

ARTICLE REVIEW

BRIEF HISTORY OF PERMANENT CARDIAC PACING

Dr. Franco Zoppo MD, PhD, FESC¹

¹ MD, PhD, FESC.
Department of Cardiology, San
Giovanni di Dio Hospital,
Gorizia, Italy

A permanent cardiac pacemaker is an implantable device used to maintain a sufficient heart rate when the natural mechanisms fail, either as a result of a deficiency with the natural pacemaker or the conduction system in the heart.

With an increasing older population is inevitable that we will face with this kind of cardiologic problem.

The normal atrial impulse starts at the sino-atrial node and then propagates through the atrial conduction specialized fibers to reach the atrio-ventricular node and then, through the His bundle, the ventricular final activation is made.

Depending of which part of the entire conduction system is functionally or structurally damaged, the cardiac pacing can supply the natural pacing and conduction system in a specific way which means that for patients without a preserved atrial function, such as in permanent atrial fibrillation, a solely ventricular pacing could be enough for restoring the cardiac chronotropic function, while for the majority of patient with a preserved atrial function, a sequential atrial and ventricular pacing should be provided, to restore the physiologic chronotropic activity.

Cardiac permanent pacing has been used in the treatment of brady-arrhythmias for more than 50 years and during that time an impressive body of research have proved its effectiveness objectively, in terms of parameters that include the

patients' quality of life, morbidity and mortality.

There is also no doubt that the related technology has made great strides over the same period. (1, 2, 3, 4, 5)

Today, thanks to the microelectronics' development, the pacemakers are smaller, the programming options wider and the pacing leads are thinner and long-lasting than before.

All these hardware and software engineering have aimed to provide an appropriate correction of pulse and conduction defects, in such way to simulate the physiological activity and natural electrical behavior as closely as possible.

The first epicardial pacing system has been implanted by Senning in 1958 subsequently followed by a complete trans-venous system, soon in the years later.

The further sophistication of the sensing circuit made possible to improve the pace maker software with a sensing function and not only pacing capabilities, which was followed, in 1963 by the first ventricular pacemaker implantation with the so called "on demand" function.

Although atrial synchronous systems and dual chambers system have been described during the 1950s, the routine clinical use of an atrial permanent pacing added to a ventricular one in a dual chamber technology did not occur for many years.

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The 1970s were significant for the introduction of lithium battery accumulators and for the multi-programmable capable devices. (6, 7, 8, 9, 10)

The milestone of the 1980s was the introduction and the wide acceptance of the dual chamber pacemakers, incorporating a double (atrial and ventricular) lead technology.

This new developing pacing techniques have therefore followed the previous studies about the use, safety and performance of the atrial leads, added to the well known and little bit “older” ventricular leads technology.

One of the first study regarding the atrial leads technology and clinical performance, have been published in the 1977, followed by other studies until the first 1980s.

Among these latter, one of the largest retrospective studies regarding the endocardial anchorage lead technology (active screw-in leads and passively tined leads) has been performed by Perrins et al, who compared the above anchorage system in 315 atrial and ventricular leads.

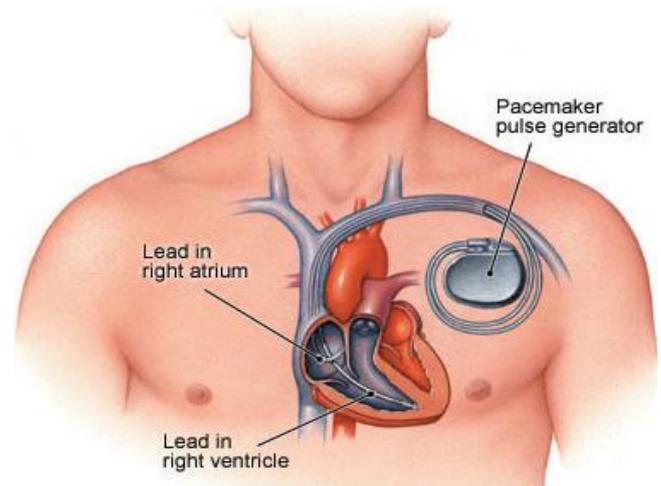
They concluded that the active fixed screw-in atrial leads and short tined passive fixed ventricular lead might be the preferable choice, which could provide the virtual elimination of lead displacement and a very low incidence of lead related complications.

(11, 12, 13, 14, 15)

The further years over the 1990s have witnessed the continuing sophistication of sensor and automaticity of the devices' softwares.

The traditional position for the lead insertion for the atrial and ventricular pacing since the beginning of cardiac pacing, have been the RAA and the right ventricle apex. (FIG. 1)

FIG. 1 - SCHEMATIC ANATOMY OF PACEMAKER POSITION AND RIGHT ATRIUM AND VENTRICLE LEADS PLACEMENT



Late in the last century, the further most important changes in the technical development were proposed mostly by French authors, who were starting to insert ventricular lead in different positions.

The different positions proposed as first were the inter-ventricular septum pacing, in the higher part (below the pulmonary artery, therefore the right ventricle outflow tract) and the lower part of the septum.

Soon the exploring of the left ventricle, by means of coronary sinus navigation, therefore epicardially, was proposed, and a new dedicated leads technology was launched in the pacing market, with special features to ensure the stable deployment into the coronary sinus branches.

This technology and implant technique been proposed for simultaneous pacing of right ventricle (via the ventricle apex) and left ventricle (via an epicardial left ventricle pacing) was, and is currently, the most reliable and safely available one for the so called cardiac resynchronization therapy (CRT).

The following fast advance of this multisite pacing was then the established worldwide development of the CRT, by means of biventricular pacemakers.

Thus, these years were witnessing for the first time the pacing indications not only proposed for bradycardia

correction but also for left ventricular dis-synchrony and failure correction.

The CRT was indeed proposed for resynchronize the “failing left ventricle” when this was related to the electrical right-to-left ventricle dis-synchrony, due to the enlargement of the QRS duration on the ECG, due to left bundle branch block, or due to right ventricular pacing (in so called upgrading procedures from VVI/DDD to CRT pacing).

Soon the CRT technique showed, by means of several randomized controlled trials, to be striking for all the strong endpoints in heart failure for functional, clinical and mortality outcomes.

As well as in the ventricular pacing research field, also for atrial pacing new indication were proposed by the beginning of the 2000s, not only proposed for bradycardia correction but also aiming to the atrial electrophysiology electrical synchronization, especially for atrial fibrillation prevention.

The alternative atrial pacing sites, mainly interatrial septal, were then proposed alternatively to the RAA pacing.

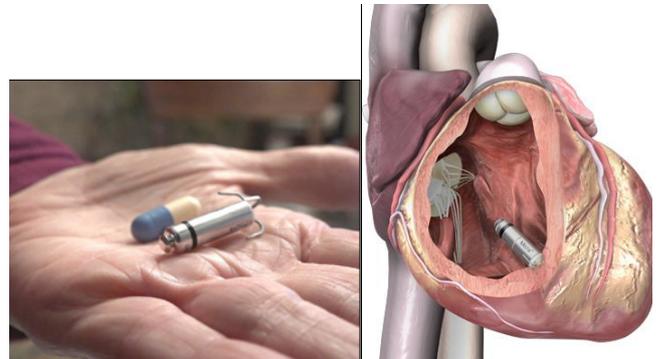
The two conventional site of atrial septal pacing were the high interatrial septum (the so called Bachmann atrial pacing) and the low interatrial septum (the so called Koch triangle pacing).

Both techniques have been developed to ensure a better biatrial electrical synchronization with the aim to prevent the atrial fragmentation of the impulse propagation and the dispersion of atrial activation and refractoriness.

Both mechanisms are believed as critical for atrial fibrillation development. ^(16, 17, 18, 19, 20, 21)

The new frontier reached recently was to move toward a leadless technology pacemaker which is believed to be the standard set up for the next years. (FIG. 2)

FIG. 2 - LEADLESS PACEMAKER



PACEMAKERS INTERNATIONAL NOMENCLATURE CODE

A 3-letter code describing the basic function of the various pacing system was proposed in the 1974.

Since that time, responsibility for periodical updating the code has been assumed by the North American Society of Pacing and Electrophysiology (NASPE) and the British Pacing and Electrophysiology group.

The code has been designed in 5 positions, but the fifth is rarely used.

THE FIRST POSITION reflects the chamber or the chambers in which the pacing occurs (A= atrial, V= ventricular, 0= none, D=dual, atrial and ventricular).

Some manufacturers also use the letter S to indicate the single chamber of either pacing or sensing function.

THE SECOND POSITION refers to the chamber or chambers of sensing function (the same letter meaning as described above).

THE THIRD POSITION refers to the mode of sensing, or how the pacemaker respond to a “sensed” event (I= inhibition, which indicates that a sensed event inhibits the pacing output pulse, T= triggered, which indicates that an output pacing pulse is triggered by a sensed event, D= dual, i.e. I and T response may occur).

THE FOURTH POSITION reflects both programmability and rate responsive modulation (R= rate-responsive) and means that the device incorporates a rate-accelerating sensor, which can increase the pacing rate, independently of intrinsic cardiac chronotropic activity.

THE FIFTH POSITION describes multisite pacing functionality. Atrial multisite pacing is being investigated as way to prevent atrial fibrillation. Ventricular multisite pacing is a treatment for pacing a patient with dilated cardiomyopathy. It is very rare used.

The following schematical table display the current updated code nomenclature.

TAB.1 : CURRENT UPDATED CODE NOMELCATURE

POSITION 1	POSITION 2	POSITION 3	POSITION 4	POSITION 5
(Chamber Paced)	(Chamber Sensed)	(Response to Sensed Event)	(Programmability, Rate Modulation)	(Multisite Pacing)
O = none	O = none	O = none		O = none
A = atrium	A = atrium	I = inhibited		A = atrium
V = ventricle	V = ventricle	T = triggered	O = none	V = ventricle
D = dual (A+V)	D = dual (A+V)	D = dual (T+I)	R = rate modulation	D = dual (A+V)

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