New Advances in Left Ventricular Lead Technology

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KEYWORDS

• Lead technology • Cardiac resynchronization therapy • Congestive heart failure

KEY POINTS

- Cardiac resynchronization therapy (CRT) has been demonstrated highly efficacious in the treatment of congestive heart failure in patients with a wide QRS.
- Achieving successful left ventricular (LV) lead placement is the key step in achieving successful CRT.
- Leads have been developed that reduce the possibility of lead dislodgement after implantation.
- Lead technology has been developed that allows for the reprogramming of the stimulation vector so that phrenic nerve stimulation can be avoided while maintaining successful resynchronization therapy.
- Implantation tools have been developed that help achieve successful CRT implantation.

INTRODUCTION

CRT has been demonstrated to improve outcomes and mortality in patients with moderate to severe congestive heart failure and a wide QRS complex.[1–5] The LV lead position is critical to the success of CRT.[6–8] The limiting factor in the implementation of successful CRT is usually the anatomy of the coronary veins and the association of the cardiac veins with the phrenic nerve.[9–13] Challenges include the unavailability of a good vein position, the possibility of lead movement after implantation, and the problem of patient posture causing a change in the relationship of the LV stimulation site and the phrenic nerve. In one study, there was a 12% rate of CRT failure postoperatively related to either loss of LV capture or phrenic nerve stimulation.[14]

In response to this challenge, manufacturers of leads for CRT devices have developed an array of leads. In addition to the original unipolar LV leads, bipolar leads and quadripolar leads are now available.

The initial studies of leads developed specifically for CRT showed promising results. For example, the Medtronic 4193 lead was studied in more than 1000 patients. The mean chronic stimulation threshold was approximately 2 V. The overall complication rate was approximately 10%.[15] Another comparative study of several different Medtronic LV leads showed phrenic nerve stimulation in 13% of patients. Of these, 1.6% required either reoperation or discontinuation of LV pacing. Unipolar leads were more likely to have phrenic stimulation, and leads positioned in a midventricular site and an apical site were more likely to have phrenic nerve stimulation.[16]

ADDRESSING THE VENOUS POSITION ISSUE

In an attempt to address the problem of the variety of venous anatomy, manufacturers have

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developed an array of leads to help fit and engage the veins and an array of additional tools to help place the leads into position. There is huge variation in the anatomy of the coronary sinous venous branches. Fig. 1 displays examples of the variety in coronary venous anatomy.

One of the challenges in LV pacing is that the phrenic nerve lies adjacent to the lateral LV, a common site for LV pacing. The original LV leads were all unipolar and the anode was typically the right ventricular (RV) coil. Later, widely spaced bipolar leads were developed. In both of these designs, the virtual electrode size is often large enough to capture the phrenic nerve.[10,13,16,17]

It has been demonstrated that reducing the interelectrode spacing reduces the size of the virtual electrode and thus the incidence of phrenic nerve stimulation.[18] As discussed later, programmability of the vector of LV leads has undoubtedly helped avoid phrenic nerve stimulation. Leads with narrow interelectrode spacing are now available throughout most of the world. Fig. 2 displays the choices in these LV leads. In the Medtronic leads, the interelectrode spacing is identical on the 3 leads but the shapes are different. The Medtronic 4298 lead is a canted shape and the force of the cant is intended to provide stability. The S shape is intended for smaller veins and the straight lead, with tines, is intended to provide stability in small, short veins. There is a great deal of variability in the preference of implanters. Boston Scientific leads have varying interelectrode spacing between poles 1 and 2. This is intended to keep the short-spaced bipole away from the tip and allow for distal lodging, allowing electrical stimulation distance from the phrenic nerve. Table 1 displays the characteristics of LV leads that are currently available.

Another concept in LV pacing is that the presence of LV stimulation at a high output may not prevent achievement of good long-term lead performance. In one study, the presence of phrenic nerve capture at 4 times the LV stimulation threshold was considered acceptable.[19] Using this approach, only 2 of 174 patients had phrenic nerve stimulation that was not remedied by reprogramming.

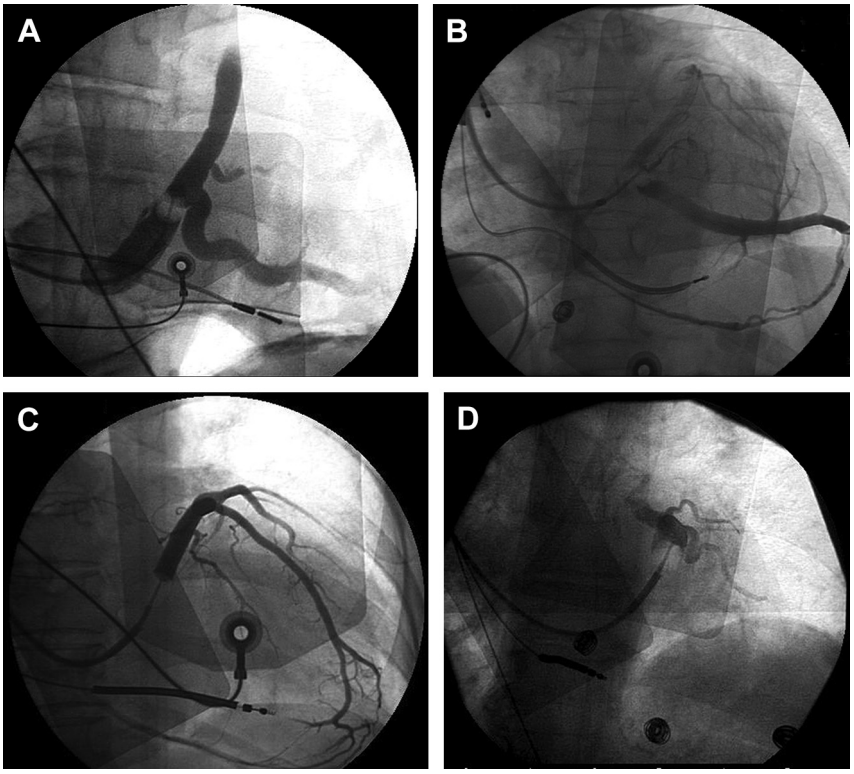

Fig. 1. The anatomy of the coronary sinus vasculature is variable. Sometimes the veins are large and there may be difficulty lodging a lead in place (*A, B*). Sometimes the veins are smaller (*C*), and sometimes the veins are small and tortuous, presenting great difficulty engaging the lumen (*D*).