A Road to Physiological Pacing

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Incidence of conduction system disease will continue to grow worldwide as the age of the population increases. Cardiac pacing is the standard and effective therapy for the management of patients with symptomatic bradycardia. It is estimated that nearly 1 million new pacemaker implantations will be done annually in the next decade and the numbers will continue to swell with the availability of more sophisticated tools to diagnose the conduction system disease at an early stage.

Right Ventricle as a Site for Pacing

Right ventricle (RV) has been the standard pacing site for the past 60 years. Ease of access through subclavian vein, the trabeculations at the apex, and the lead design favored RV apex as an automatic first choice. RV apical pacing (RVAP) is a safe, time-tested, and well-tolerated procedure flourished with plenty of clinical data. Though a gold standard technique, RVAP is fraught with reduction in left ventricular (LV) systolic function, heart failure (HF), and increased mortality. RV pacing produces left bundle branch (LBB) block morphology on the surface electrocardiography (ECG), resulting in nonphysiological activation of the LV due to pre-excitation of the interventricular septum. Nonphysiological pacing is the likely cause of poor hemodynamic output in RVAP as compared to sinus rhythm and adverse mechanical effects of cardiac function. This results in myofibrillar disarray, increased fibrosis, and reduced LV ejection fraction putting the patient at risk of arrhythmias and HF hospitalizations.

Quest for an Alternative Site

The pursuit for an alternative site of pacing tasted limited success as pacing the septum or outflow tract failed to overcome the pacing-related complications. During the early 1990s, there was a considerable interest in the concept of “physiological pacing,” which denoted dual chamber as opposed to single chamber pacing. By allowing atrioventricular (AV) synchrony, dual-chamber pacing was thought to promote physiological ventricular function. Despite great belief in the concept, the advantages were modest in terms of reduction in incidence of atrial fibrillation in patients with sinus node dysfunction. Large randomized studies failed to demonstrate the superiority of dual chamber in avoiding the pacing-related complications. It is the dyssynchronous ventricular contraction that decides the long-term consequences of RVAP rather than lack of atrial contribution during ventricular pacing. With the evidences accumulating on the deleterious effect of chronic RV pacing, efforts were made to minimize the ventricular pacing by various algorithms. The ultimate goal of pacing is to develop a strategy which would mimic as closely as possible to normal ventricular activation in terms of electrical and mechanical synchrony. In other words, a strategy wherein the cardiac conduction system is directly captured is the holy grail of pacing.

His Bundle Pacing

Though Kosowsky et al showed the physiological advantage of direct His bundle pacing (HBP) in 1968, it was not until 2000 when Deshmukh et al first published the clinical feasibility of permanent HBP. Direct HBP was successful in 12 of 14 patients with atrial fibrillation with dilated cardiomyopathy. LV-ejection fraction improved from 20% to 31% with significant reduction in LV-end diastolic diameter. This landmark study subsequently rekindled the interest of conduction system pacing, resulting in exploration of His bundle (HB) as an alternative pacing site. HB, a narrow band of fibers extending from the AV node in the Koch’s triangle
till the crest of ventricular septum, can be targeted anywhere along the membranous septum. Direct capture of HB results in electrically and mechanically synchronized activation of the ventricles with normal-paced QRS morphology. A 4.1-F sized 3830 SelectSecure lumenless pacing lead (Medtronic Inc, Minneapolis, MN) is used along with C315 sheath for deploying the lead. Mapping of the HB is done to get a site with sharp His signal and ventricular electrogram with a normal HV interval (35-55 ms) before placing the lead. Pacing maneuvers must be done to make sure that the lead is positioned distal to site of diseased HB. Vijayaraman et al10 showed 84% success rate for HBP in patients with AV block. AV nodal block patients had a higher correction rate (93%) as compared to those with infranodal block (76%). The proposed mechanism for the correction of infranodal block is (a) pacing distal to the site of block, (b) virtual electrode polarization effect, and (c) differential source-sink relationship.

Hitting the HB for Resynchronization Therapy

With the availability of better tools, HBP gathered momentum in the earlier part of the last decade globally and considered no longer a difficult procedure. With the support from several multicenter observational studies and social media platform (#dontdisthehis), HBP revived the interest in conduction system pacing. The concept of predestined fibers bundled inside the HB created a window of opportunity for correcting the bundle branch block morphology in the surface ECG. Though biventricular devices (BiV) were extensively tested in randomized trials for patients with cardiomyopathy and wide QRS duration, the rate of nonresponders remains high (30-40%).7 Moriña-Vasquez et al8 first demonstrated the feasibility of permanent HBP for bundle branch block correction. Sharma et al9 showed 90% success rate for HBP in 106 cardiac resynchronization therapy (CRT)-eligible patients. QRS duration was reduced from 157 to 117 ms along with improvement in LVEF from 30% to 43% during a mean follow-up of 14 months. Lead-related complications were noted in 7.3%. Upadhyay et al10 showed superior electrical resynchronization and higher echocardiographic response in patients receiving HIS-CRT as compared to BiV-CRT. HBP gained another surge as an alternative to BiV devices for cardiac resynchronization therapy.

LBBP an automatic first choice pacing strategy? It is a recent innovation which is yet to be tested in randomized controlled trials. Evidences so far published are from single or multicenter observational or nonrandomized studies which cannot be extrapolated to the general population. Lead damage due to myocardial contraction, coronary arterial injury, dislodgement into the LV cavity, and thromboembolic episodes are potential complications to be monitored during follow-up. Lead extraction is another major concern as the currently available tools may not be suitable to extract the deeply placed pacing lead.

A balanced approach would be the need of the hour weighing the risks and benefits of both the modes of physiological pacing. Pacing-induced cardiomyopathy occurs in significant proportion of patients requiring >40% committed ventricular pacing. Conduction system pacing would help in this group of patients by providing synchronized physiological activation of the ventricle. In patients with symptomatic AV block, HBP has a higher success rate if the
level is nodal as compared to infranodal. HBP can be accepted if the capture threshold is <1.5 V at 1 ms pulse width. Any values higher than this would require placing the lead in LBB area to capture the conduction system. As an alternative for CRT, HBP could be an acceptable option if the bundle branch block correction threshold is <1.5 V at 1 ms pulse width. LBBP has a higher chance for correcting bundle branch block at low capture threshold (<1 V at 0.5 ms pulse width). If there is no complete correction by either HBP or LBBP, optimization can be done by placing additional lead in coronary sinus (His optimized-CRT/LBBP optimized-CRT) to achieve better resynchronization. Patients who had undergone LBBP need periodic screening to monitor the lead position and thromboembolic complications.

Physiological pacing has witnessed a tremendous growth in the last 10 years. LBBP is a surprising addition to the armamentarium with excellent mid-term results. Randomized trials involving multiple centers are warranted in cementing the role of HBP or LBBP as a workhorse pacing strategy.

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Ethical Statement
The study was conducted after getting the ethical committee’s approval.

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