were performed without pharmacological interventions (Impella was tested without drugs and during norepinephrine infusion). Hemodynamic support was evaluated by the mean arterial pressure. The end point of the study was maintenance of mean arterial pressure of 70 to 80 mm Hg achieved only by adjusting the pump speed. Considering the characteristics of each system and the method of evaluation of hemodynamic support, the results obtained are not surprising. Although no differences were present during pacing at 200 beats per minute, differences increased during pacing at 300 beats per minute and during ventricular fibrillation and in the last condition became statistically significant. ECMO provided the greatest hemodynamic support followed by the TandemHeart and Impella systems, respectively. The extent of support achieved by the latter systems, however, may not be adequate, particularly with the current version of the Impella, to substitute for the decreased cardiac output that occurs during prolonged episodes of fast VT. The ECMO proved the only system capable of a true total support at very high rates or even during ventricular fibrillation. ECMO also has limitations. Institution of ECMO is a very lengthy process that requires the cooperation of different teams of specialists, including intensive care physicians, a perfusionist, and likely vascular surgeons. ECMO does not provide unloading of the LV, and the increased cardiac output provided by the system can impose a considerable increase in LV afterload, which may unfavorably affect myocardial metabolic balance. All of these systems provide only LV support, and therefore they are contraindicated in patients with severe right ventricular dysfunction, although ECMO may be marginally better in this regard by allowing a more careful titration for the right ventricular preload.

Despite the growing interest of the use of pVAD assistance during VT ablation, data are limited to only a small number of case reports, single-center, or observational multicenter studies.\(^{5-14}\)

The original hypothesis of providing hemodynamic support for the ablation of untolerated VTs originated at a time before the potential for substrate modification was appreciated, and 3-dimensional mapping systems were widely available. Now, the vast majority of untolerated VTs can be successfully treated during sinus rhythm with very reasonable long-term success rates and very low morbidity. In the years between 2003 and 2007, 19 procedures of catheter ablation for untreated VTs supported by cardiopulmonary support (ECMO) were performed in a population of 210 patients with VT in our center. In our latest experience (2007–2012), circulatory support has been required in 3 of 643 patients: all these 3 patients had presented with truly intractable almost incessant, untreated fast VT presenting emergently.

We are aware of 2 studies investigating the role of a pLVAD in treating unstable VTs. Miller et al\(^{9}\) have shown that in the group of patients supported by LVAD, VT could be maintained for a longer time compared with the unsupported group. The acute success rate, as well as the short-term (3 months) recurrence rates, was identical between the groups. In another study\(^\) performed in 13 patients with unstable VTs, the substrate modification strategy was compared with a conventional ablation where activation mapping and entrainment of the targeted unstable VT were achieved through the use of the TandemHeart pLVAD. In this study, also the acute and short-term success rate, as well the incidence of complications, proved similar for both groups. We should be aware that the Impella, the TandemHeart, and ECMO provide only LV support, and their efficacy has been shown in specific settings (acute heart failure, high-risk percutaneous coronary intervention) in patients not in VT with a rapid heart rate. The support offered at very fast heart rates is at best partial and probably can be considered only for a limited time. Probably, their best utilization could be the support of truly unstable patients in emergency settings (both during and after the procedure) rather than to support an induced unstable VT in an otherwise stable patient.

At the present time, therefore, there are no strong data to select the use of pLVAD for support mapping for catheter ablation of untreated VTs over the use of a strategy of ablation to modify the substrate during sinus rhythm. Cost is an additional consideration. Costs for use of an Impella device ranges from 7500 to 13 500, and it requires extra personnel, procedure duration times (considerable time to set up the pLVAD), and has additional complications. This is not to deny the possible usefulness of this new and interesting technology; in the end, however, only prospective studies focusing on the overall success, complication rate, and cost-benefit ratio will clarify the best strategy for ablation of unstable VTs.
Disclosures
Dr Paolo Della Bella is consultant for St Jude Medical and has received honoraria for lectures form Biosense Webster, St Jude Medical, and Biotronik. The other author has no conflicts to report.

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Temporary Percutaneous Left Ventricular Support for Ablation of Untolerated Ventricular Tachycardias: Is It Worth the Trouble?
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