The Utility of Atrioventricular Pacing via Pulmonary Artery Catheter During Transcatheter Aortic Valve Replacement

William J. Vernick, MD,§ Wilson Y. Szeto, MD,† Robert H. Li, MD,‡ Pavan Atluri, MD,† John G. Augoustides, MD, FASE, FAHA,§ Jeremy D. Kukafka, MD,§ Prakash A. Patel, MD,§ and Jack T. Gutsche, MD*

THE DEVELOPMENT OF TRANSCATHETER aortic valve replacement (TAVR) has led to the treatment of calcific aortic stenosis in patients whose condition might otherwise be considered inoperable if relegated to traditional aortic valve surgery. Although the ability to replace a patient’s aortic valve in this manner represents an important advancement in the treatment of aortic valve disease, there remain many challenges associated with successfully performing the procedure.

One of these challenges is the ability to maintain hemodynamic stability during valve positioning and then recover stability after its deployment. Several factors can complicate this mission. The most obvious relate to the patient’s underlying aortic valve pathology as well as other concomitant cardiac disease. During valve positioning, the interposition of the deployment system across an already compromised aortic valve will further limit the native valve’s effective orifice area and also can promote regurgitation. Mechanical or functional mitral regurgitation also may occur during this process, producing additional strain on the myocardium. The cardiovascular system is further burdened by the need for cardiac “stand-still” during valve deployment. This is achieved by inducing rapid ventricular pacing (V-pacing). Hemodynamic recovery after this may be difficult, particularly if the pacing runs are protracted or successive. Delayed recovery can promote further myocardial ischemia, initiating a downward spiral that may prove intractable without significant intervention, including the need for mechanical circulatory support.

Management can be complicated further by the development of conduction abnormalities (CA) after TAVR. This association has been well documented, but most of the literature has discussed them in regard to postoperative management, particularly the potential need for permanent pacemaker (PPM) placement.1-4 However, CAs typically present during or immediately after valve deployment and their acute hemodynamic effects have, in contrast, largely been ignored in published reports. This may be an important omission because the acute loss of atrioventricular (AV) synchrony may be tolerated poorly given the common association of ventricular hypertrophy and diastolic dysfunction in patients with aortic stenosis. In addition, because of the percutaneous nature of the procedure there are limited intraoperative rhythm management options available should the CA be associated with hemodynamic instability.

Because of these concerns, all patients undergoing TAVR at this institution have percutaneous right atrial (RA) and right ventricular (RV) endocardial pacing wires placed via a specialized pulmonary artery catheter (PAC), unless they already have a PPM or have pre-existing atrial fibrillation (Fig 1). What follows is the discussion of a case that exemplifies the important benefits of this technique.

CASE

A 91-year-old woman with progressive dyspnea on exertion secondary to critical aortic stenosis presented for TAVR. The patient’s medical history also was significant for coronary artery disease with drug-eluting stents placed 2 years earlier, non-insulin-dependent diabetes mellitus, and temporal arteritis. Preoperative echocardiography revealed normal left ventricular function but with severe concentric hypertrophy, moderate mitral valve stenosis and regurgitation, and moderate-to-severe tricuspid regurgitation. The baseline electrocardiogram (ECG) was notable for sinus rhythm at 76 beats/min with an incomplete right bundle-branch block (RBBB) and a PR interval of 156 ms. A transaortic surgical approach was chosen because of the presence of a small and tortuous aorta with significant atheroma as well as the patient’s small body size, the combination of which limited both transapical and transfemoral deployment.

After the induction of general anesthesia, a thermodilution PAC with two additional ports allowing the introduction of endocardial pacing wires into both the RA and RV (A-V Paceport Catheter, Edwards Lifesciences Corp., Irvine, CA) was inserted through a 9-French introducer sheath that had been placed into the right internal jugular vein (IJV). In order to properly position the pacing wires, the PAC was advanced while the pressure waveforms of both the catheter tip and the RV Paceport orifice were simultaneously monitored. Once the catheter tip entered the pulmonary artery (PA), it was further advanced until an RV pressure waveform was seen from the RV Paceport orifice, which indicated that this port had crossed the tricuspid valve.
valve. A flexible-tipped pacing wire (Chandler Transluminal V-Pacing Probe, Edwards Lifesciences Corp., Irvine CA) then was inserted through the RV Paceport while connected to a Medtronic 5388 Dual Chamber Temporary Pacemaker (Medtronic Inc., Minneapolis, MN). The pacing wire was advanced 4.5 cm until ventricular capture occurred at 2.5 mA. Next, the atrial wire (Flex-Tip Transluminal A-Pacing Probe, Edwards Lifesciences Corp., Irvine CA) was passed through the RA Paceport. Using transesophageal echocardiography (TEE), the wire was visualized advancing into the right atrial appendage (5 cm beyond the port) (Fig 2). Consistent atrial pacing (A-pacing) using an atrial sensing mode at 5 mA confirmed proper positioning.

The case proceeded in usual fashion for transaortic access, which uses an upper “mini-sternotomy” followed by cannulation of the ascending aorta. During aortic balloon valvuloplasty, rapid V-pacing at 170 beats/min was instituted via the RV pacing wire. Upon discontinuation of rapid V-pacing, maintenance of AV synchrony with A-pacing alone was achieved and a rapid restoration of the patient’s hemodynamics occurred. After insertion of the valve delivery system into the ascending aorta with subsequent positioning of the valve within the native aortic root, deployment of a 23-mm Edwards SAPIEN valve (Edwards Lifesciences Corp., Irvine, California) was facilitated again by rapid V-pacing at 170 beats/min. Isolated A-pacing, however, was now complicated by complete heart block with no observable ventricular escape rhythm seen. Immediate and successful AV-pacing then was employed, ensuring a successful resuscitation (Fig 3). Valve positioning and function were deemed to be excellent.

After removal of the valve delivery system from the ascending aorta, significant bleeding occurred and a limited aortic repair was required. This period of acute hypovolemia was well tolerated. The remainder of the procedure was uneventful. The patient’s ECG upon arrival to the intensive care unit was dramatically different from the preoperative ECG and was notable for second-degree heart block, Mobitz type I (Fig 4). AV pacing was employed for the first several hours after surgery, with gradual recovery of normal sinus rhythm over the next several hours. The patient was extubated later that same day of surgery. The postoperative day 1 ECG displayed to normal sinus rhythm with a PR interval near baseline (158 ms).

DISCUSSION

The development of a new CA after TAVR is a common occurrence. For example, the CoreValve registry (CoreValve Revalving System, Medtronic Inc., Minneapolis, MN) described new or worsening AV conduction delay in 77% of patients. Although the rates appear highest with the CoreValve, CAs are not unique to this deployment system. The SAPIEN valve has been associated with new CAs in up to 15.2% of patients and an even higher incidence of new left bundle-branch block (14.5% compared with 29.5%). Most of these abnormalities occur during or shortly after surgery and may be associated with hemodynamic instability. However, because of the procedure’s inherent percutaneous nature,
options for cardiac rhythm intervention are limited. In most centers, either the native rhythm must be tolerated or V-pacing via a temporary transvenous wire is employed.

The presented case, in which complete heart block without an escape rhythm occurred immediately after valve deployment, highlights the ability to preserve AV synchrony through use of an AV-pacing catheter. This catheter is used in all patients undergoing TAVR at this institution, except in those who present with atrial fibrillation or have an in-situ PPM. Ideally, it would be possible to clearly identify those patients at high risk for CAs before deciding in whom to use this approach. Unfortunately, despite the high incidence of CAs after TAVR, the only consistent predictor of high-grade AV block is the preoperative presence of an RBBB. It is worth noting that the baseline incomplete RBBB in this patient may have represented a risk factor.

The long-term outcome associated with the development of CAs after TAVR remains unclear. Their acute consequences have been even less well studied in the literature and are likely not accurately represented by 1-year survival data. Perioperative hemodynamic instability may be multifactorial, and practitioners may not necessarily attribute it to a new CA. In addition, the hemodynamic consequences related to loss of AV synchrony often can be mitigated through escalating doses of vasoactive medications. Thus, a more focused study would be required in order to determine the isolated effect of CAs. As of now, there is no literature to support the prophylactic use of an AV-pacing catheter for management of CAs after TAVR, but such a trial currently is underway at this institution. This study will examine beyond traditional outcome measures by comparing both the time to hemodynamic recovery after valve deployment as well as the degree of pharmacologic and mechanical support needed to achieve this recovery. The current extensive but anecdotal experience suggests that the ability to

Fig 3. The hemodynamic data after transcatheter valve implantation. Notice the successful AV-pacing. The temporary disconnection of the ventricular pacing wire is indicated by A., displaying the underlying heart block without a ventricular escape beat.

Fig 4. Electrocardiogram on arrival to the intensive care unit immediately after transcatheter aortic valve replacement. Second-degree heart block, Mobitz type I, was now present.
ensure AV synchrony not only speeds recovery after valve deployment but also helps avoid overly aggressive resuscitation and associated hypertension, which may be particularly problematic with transapical or transaortic approaches.

In this presented case, a trial of V-pacing alone was not attempted, and, therefore, the authors did not prove that AV pacing in this patient was necessary for an acceptable hemodynamic recovery. With that said, maintaining AV synchrony likely provided a superior hemodynamic profile compared with V-pacing alone, particularly in light of the concomitant moderate mitral stenosis and the degree of ventricular hypertrophy. Although it can be argued that the acute relief of aortic stenosis may limit the importance of AV synchrony after TAVR, it must be recognized that regression of left ventricular hypertrophy after aortic valve replacement is a much more gradual process.6,10

Although the placement of an AV-pacing catheter in those who do not suffer from an acute CA may not be absolutely necessary, there also does not appear to be a significant downside, particularly if a standard PAC is going to be inserted anyway. In addition, the avoidance of bradycardia through AV pacing may be beneficial. The potential for tachyarrhythmias or direct injury as a result of the endocardial wires does exist, but in the authors’ experience these events have not occurred and the system has been used effectively, reliably, and safely. The added disposable costs related to the equipment, the additional time needed to place the pacing wires, and any increased risks associated with its use are typically offset by avoidance of the separate temporary transvenous wire used for rapid ventricular pacing wire, which, unlike our approach, requires an additional introducer sheath to be placed.

REFERENCES