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Estimulação Cardíaca Artificial
Artigo de Revisão

Cardiac resynchronization therapy: overcoming anatomical challenges

Terapia de ressincronização cardíaca: superando desafios anatômicos

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RESUMO

A anatomia venosa coronária pode dificultar ou impossibilitar o implante com sucesso de um dispositivo de terapia de ressincronização cardíaca. O objetivo desta revisão foi o de apresentar uma abordagem interventiva com muitas técnicas e ferramentas que precisam ser aprendidas e conhecidas para melhorar os resultados desta terapia e a saúde dos pacientes.

DESCRITORES: Cardiac Resynchronization Therapy, Coronary Sinus, Phrenic Nerve, Cardiac Pacing Artificial

ABSTRACT

Coronary venous anatomy can make successful implantation of a cardiac resynchronization therapy device difficult or impossible. The aim of this review is introduce an interventional approach with many techniques and tools that are needed to be learned and known in order to improve the results of this therapy and the health of patients.

KEYWORDS: Terapia de Ressincronização Cardíaca, Seio Coronário, Nervo Frênico, Estimulação Cardíaca Artificial

INTRODUCTION

In some cases left ventricular (LV) lead implantation can be difficult. No amount of skill and experience replaces having the specific tools and techniques described in this article. It is essential to recognize that device companies will not provide the full information that you may need.

To the implanting physician is very important to take the initiative and acquire the tools and knowledge required in the procedure. It is an investment that pays off for both the patients and the physicians. For example, combining the Cook Amplatz wire with the "vertebral vein selector" is useful for both initial coronary sinus (CS) cannulation (table 1, videos 3 e 4) and to stabilize CS access (table 2 and videos 4, 8, 11, 12, 13, 15). The term "Amplatz Vertebral Vein Selector technique" refers to the situation where the Amplatz wire & vein selector are used to facilitate CS cannulation while the "Amplatz support wire technique" refers to the situation where the wire is used to stabilize CS access (Table 2). If you don't have Cook Amplatz wire and the vertebral vein selector on hand, these essential techniques are not an option.

The objective of this article is focuses on specific issues that can occur in the sequence of implantation of a cardiac resynchronization therapy device and showing problems and solutions for then including videos (all then with permission of Seth J Worley) and images to support it.

Table 1. Amplatz vertebral vein selector CS cannulation technique step by step

1. The Amplatz Vertebral Vein Selector CS cannulation tech wire technique works for all catheters used for CS access.
2. Advance a "Vertebral Vein Selector" over an angled 0.035-in glide wire deep into the CS. When using the Worley sheath this will be through the braided core.
3. Keeping the Vertebral Vein Selector deep in the CS replace the glide wire with a 0.035-in 180 cm J tip Cook Amplatz extra stiff wire. The short taper of the Cook Amplatz is important & not found in J tip Amplatz wires from other companies.
4. The combination of the Cook Amplatz wire and the Vertebral Vein selector deep in the CS provides a rail over which the sheath can be advanced despite stenosis or tortuosity.
5. Once the CS is cannulated the Amplatz wire can be left in place if the 9-F Worley sheath is used for CS access.

Room set up and ergonomics

Difficult implants of cardiac resynchronization therapy devices are more likely to be successful when you are prepared by having the necessary equipment in the room e readily available on a cart like the on showed in the figure 1. The details of the equipment on the cart are described in the table 3. The proper table position (figure 2) and a table designed for LV lead implantation (figure 3) are also important. The proper table is

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Table 2. Amplatz support wire technique step by step

1. Amplatz wires are stiff thus do not advance well into the CS but provide excellent support once in place. The Vertebral Vein selector serves as a conduit through which to introduce the Amplatz wire. To avoid perforation always use a J tip Amplatz wire.
2. The 9-F internal diameter "Worley" sheath (WOR-CSG-B1-09 Merit Medical) provides the option to use the Amplatz support wire technique. The support wire technique is not an option with 7-F CS access catheters provided by the device companies.
3. Advance a "Vertebral Vein Selector" over an angled 0.035-in glide wire deep into the CS.
4. Keeping the Vertebral Vein Selector deep in the CS replace the glide wire with a 0.035-in 180 cm J tip Cook Amplatz extra stiff wire. The short taper of the Cook Amplatz is important & not found in J tip Amplatz wires from other companies.
5. Remove the "Vertebral Vein Selector" keeping the Amplatz wire in place.
6. With the 9-F sheath stabilized by the Amplatz wire the Vein Selector telescoped inside the sub selector is advanced beside the Amplatz wire. The shape of the vein selector depends on the takeoff of the target vein. For target veins at the ostium of the CS the sheath is withdrawn to uncover the target vein without loss of access.

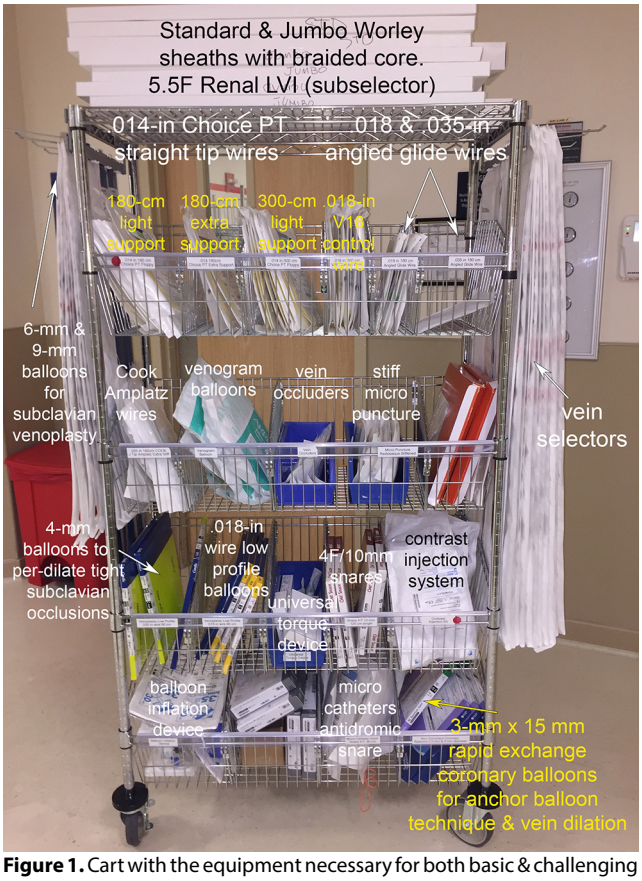

Figure 1. Cart with the equipment necessary for both basic & challenging LV lead implantation as well as subclavian venoplasty (See table 1 for details). Having the proper tools on hand will often make the difference between a long difficult frustrating case and an easy success.

Table 3. Implant equipment List

1. Worley Advanced Standard Curve; Order # WOR-CSG-B1-09 Merit Medical.
2. Worley Advanced Jumbo Curve; Order # WOR-CSG-B2-09. Merit Medical.
3. Catheters for Right side CS access & difficult to locate CS are hand shaped to resemble the braided core. 6F Boston Scientific Runway MP2 (Multipurpose 2) Ref H74938969390 (Alternatives # 1 = 6 Fr. Boston Scientific Mach 1 MP2 Order 34356-39, Alternative # 2 = 6 Fr. Medtronic MB1 Z2 Guiding Catheter Medtronic Vascular Z26MB1. Alternative # 3 = 6 Fr. Medtronic Launcher MB2 Ref LA6MB2. Alternative # 4 = 6 Fr. Cordis Vista Bright Tip MPB 1 Ref 670-275-00.
4. Worley Standard Vein Selector (5 Fr. x 75cm) Merit Order # 57538CS-WOR Merit Medical.
5. Worley Vert Vein Selector (5 Fr. x 75cm) Merit Order # 57538CSV--WOR Merit Medical.
6. Worley Hook Vein Selector (5 Fr. x 75cm) Merit Order # 57538CSHK--WOR Merit Medical.
7. Contrast Injection System Worley Advanced Kit 1 CAK 1(comes w/ contrast bowl and labels) (order # K12-WORLEY1 Merit Medical).
8. Sub selector = 5.5 Fr. ID Worley advanced Telescoping LVI, Order # WORLVI-75-5-62-55-RE
9. 5 Fr. Micro-puncture Kit with .018 Nitinol wire and stiffened radio-paque dilator Merit Medical. Order # S-MAK501N15BT.
10. 5 Fr. Impress KA 2 Hydrophilic Angiographic Catheter 5Fr. 65 cm (Order # 56538KA2-H Merit Medical) to assist crossing difficult subclavian obstruction.
11. 4 Fr. Impress KA 2 Hydrophilic Angiographic Catheter 4Fr. 65 cm (Order # 46538KA2-H Merit Medical).
12. 0.014 in. CholCE PT (Polymer Tip) Straight tip Light Support (order # 1211-01 Boston Scientific). (see annotated list below for options).
13. 0.014 in. CholCE PT (Polymer Tip) Straight (not angled) Tip Extra Support (order # 12161-01 Boston Scientific).
14. 0.014 in. CholCE PT (Polymer Tip) Straight (not angled) tip Light Support 300 cm Boston Scientific.
15. 0.018 V-18 Control Wire Guidewire wICE Coating Polymer Tip Hydrophilic (0.018 in 200 cm short taper) Boston Scientific (Catalog # 46-852).
16. COOK Amplatz Extra Stiff Wire Guide, 0.035 in, 180 cm, 3mm tip curve Cook (THSCF-35-180-3-AES) (another ref # on the package is G03565). (Do not substitute).
17. Angled (not straight) polymer tip hydrophilic wire 0.035 in. x 180 cm Laureate wire (Order # LWSTDA35180 Merit Medical) (AKA Glide wire or Terumo).
18. Angled (not straight) polymer tip hydrophilic wire 0.018 in. x 180 cm (Laureate Wire Order # LWSTDA18180 Merit Medical). (AKA Glide wire or Terumo).
19. Snare (Micro) 10 mm loop /4 F snare catheter Merit One Snare ONE 1000 (snare = 10 mm loop, 120 cm length; catheter = 4 Fr. 100 cm length inside diameter 1.02 mm). This 10 mm snare fits into the 9 French internal diameter CSG Worley beside the vein selector. (order # ONE100 Merit Medical).

20. Micro catheter for the antidromic technique Merit SureCross Support Catheter (length 90 cm, wire diameter 0.014 in, tip diameter 0.020 in {1.52 Fr.}) Catalog Number SC1490.
21. Subclavian venoplasty balloon 6 mm diameter x 4 cm length x 75 cm. CONQUEST Order # CQ-7564 Bard Peripheral Vascular rated burst pressure 30 atm.
22. Subclavian venoplasty 9 mm x 4 cm X 75cm balloon Order # CQ-7594 Bard Peripheral Vascular rated burst pressure 26 atm.
23. Cordis Powerflex Pro OTW (0.035 in wire) Balloon Catheter: Balloon 4 mm diameter by 40 mm long; shaft length 80 cm Order # 4400404S.
24. Non-compliant rapid exchange coronary balloon e.g. NC Sprinter from Medtronic 3.0 mm diameter by 15 mm length Catalog # = H7493912415300 GITN # = 08714729783374.
25. Cook Needle's Eye Snare alone = 13 mm Femoral Snare & straight 12 Fr. sheath without work station - Ref: - G26518 Ref: LR-SSN001
26. Cook Needle's Eye Snare alone = 20 mm Femoral Snare & straight 12 Fr. sheath without work station - Ref: G26516 Ref: LR-SSN002
27. 16 Fr Curved Work Station alone 16 Fr. Curved Work Station (Femoral Introducer Sheath Set) – Ref: G26566 Ref: LR-CSS16.

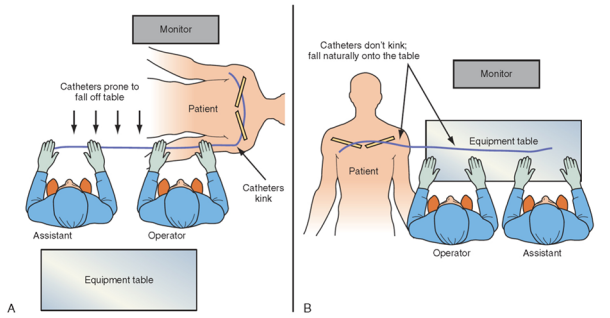

Figure 2. Importance of table position for successful LV lead implantation. The perpendicular table position improves the ergonomics of catheter & wire exchange, catheter torque control is improved by removing an acute angle and wires are less likely to fall off the table.

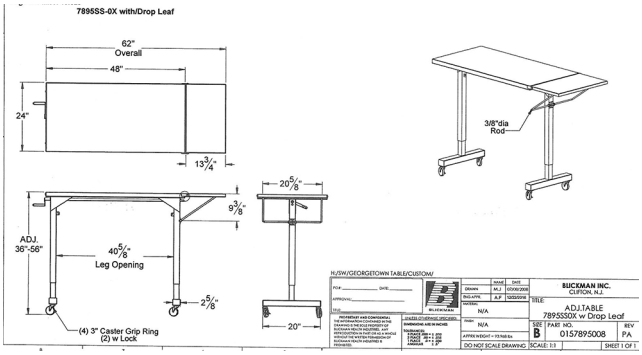

Figure 3. A table designed for the interventional approach to device implantation will make implants easier and more likely to be successful. The table height can be adjusted to the height of the patient table. The extension allows the x ray tube to be rotated right anterior oblique (RAO) without hitting the legs of the table. Having the patient table and the work table at the same height makes the Amplatz support technique more stable and catheter exchanges easier.

also useful when a subclavian occlusion needs crossed and dilated for venous access.

Venous access

The importance of subclavian venoplasty for venous access in patients with previous leads cannot be overstated.

Locating the coronary sinus

Trying to locate the CS with an electrophysiology (EP) catheter or wire (poke and pray) while often is a successful method it is also a intrinsically limited one. Locating the CS via catheter manipulation with contrast injection (described in the video below) is a intrinsically superior method but requires changes in the approach for implanting physicians[1].

1. **Problem:** how to locating the CS for CS cannulation (figure 4)?
   Solution: contrast injection and catheter manipulation to use Eustachian ridge & Thebesian valve to facilitate the CS cannulation.
   Video 1 - CS Cannulation using the Worley Sheath:
   https://www.youtube.com/watch?v=OE0yimc13uQ

2. **Problem:** unable to locate the CS despite using contrast and catheter manipulation probably because of CS atresia (figure 5).
   Solution: look for a persistent vein of Marshall through which to implant the LV lead.
   Video 2 - Lead implantation despite CS atresia via persistent Vein of Marshall:
   https://www.youtube.com/watch?v=1mLRpwJ1k8A

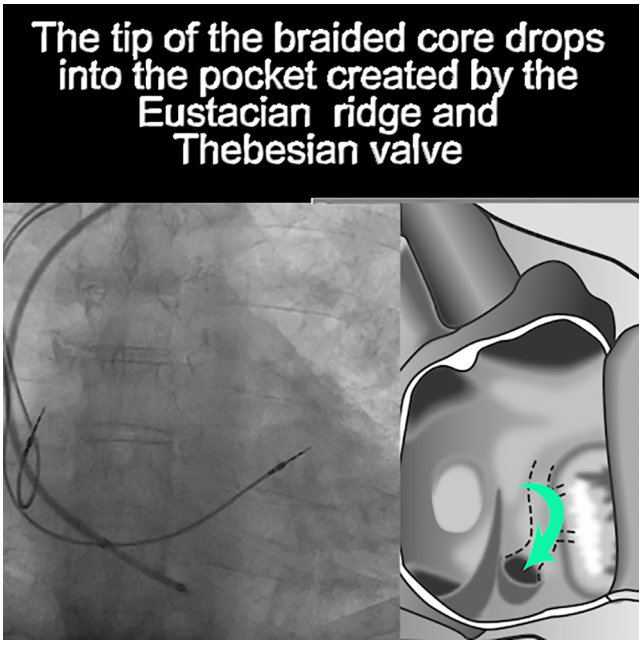

Figure 4. How to cannulate the CS utilizing catheter manipulation and contrast injection (watch video 1 for details).

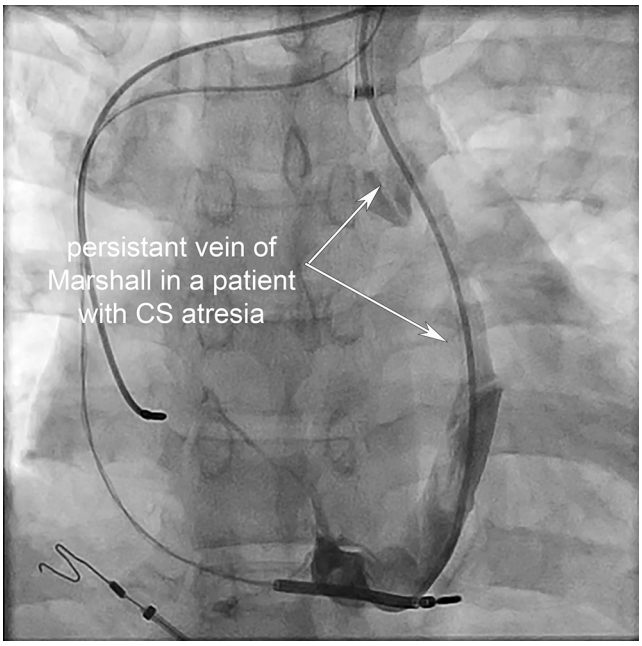

Figure 5. patient with CS atresia and persistent vein of Marshall through which the LV lead can be implanted. When full strength contrast via a contrast injection system plus a properly shaped open lumen catheter are used to locate the CS, the CS will be identified within 5 minutes. If not, other options need to be considered including CS atresia with or without an unroofed CS. Don't waste time & effort looking for the CS with an EP catheter or trying to locate the CS via femoral access. Use the standard vein selector to look for a persistent vein of Marshall at the sternal-clavicular junction and/or proceed to coronary injection with levophase visualization of the CS paying attention for a persistent vein of Marshall (watch video 2 for details).

Coronary sinus annulation once the CS is identified

1. **Problem:** difficult to advance into the CS (figure 6).
   Solution: vertebral vein selector & Cook Amplatz wire.
   Video 3 - CS Cannulation using Vertebral & Amplatz:
   https://www.youtube.com/watch?v=SB4nNBmy-3g

2. **Problem:** Impossibility to establish stable CS access in huge right atrium (figure 7).
   Solution: jumbo Worley Sheath and Cook Amplatz support wire.
   Video 4 - CS Cannulation using Jumbo sheath & Vertebral & Amplatz wire:
   https://www.youtube.com/watch?v=5P7gJItePP8

3. **Problem:** drain pipe CS unable to advance sheath into the CS (figure 8).
   Solution: the anchor balloon technique[2].
   Video 5 - CS Cannulation using the anchor balloon technique:
   https://www.youtube.com/watch?v=hmXtcsVjsyw

4. **Problem:** vieussens valve prevents access to the great cardiac vein (figure 9).
   Solution: "Vertebral Vein Selector" to advance past Vieussens valve.
   Video 6 - CS Cannulation using the Vertebral to get beyond Vieussens valve:
   https://www.youtube.com/watch?v=SdTEB3R6W8M&t=5s

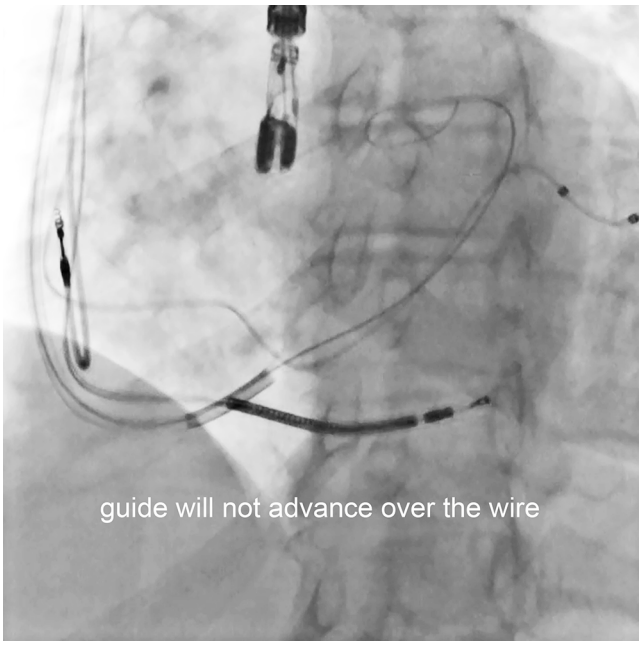

Figure 6. Example of the Cook Amplatz wire/ Vertebral Vein selector CS cannulation technique for patients with tortuous and/or stenotic CS. A patient with a stenotic CS where the device company delivery systems could not be advanced. Using the Merit "Vertebral Vein Selector" & Cook Amplatz wire, CS cannulation was successful. The vein selector/Amplatz wire technique also works well for a tortuous CS (watch video 3 for details).

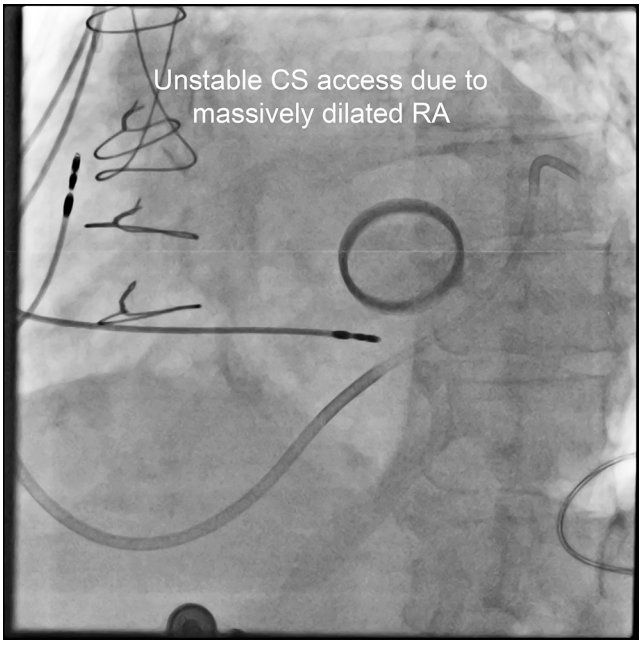

Figure 7. Example of the Cook Amplatz wire/Vertebral Vein selector support wire technique. Using several different device company delivery systems it was impossible to establish stable CS access in this patient with a massively dilated right atrium. The Jumbo Worley sheath and Cook Amplatz support provide stable CS access followed by successful LV lead delivery. Sometimes switching from the Standard Worley sheath to the Jumbo Worley sheath facilitates initial CS cannulation (watch video 4 for details).

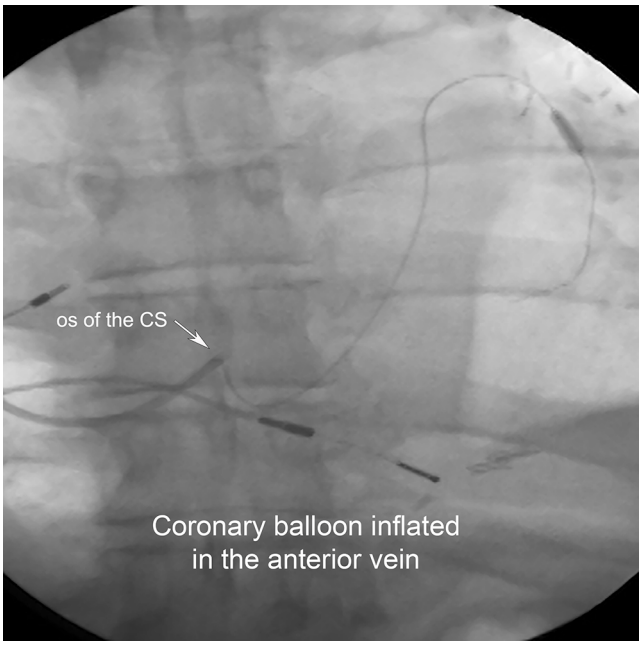

Figure 8. Previous attempts to cannulate the "drain pipe" were unsuccessful. As the catheter was advanced the tip served as a fulcrum and the proximal segment dropped into the right atrium. The CS was successfully cannulated using anchor balloon technique (watch video 5 for details).

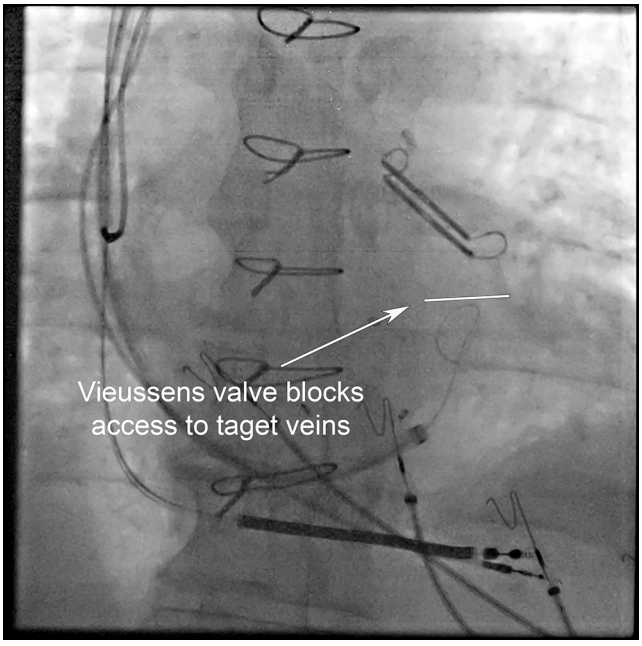

Figure 9. Vieussens valve blocked access to target veins resulting in two failed attempts at LV lead implantation. Using the "Vertebral Vein Selector" & contrast injection system the valve was crossed, and lead placed (watch video 6 for details).

Occlusive CS Venogram

Start by using full strength contrast and a control syringe for an adequate CS venogram. Insure the balloon is occlusive by placing the balloon above Vieussens valve. Don't assume that it is safe to inflate the balloon because it was advanced over a wire; you could be in the vein of Marshall, always do a gentle test injection first. Watch for retrograde filling of proximal veins.

1. **Problem:** high outputs and phrenic pacing throughout the only viable target vein identified on CS venogram (figure 10).
   Solution: full-strength contrast injection through a "vein selector" advanced over a wire into the branch to demonstrate an alternative target vein off CS.
   Video 7 - vein selector venogram to identify alternative targets off the CS:
   https://www.youtube.com/watch?v=23nhCd2h9Gw

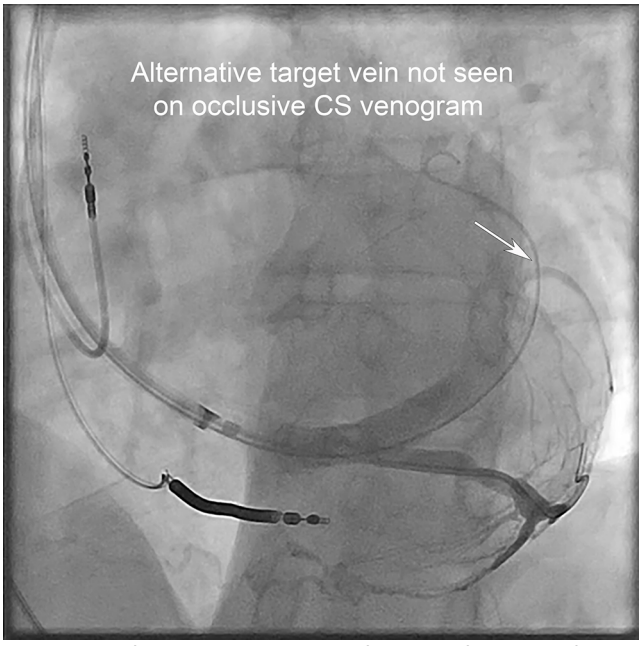

Figure 10. Selective venogram using the Vein Selector reveals a CS target vein not seen on occlusive venography. (watch video 7 for details).

2. **Problem:** high outputs and phrenic pacing throughout the only viable target vein identified on CS venogram (figure 11).
   Solution: full-strength contrast injection through a "vein selector" advanced over a wire into the branch vein demonstrates a side branch off the target vein.
   Video 8 - vein selector venogram to identify side branch for an alternative target site:
   https://www.youtube.com/watch?v=mWVeJlYC92s

Left ventricular lead Implantation

1. **Problem:** using the "poke & pray" approach it can be difficult to advance a wire into the target vein (figure 12).
   Solution: use of three vein selector shapes designed to be telescoped into the sub selector. Vein selectors attached to the contrast injection system are designed to locate the target vein with a puff of contrast as you might locate the right coronary artery. Once the vein is located a wire is advanced. The vein selector is then advanced over the wire deep into the target vein. To facilitate advancing the vein selector into a difficult target vein up to four 0.014-in angioplasty wires can be advanced through the 0.018-in lumen. The sub selector

is then advanced over the wire stabilized vein selector deep in the target vein. The vein selector is removed retaining one wire for LV lead delivery.
Video 9 - Vein selector overview: https://www.youtube.com/watch?v=IsawLqHGq-g

2. **Problem:** drain pipe target vein (figure 13).
Solution: the "hook vein selector" telescoped in the renal lateral vein introducer (LVI) sub selector plus the use of multiple wires to advance the vein selector deep into the target vein.
Video 10 - Hook vein selector for acutely angulated target vein off great cardiac vein:
https://www.youtube.com/watch?v=I9gEdLSNcFg

3. **Problem:** angulated stenotic target vein near the ostium of the CS (figure 14).

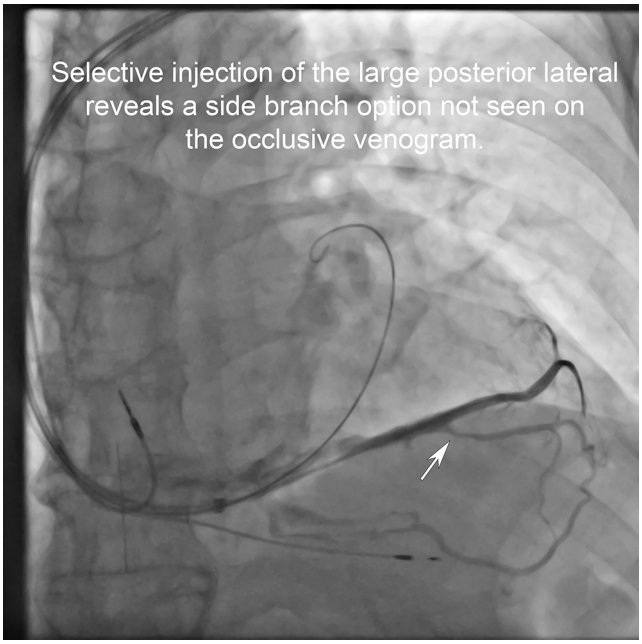

Figure 11. Selective venogram using the Vein Selector reveals a side branch off the target vein not seen on occlusive venography (watch video 8 for details).

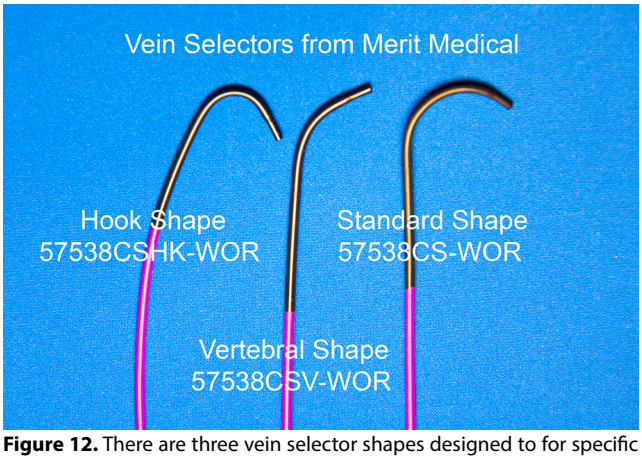

Figure 12. There are three vein selector shapes designed to for specific anatomy (watch video 9 for details).

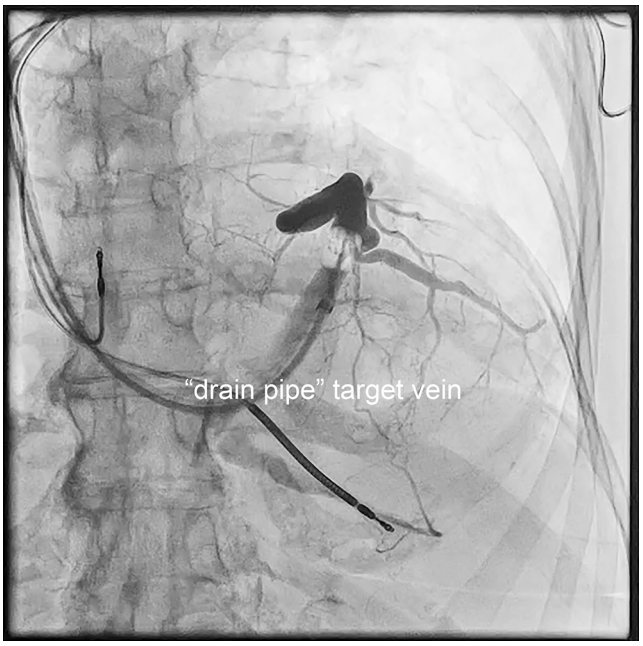

Figure 13. Target veins with "drain pipe' origin from the CS can be difficult to implant. This patient had a previously failed attempt. The "Hook Vein Selector" telescoped inside the "Renal LVI" sub selector makes implantation possible (watch video 1 for details).

Solution: The "Hook Vein Selector" telescoped in the renal LVI sub selector through the 9-F sheath supported by the Cook Amplatz wire.
Video 11 - Hook vein selector and support wire for acute angle near the CS:
https://www.youtube.com/watch?v=fQynQNB-jp0

4. **Problem:** target vein at the ostium of the CS (figure 15).
Solution: The "Vertebral Vein Selector" telescoped in the renal LVI sub selector through the 9-F sheath supported by the Cook Amplatz wire.
Video 12 - Vertebral vein selector and support wire to implant LV LD with target vein near CS: https://www.youtube.com/watch?v=4XYwfi5Ba6U

5. **Problem:** angulated target vein (figure 16).
Solution: the standard vein selector telescoped in the renal LVI sub selector.
Video 13 - Standard vein selector for previous implant failure:
https://www.youtube.com/watch?v=0apbC0kPumo&t=7s

6. **Problem:** tortuous small and or stenotic target vein (figure 17).
Solution: orthodromic snare technique[3] (tables 3 and 4).
Video 14 - Orthodromic snare technique step by step:
https://www.youtube.com/watch?v=tmr8z7bltN0

7. **Problem:** inability to advance a wire into the target vein (figure 18).

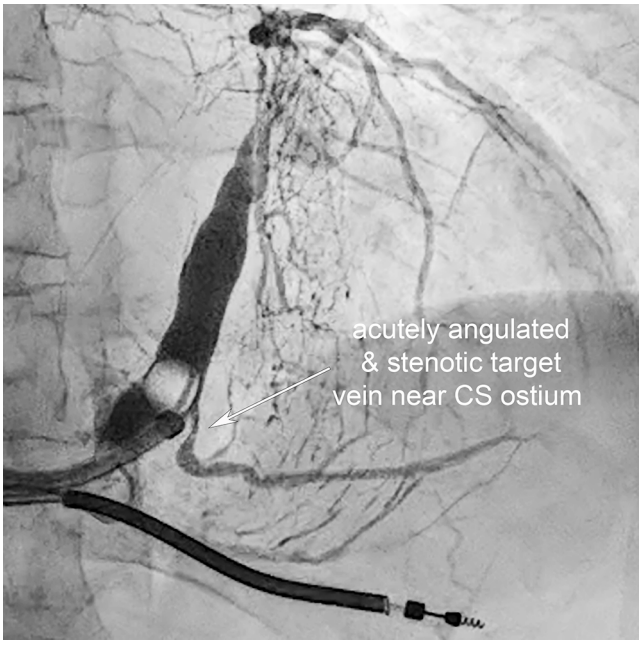

Figure 14. Target veins with acute angulation near the ostium of the CS can be implanted using the "Hook Vein Selector" telescoped inside the "Renal LVI" sub selector with the Worley sheath supported by the Cook Amplatz wire (watch video 11 for details).

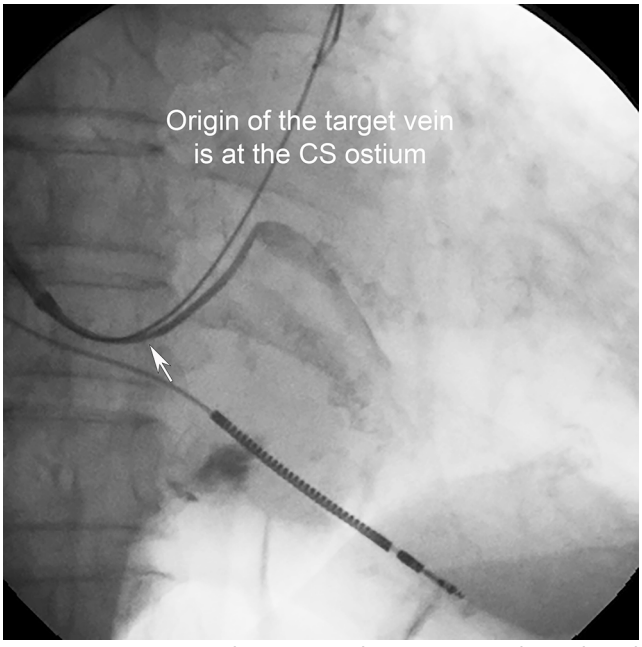

Figure 15. Target vein with its origin at the CS ostium can be implanted easily using the Cook Amplatz support wire technique and "Vertebral Vein Selector" telescoped inside the "Renal LVI" sub selector. (watch video 12 for details).

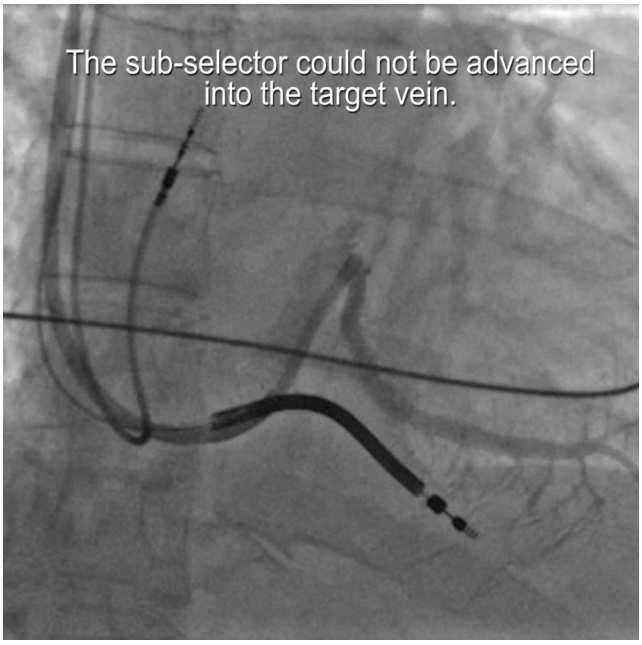

Figure 16. LV lead could not be placed in this angulated target vein using device company sub selector despite multiple attempts by several physicians over the course of several hours. Using the "Standard Vein Selector" telescoped inside the "Renal LVI" sub selector the LV lead was easily placed in 15 minutes (watch video 13 for details).

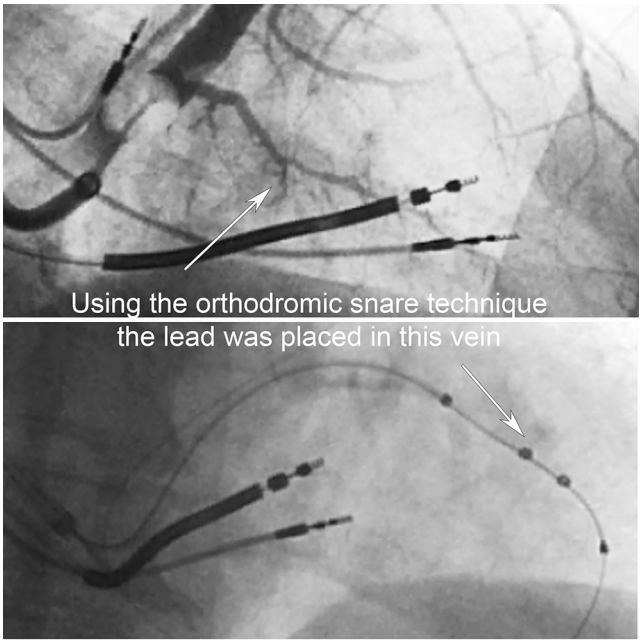

Figure 17. Target vein too small for LV lead placement using traditional techniques successfully implanted via the orthodromic snare technique. Watch Video 14 for details on how to implement the orthodromic snare technique (watch video 14 for details).

Solution: antidromic snare technique (table 5).
Video 15 - Antidromic snare technique step by step: https://www.youtube.com/watch?v=ez4Kvd2iYiE

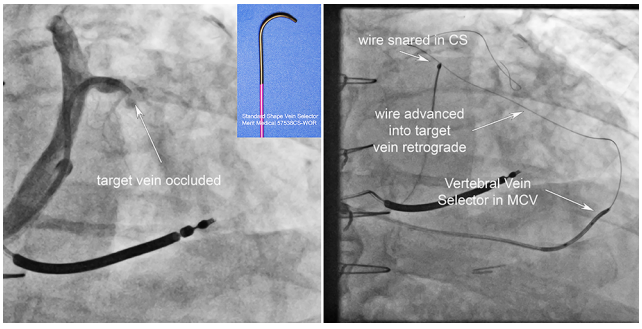

Figure 18. Unable to advance a wire into the occluded target vein occluded from prior unsuccessful LV lead placement. Wire advanced out of the target vein using collaterals from the middle cardiac vein. Lead placed using the antidromic snare technique and coronary vein venoplasty (watch video 15 for details).

Table 4. Sheaths, Catheters and Wires Required for the Orthodromic and Antidromic Snare Technique

1. Worley Advanced Standard Curve; Order # WOR-CSG-B1-09 Merit Medical or Worley Advanced Jumbo Curve; Order # WOR-CSG--B2-09. Merit Medical.
2. Worley Standard Vein Selector (5-F x 75cm) Merit Order # 57538CS-WOR Merit Medical.
3. Worley Vert Vein Selector (5-F x 75cm) Merit Order # 57538CSV--WOR Merit Medical.
4. Worley Hook Vein Selector (5-F x 75cm) Merit Order # 57538CSHK-WOR Merit Medical.
5. Contrast Injection System Worley Advanced Kit 1 CAK 1(comes w/contrast bowl and labels) (order # K12-WORLEY1 Merit Medical).
6. 4-F Impress KA 2 Hydrophilic Angiographic Catheter 4-F 65-cm (Order # 46538KA2-H Merit Medical).
7. .014-in ChoICE PT (Polymer Tip) Straight tip Light Support 180-cm (order # 1211-01 Boston Scientific).
8. .014-in ChoICE PT (Polymer Tip) Straight (not angled) tip Light Support 300-cm Boston Scientific.
9. COOK Amplatz Extra Stiff Wire Guide, .035in, 180cm, 3mm tip curve Cook (THSCF-35-180-3-AES) (another ref # on the package is G03565). (Do not substitute).
10. Snare (Micro) 10-mm loop /4 F snare catheter Merit One Snare ONE 1000 (snare = 10-mm loop, 120-cm length; catheter = 4-F 100-cm length inside diameter 1.02-mm). This 10-mm snare fits into the 9 -F internal diameter CSG Worley beside the vein selector. (order # ONE100 Merit Medical).
11. Micro catheter in case the snared wire gets bent and for the antidromic snare technique Merit SureCross Support Catheter (length 90-cm, wire diameter .014 in, tip diameter .020 in {1.52-F}) Catalog Number SC1490.

Table 5. Orthodromic Snare technique - Step by Step

1. Engage the target vein with the appropriate shape "Vein Selector".
2. Advance a straight light support polymer tip wire into the vein (Choice PT Floppy Boston Scientific).
3. Once the wire is in the vein, advance the vein selector a 3-7-mm over the wire into the vein.
4. If the wire becomes bent as it is advanced, it may not traverse the collaterals. Once it is bent withdrawing the wire back into the vein selector does not straighten the wire. Do not remove the bent wire. Add a second wire. The bent wire orients & supports the vein selector, so the second wire remains straight as it exits into the vein.
5. The straight second wire is advanced through the collaterals into an adjacent vein (exit vein) and back into the CS.
6. If there is difficulty advancing the wire through the collaterals one option is to add a microcatheter as follows; 1. remove the Y adapter from the hub of the injection system 2. advance a .014-in micro catheter (SureCross) over the existing wire. 3. Exchange the existing wire for a fresh wire. 4. The microcatheter provides support to advance the fresh wire through the collaterals.
7. To confirm that the wire is back in the CS check the LAO and RAO projections.
8. Once the wire traverses the collaterals, load the 10-mm loop into the 4-F snare catheter.
9. Holding the vein selector in position advance the 4-F 10-mm snare into the 9-F sheath beside the 5-F "Vein Selector". (As the snare is advanced hold the vein selector (or lead) in place otherwise friction can cause the vein selector (or lead) to advance.)
10. How the wire is snared depends on the direction the wire takes once it reaches the CS;
11. either 1. up the CS toward the great cardiac vein or 2. out of the CS into the RA.

11.1. When the wire turns up into the CS toward the great cardiac vein, the snare is positioned in the body of the CS above the "exit vein" (usually the MCV) and the wire advanced into the open loop.

11.2. When the wire exits into the RA, the vein selector is held in place and the snare is positioned over the ostium of the "exit vein" (usually the MCV). It is critical to check the RAO projection to confirm that the snare is positioned over the MCV. The loop can appear to be properly positioned in the AP & LAO projection but when advanced the wire is not captured by the snare.

12. After 15 cm. of wire is through the loop the snare is closed on the wire. It is important to tighten the snare on the stiff part of the wire to avoid bending the wire or pulling off the tip.
13. To secure the snared wire: 1. The right hand presses the open hemostat against the hub of the snare catheter. 2. The left hand pulls the snare loop tight against the wire. 3. The hemostat is closed on the snare at the hub of the snare catheter.
14. With wire snared the sheath is withdrawn into the RA (holding the snare and vein selector in place).
15. To prevent the snare from being pulled down into the sheath when tension is placed on the wire, a second snap is placed on the snare catheter where it enters the hub of the sheath.
16. To advance the lead a rail is created by placing tension on the snared wire.

17. Tension on the wire creates a rail over which the lead could be advanced despite the stenosis and tortuosity. In some cases, even with the snare the lead will not advance without venoplasty.
18. With the wire still snared and the lead in place, thresholds are tested. Thresholds may change slightly once the snare is released and the wire removed. Presence or absence of phrenic pacing does not change.
19. Once satisfactory thresholds are achieved, the snare system is removed.
20. To prevent any chance of lead dislodgement the sheath is removed with the wire still snared. Again, thresholds may change only slightly once the snare is released and the wire removed.
21. To open the snare the loop is advanced 3-5-mm into the snare catheter.
22. Withdraw the wire through the open snare until the tip is clear of the snare but still in the
23. pacing lead.
24. With the wire free of the snare the loop is withdrawn into the snare catheter. Holding the lead in place the snare is removed.
25. After a final adjustment of slack in the LAO projection the wire is withdrawn.

Table 6. Antidromic Snare technique Step by Step (Video 15)

1. The first step is to engage a branch with collaterals to the target vein, usually the MCV. The 9-F internal diameter "Worley" sheath (WOR-CSG-B1-09 Merit Medical) provides the option to use the support wire technique to easily engage the MCV. The support wire technique is not an option with a 7-F CS access catheter. See the Amplatz support wire technique for details.
2. The shape of the "Vertebral Vein Selector" is well suited for cannulation of the MCV & target veins below Vieussens valve. A puff of contrast from the injection system confirms the tip of "Vein Selector" has dropped into the MCV. An angled .035-in glide wire is advanced into the MCV.
3. With the Worley sheath stabilized by the Cook Amplatz wire the "Vein Selector" is advanced into the MCV over a glide wire. The glide wire is removed & and a puff of contrast injected to define the collaterals from the MCV to the target vein. In most cases the angle of the "Vertebral Vein Selector" works well with the angle of the collaterals.
4. A 300-cm light support (floppy) straight polymer jacketed angioplasty wire is advanced into the collaterals. (Choice PT Floppy).
5. The position of the wire is assessed with a puff of contrast through the vein selector. The 300-cm wire is advanced through the collateral leading to the target vein then back into the CS.
6. If there is any difficulty advancing the wire through the collaterals, the Y adapter on the hub of the vein selector is removed and a SureCross micro catheter is advanced over the wire through the vein selector into the collateral. Because the "vein Selector is 75-cm and the SureCross is 90-cm it is important to remove the Y adapter to load the catheter over the wire. To avoid the need to remove the Y adapter and insure enough length, a longer microcatheter can be used.
7. If, when trying to cross the collaterals, the wire becomes bent it is important to replace the wire. Withdrawing the wire back into the vein selector or microcatheter does not straighten the wire.
8. Once the wire is back in the CS advance the snare catheter over the 180-cm Cook Amplatz support wire into the CS. Once the snare catheter is in the mid CS, the Amplatz wire is removed.
9. With the tip of the 4-F snare catheter in the CS load the 10-mm loop of the snare using the introducer. The 10-mm loop is advanced through the snare catheter until it is deployed in the mid CS.
10. The angioplasty wire is withdrawn toward the target vein until the tip is beyond the loop of the snare. The wire is then advanced into the open snare. The loop of the snare is closed on the wire by holding the loop and advancing the snare catheter.
11. Before tightening the snare on the wire advance 8 to 10-cm through the loop otherwise the tip of the wire will be pulled off by the snare.
12. To secure the snared wire: a. Use the right hand to press an open hemostat against the hub of the snare catheter. b. Use the left hand to pull the snare loop tight against the wire. c. Close the hemostat on the snare at the hub of the snare catheter.
13. Once the end of the wire is secured by the snare, the goal is to use the snare to withdraw 120 cm of the angioplasty wire into the sheath and out into the pocket. However, there is the potential for the cheese cutter effect.
14. To prevent the cheese cutter effect, the wire is covered with a micro catheter. The wire is advanced through the micro catheter not pulled through the collaterals.
15. With the wire snared in the CS, remove the vein selector and advance the SureCross microcatheter over the wire, through the collaterals back into the CS to the snare. (Hydrophilic micro catheter 90 cm, 0.14-in lumen 1.5-F tip SureCross Support Catheter Merit Medical)
16. Attach a Y adapter with hemostatic valve to the hub of the microcatheter close the valve and flush vigorously with heparinized saline using a 1 to 3-ml syringe. Failure to flush the micro catheter can result in seizure of the wire.
17. Do not use the snare to pull the wire through the micro catheter. The distal end of the wire is advanced into the micro catheter while the tip of the lead is withdrawn into the 9-F Worley sheath with the snare. The wire should advance easily into the micro catheter to provide slack for the snare to withdraw into the sheath. If there is any difficulty advancing the wire into STOP, close the hemostatic valve & flush the micro catheter with a 1-2-ml syringe.
18. The process of advancing the proximal end of the wire into the micro catheter & withdrawing the snared end is continued until 90-cm of wire is externalized into the pocket.
19. Once the distal end of the wire is in the pocket, the snare is opened, and the bent section of wire removed with a pair of scissors.
20. The cut snared end (tip) of the wire is back loaded into the tip of the pacing lead.
21. The proximal end of the wire is secured at the hub of the Y adapter used to flush the micro catheter.
22. Before advancing the pacing, lead be certain the sheath is out of the CS. If not withdrawn from the CS the sheath can get jammed into the crux between the MCV (wire exit vein) & the CS preventing the lead from advancing.
23. Before advancing the lead withdraw the tip of the micro catheter back into the MCV.
24. With tension on the distal end of the wire the pacing lead is advanced into the target vein. In some situations, particularly around tight curves, the lead may not advance if there is too much tension on the wire. Temporarily relaxing tension while advancing can help the lead to advance. Another situation where there can be difficulty advancing is when you forget to withdraw the micro catheter out of the target vein.
25. Once the lead is in place & thresholds confirmed the sheath is peeled away. The wire is removed through the micro catheter. As the wire is withdrawn keep the tip of the microcatheter near the tip of the pacing lead. If there is any difficulty moving the wire close the hemostatic valve and flush the micro catheter. Also flush the leads as shown in video 15.

Special Cases

When a 180-cm wire traverses the collaterals and the decision is made to implement the antidromic snare technique which requires a 300-cm wire. If the 180-cm wire is removed, you may not get a 300-cm wire back into the CS. To exchange the 180-cm wire for a 300-cm wire use the microcatheter as follows. a. Snare the end of the 180-cm wire. b. Remove the vein selector. c. Advance the microcatheter over the 180-cm wire into the CS next to the snare. d. Open the snare and remove the 180-cm wire through the microcatheter. e. Advance a 300-cm wire through the microcatheter into the CS and snare the end.

1. In some patients the "Vertebral Vein Selector" is not the correct shape to engage the collateral to the target vein. When this occurs switch to a "standard" or "hook" vein selector.
2. Although the collaterals leading to the target vein are often found off the MCV, they may be found connecting to other adjacent veins.
3. If the micro catheter will not advance through the collaterals (rare with the .014-in SureCross), the micro catheter can be exchanged for an over the wire 1.25-mm coronary balloon. Once the balloon is through the collaterals into the CS, the lumen of the balloon is used as the conduit through which to advance the wire.
4. Usually the wire is snared in the CS before the micro catheter is advanced. However, sometimes the wire traverses the collaterals to the target vein but will not advance from the target vein into the CS. To get the wire to exit the target vein the Y adapter is removed and the .014-in micro catheter is over the wire through the collaterals into the target vein. The support of the microcatheter facilitate wire passage out of the target vein into the CS. Once the microcatheter is in the target vein a bent wire can be replaced without the risk of not being able to cross the collaterals.
5. The .014-in micro catheter can be and advanced over the wire through vein selector into the collaterals into the target vein to facilitate wire passage out of the target vein into the CS. The micro catheter provides support to advance the wire and/or the bent wire can be replaced with a new wire. When the microcatheter is advanced through the vein selector a longer microcatheter may be required. The wire can then be advanced into the open snare and secured.

Special Situations

Inability to capture the wire with the snare

First confirm the position of the loop relative to the exit vein in the RAO projection. In some cases, it can be very difficult to snare the wire as it exits the MCV into the RA. One option is to position the snare inside the MCV. To get the snare in the MCV start by loading a glide wire into the snare catheter. Advance the glide wire/snare catheter into the sheath beside the vein selector. Advance the glide wire into the MCV. Advance the snare catheter over the glide wire into the MCV. Remove the glide wire and load the snare loop into the snare catheter. Deploy the loop in the MCV and advance the wire into the open snare. Alternatively, the snare catheter can be replaced with a 4-F angled catheter (KA2) to aim the loop of the snare in the desired direction.

Wire becomes bent by the snare

On occasion the snare bends the wire usually when the snared wire is inadvertently pulled back into the sheath. To prevent bending the wire withdraw the sheath into the RA once the wire is snared. When the is bent it can be impossible to remove from the pacing lead or the bent tip can fracture and embolize. When the wire is bent follows these steps: 1. Keep the wire snared. 2. Remove the pacing lead. 3. Flush and wipe the wire. 4. Advance the microcatheter over the wire through the collaterals up the snare. 4. Attach a Y adapter to the hub of the microcatheter, tighten the hemostatic valve and flush the microcatheter with hepatized saline using a 1-3-ml syringe. 5. Loosen the hemostatic valve and advance the wire into the microcatheter while the wire is withdrawn into the sheath with the snare. 6. Once the bent wire is removed, flush the microcatheter and insert a fresh wire. 7. Reinsert the snare into the CS. 8. Keeping the wire in place, withdraw the microcatheter and re snare the wire. 8. Replace the microcatheter with the pacing lead.

CONCLUSIONS

The LV lead placement is limited by the unpredictable coronary venous anatomy. The support provide by a wire is generally not adequate to allow the lead to be advanced into the target vein. This present article review introduce an interventional approach based in the use of contrast, injection system, guiding catheters, vein selectors, anchoring balloons, venoplasty, snares and the suitable ergonomics for the implant. it is completely necessary the operator of this procedure be trained in order to adopt interventional skills to optimize the chance of a success, reduce the temptation to accept a less desirable position and reduce implantation time and the likelihood of phrenic nerve stimulation, high thresholds or the impossibility to deliver the lead.

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