Chapter 1

Introductory Chapter: Practical Approach to the Use of Intracardiac Echocardiography in Invasive Electrophysiology Procedures

Umashankar Lakshmanadoss

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/65243

1. Introduction

Use of intracardiac echocardiography (ICE) has been significantly increased with the advent of invasive electrophysiology and interventional procedures. In this day and age, we as a clinician are focused more on efficient and safe procedures for the patient. Intracardiac echocardiography plays a major role in doing these interventional procedures in a safe and efficient way. In addition to this, the use of ICE significantly reduced the need for fluoroscopy and hence reduced the occupational hazards of radiation and lead aprons for the physicians. It changed the way of doing these interventional procedures and one could easily say that this is one of the paradigm shift for us. In this chapter, I intend to review the basics of intracardiac echocardiography and also describe the various views and applications of intracardiac echocardiography in invasive electrophysiological procedures.

Several types of ice catheters are available in the market currently. They could be broadly divided into two different modalities. One catheter is a mechanical non-steerable catheter, which utilizes a rotating element to create a video 360° imaging claim perpendicular to the long axis of the catheter (UltraICE® Boston Scientific). This is 9 Fr catheter using 9 MHz. The second group of the catheter is a 64 element phased array 4-way steerable catheter. AcuNav® catheter (Biosense – Webster) is one of the commonly available phased out a catheter with the frequency range of 5.5–10 MHz. This is available in 8 and 10 Fr sizes. The system uses gray scale and has the facility for performing color Doppler, tissue Doppler and 3-D localization with Cartosound®. The images from this catheter result in a 90° sector image in the form of pie. ClearICE® catheter (St. Jude Medical) is another form of 64 elements phased array site looking highly steerable catheter with two sets of electrodes for integration of 3-D localization with NavX®. In addition to the gray scale and tissue Doppler, this can also do synchronization mapping which speckles tracking. In our electrophysiology laboratory, we commonly use the phased array 8 or 10 Fr AcuNav® catheter. For the purpose of this chapter, one the images from phased array system is included.

2. What are all the moments possible with the ICE catheter?

There are totally eight movements possible with this steerable catheter. With these eight movements, an experienced operator should be able to navigate through the important structures of the heart.

1.	Clockwise: rotation of the catheter away from the operator
2.	Counterclockwise: rotation of the catheter towards the operator
3.	Anterior flexion: catheter bends forward
4.	Posterior flexion: catheter bends backward
5.	Right tilt: catheter bends towards the right side
6.	Left tilt: catheter bends towards the left side
7.	Push: catheter is advanced in further
8.	Pull: catheter is withdrawn

3. How to advance the ICE catheter into the heart?

In our laboratory, the imaging catheter is mostly advanced, either from the right or left femoral vein into the right atrium. This could be performed without the use of fluoroscopy. After getting a venous access, the ICE catheter is advanced through the sheath into the femoral vein. Once the catheter is out of the venous access sheath, one should be able to visualize the lumen of the venous system. We typically advance the catheter making sure that there is a sufficient lumen seen at the tip of the catheter. To negotiate the side branches and tortuous veins, we use the knob of the ice catheter to do the various possible movements as described above. While advancing the catheter, one could clearly visualize the structures including liver. Once we reached right atrium, we typically leave the catheter to get the home you as described below. Fluoroscopy guidance should be used by less experienced operators as the catheter tip is not soft.

http://dx.doi.org/10.5772/65243

4. What settings does one need to have to optimize the ice images?

It is also important to understand the basics and physical principles of echocardiography to optimize the images obtained.

1. Frequency: the frequency range of the ice catheter is 5.5–10 MHz. High frequency lengthens the near field and hence has higher resolution. However, the depth of the penetration is reduced and thereby limiting its usefulness. A frequency setting of 7.5 MHz is a good starting point for most of the electrophysiological procedures. If we need to examine one particular area with a higher resolution, then the operator could use higher frequency mode. For example, lower frequencies (5.5 MHz) may be required to visualize distant structures such as the inferior and lateral wall of the left ventricle in the dilated heart. Similarly, higher frequencies (8.5–10.0 MHz) may be required to visualize a near field structure with a high resolution as in the case of outflow tract tachycardia.

2. Depth: depth of the imaging sector could be either increased or decreased to include the area of interest. For the purpose of transseptal access and imaging of the right-sided pulmonary veins from the right atrium, and the setting of 60–80 mm would be sufficient. For imaging, the left-sided pulmonary veins and left atrial appendage from the right atrium at the setting of 80–100 mm would be optimal. If the operator wants to evaluate the pericardium for the purpose of pericardial effusion, a depth setting of 100–120 mm could be sufficient. For the purpose of imaging right ventricle and left ventricle from the right atrium, a wide range of depth setting of 100–120 mm could be used depending on the size of the ventricles.

3. Gain: gain is the amplitude of the received signal. When the gain is increased, we are amplifying the received signal, and hence the image becomes brighter. However, an excessive increase in grain and noise to the image and hence lateral resolution is not great. Hence, to enhance lateral resolution, the minimum amount of system gain should be used.

4. Focus: usually, it is not needed to adjust focus. Most of the imaging sectors have the focal zone set to a region that is 2/3 of the total. If the how to evaluate the near-field structure is with more detailed analysis (visualizing right atrium lead thrombus from the right atrium)], then we have to adjust the focus.

5. Dynamic range: dynamic range refers to the range of ultrasound intensities that can be displayed; it is one of the methods of controlling the contrast of the image. The higher the dynamic range, the better the contrast resolution. During ablation, if there is any doubt of the thickness of the structures, one could reduce the dynamic range and see if the thickness of the structures is increased or not. This could be very helpful to assess the catheter contact with a left atrial appendage, left the atrial ridge and other endocavitary structures.

6. Mechanical index: during an ablation procedure, ablationist would be interested in looking for the bubbles from the tissue which could be an impending sign of steam pop. If the mechanical index is very high, these microbubbles could be destructed with the subsequent admission of high intensive signals. Hence, the mechanical index should be kept as intermediate if one wants to see the microbubbles.

7. Tissue Doppler: tissue Doppler could be used to find the area of scar or fibrosis. This could be of vital importance in ventricular tachycardia ablation.

8. Color Doppler and continuous wave Doppler: this could be used in evaluating pulmonary veins and valves.

5. What are all the structures one could view using ICE catheter?

Right atrium:

Superior vena cava

Eustachian valve

Crista terminalis

Right atrium appendage

Tricuspid valve

Ostium of the coronary sinus

Cavotricuspid isthmus

Right ventricle:

Right ventricular inflow

Tricuspid valve attachments

Papillary muscle

Moderator band

Right ventricular inferior wall, apex, and lateral wall

Para Hisian region

Right ventricular outflow tract

Pulmonic valve

Left atrium:

Inter atrial septum

Left-sided pulmonary veins

Right-sided pulmonary veins

Left atrial appendage

Left atrial posterior wall

Mitral annulus

Coronary sinus

Left ventricle:

Left ventricular inflow

Anterolateral and posteromedial papillary muscle

Left ventricle apex

Left ventricular outflow tract

Aortic valve

Aorta

Miscellaneous:

Pericardial effusion

Thrombus or mass attached to the intracardiac leads

Adequate contact of the catheter with the tissue

Echogenicity of the tissue during ablation

Left atrial appendage closure device

Atrial septal defect closure device

Esophagus

6. How does one use the ICE catheter in atrial fibrillation ablation?

While advancing the ice catheter from the femoral vein, one could visualize the liver. At this time, the catheter is slightly advanced into the mid-right atrium. When the catheter in this position, we could visualize most of the right atrium, tricuspid valve, and right ventricle. This is referred to "home position". The catheter is left over here in an unlocked are a neutral position. This whole meal allows the assessment of the tricuspid valve structure, function and estimation of pulmonary artery systolic pressure using tricuspid regurgitation. This view also gives a better sense about right atrium and the right ventricle leads. Whenever the operator feels that he is lost secondary to the unfamiliar imaging plane, he just needs to put on the catheter to the home view by removing all catheter deflections and gently rotating the ice catheter in the clockwise and counterclockwise rotation until the tricuspid valve is visualized (**Figure 1**).

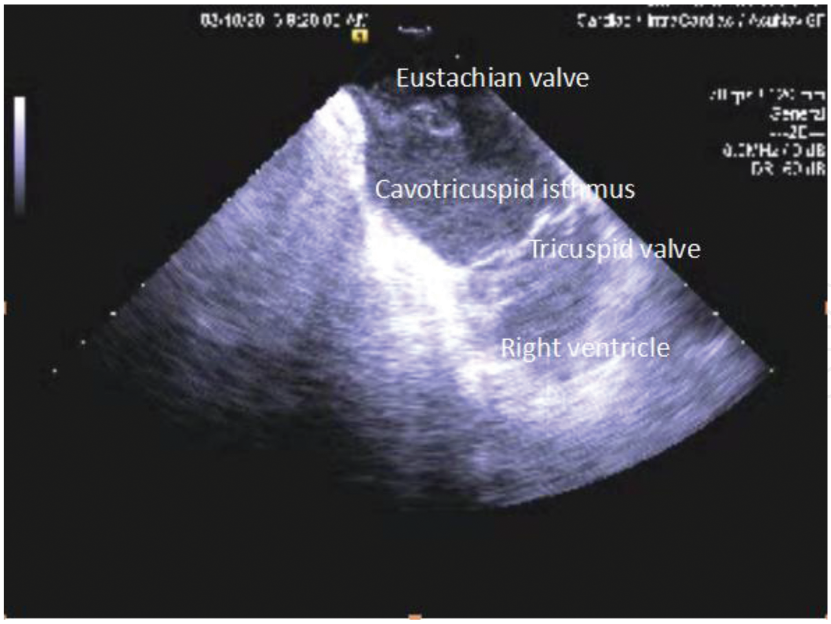

Figure 1. Home position.

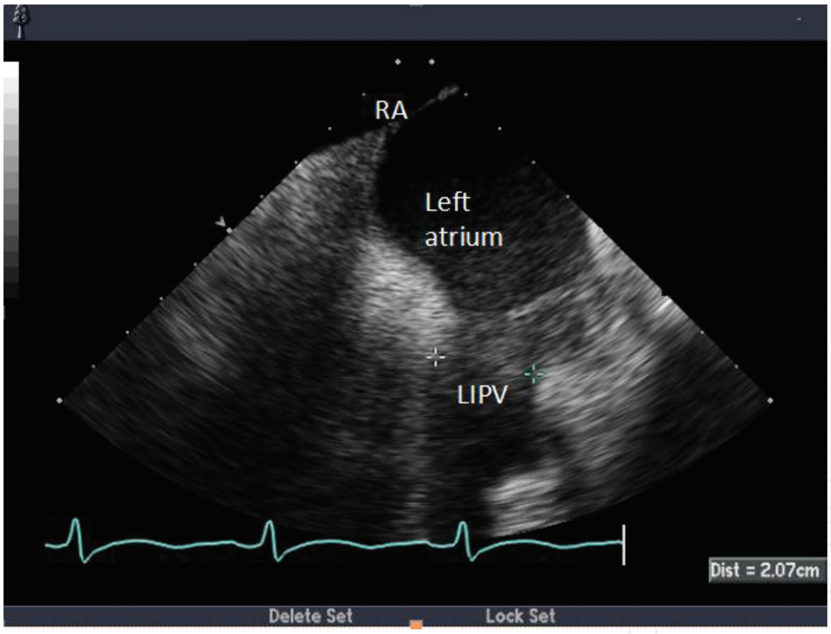

Figure 2. Left atrium and pulmonary veins.

From the home position, with the mild clockwise rotation, we can direct imaging plane posteriorly and left the ward. Initially, we can see the aortic valve, right ventricle inflow and right ventricle outflow just below the aortic valve. From this view, for the clockwise rotation of the catheter with about 45°, we can see the long axis of the aortic root. Here, we can analyze any atheroma of the aorta. This could be of vital importance when the operator is planning for a retrograde aortic approach. The aortic valve is also visualized well in this view. This is a good

http://dx.doi.org/10.5772/65243

view to look for any regurgitation through the aortic valve. Just behind the aortic valve, one may be able to see the pulmonary artery and pulmonic valve. A continued clockwise rotation from this view will direct the image plane more posteriorly. This view is a good view to visualize left atrial appendage, mitral annulus and ostium of the coronary sinus. Many operators use this view to interrogating left atrial appendage for any thrombus. This view can also be used to help in cannulation of the coronary sinus in the case of any technical difficulties (**Figures 2** and **3**).

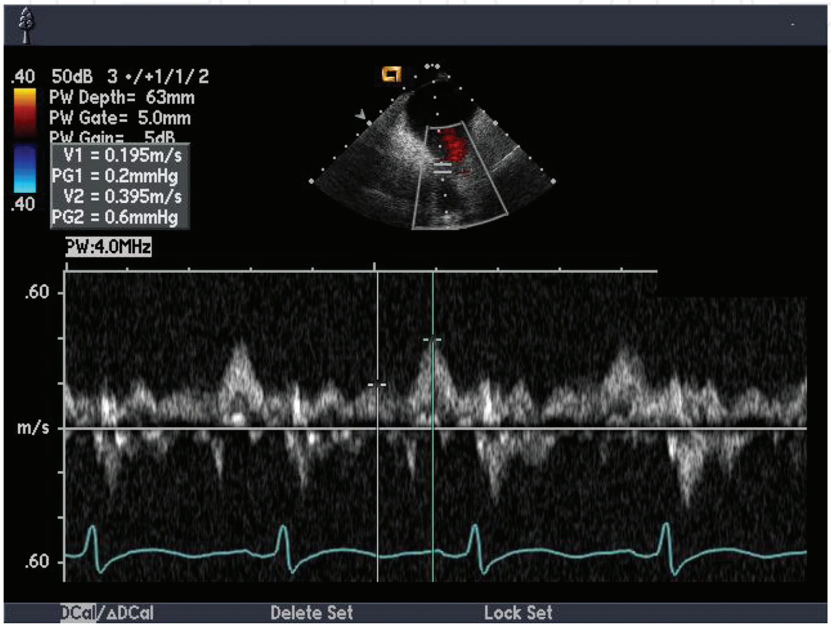

Figure 3. Continuous wave Doppler of the pulmonary veins.

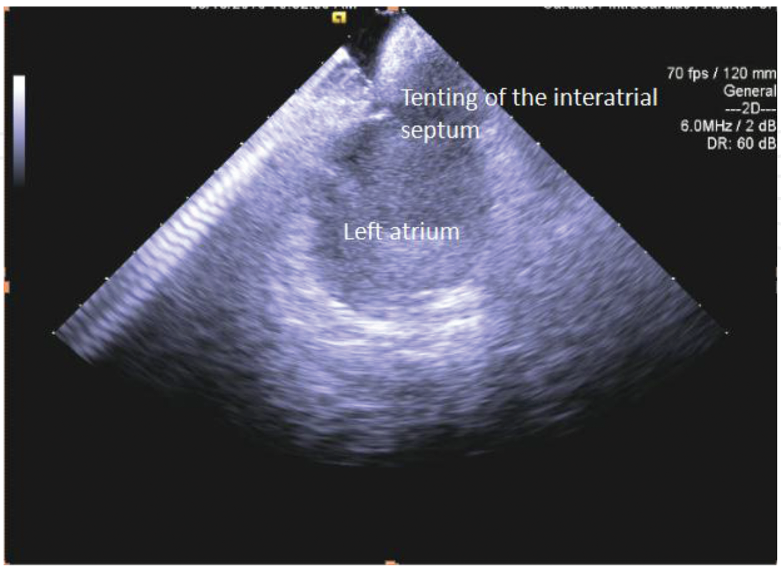

Figure 4. Tenting of the interatrial septum.

From this view, the catheter is slightly rotated clockwise. In this plane, one could visualize both left-sided pulmonary veins. The left superior pulmonary vein is usually visualized earlier and further clockwise rotation from that angle will bring left inferior pulmonary vein into visualization. This is a good view to measure the dimensions of the pulmonary vein, color Doppler of the pulmonary vein and continuous wave Doppler to evaluate the velocity of the pulmonary vein. During atrial fibrillation ablation, this view could be used to avoid ablation deep into the veins (**Figure 4**).

For the clockwise rotation of the ice catheter from this view will typically show the posterior wall of the left atrium. In this view, one could visualize esophagus and descend aorta. Esophageal temperature probe catheter can be visualized in the esophagus from the right atrium using this view. During ablation of the posterior wall of the right atrium, it would be easy to visualize the echogenicity of the lesion and proximity to the esophagus. Continued clockwise rotation of the ice catheter from this view will bring the right-sided pulmonary veins closer to the imaging surface of the ice catheter. The right-sided pulmonary veins will be visualized in a short axis. Using color Doppler, we could identify the pulmonary vein flow. Further advancement of the catheter into the right atrium and continued clockwise rotation from this level will bring up the right superior pulmonary vein in a better imaging plane. We will be able to see both right-sided pulmonary veins and pulmonary artery at this level. Usually, the right superior pulmonary vein is one of the most difficult veins to visualize. Sometimes the addition of a slight posterior tilt and right or left steering can further optimize this image to visualize the right superior pulmonary vein. Further clockwise rotation from this view will bring the catheter to the home view.

From the home position, ice catheter is advanced with a little bit of posterior flexion and rightward tilt. At this view, one could visualize the junction of the superior vena cava with right atrium. This view is commonly used to advance the guidewire into the superior vena cava before transseptal puncture. From here, the ice catheter is pulled down a little bit with continued posterior and right tilt. Now, they can clearly visualize interatrial septum including limbus and fossa ovalis. Typically, the operator advances the transseptal access needle in this view. One will be able to identify the tenting of the interatrial septum and further advancement of the transseptal needle into the left atrium. Slight clockwise rotation over here will help the operator to visualize and estimate the distance between the transseptal access site and posterior left atrial wall, thereby avoiding perforation into the left atrial posterior wall during transseptal access. Similarly, the distance between the transseptal access and left lateral wall can also be assessed in the previous imaging plane and hence avoiding left atrial perforation during transseptal access.

7. How does one use ICE catheter in ventricular tachycardia ablation?

From the home view, the catheter is tilted anteriorly. Now, we can visualize the posterior tricuspid leaflet and inferior wall of the right ventricle. The catheter is further advanced through the tricuspid valve into the right ventricle with continuous monitoring of the ICE

http://dx.doi.org/10.5772/65243

imaging. Once the catheter is just below the aortic valve in this view, further anterior tilt will make the catheter flex towards the inferior part of the right ventricle. This view is a good view to visualize the long axis of the posteromedial papillary muscle. From here, the anterior tilt is gently released in the catheter is further advanced towards the right ventricular apical region. Here, the catheter is brought to a neutral position with no tension on the knob. From here, clockwise rotation of the catheter will help us in visualizing the interventricular septum. This is also a good view of the epicardial axis as the right ventricular apical region is well visualized over here. With continuous clocking from here, we could visualize the posteromedial papillary muscle, and further clocking will bring the popular anterolateral muscle. The left ventricle cavity will be well visualized. Further clocking will also bring aortomitral continuity into the picture. Further advancement of the catheter into the right ventricle outflow tract with continued clockwise rotation will bring left ventricular outflow tract into the picture in a short axis view. We will be able to see all the three cusps of the aortic valve. Here noncoronary cusp will be adjacent to the inter-atrial septum; right coro-

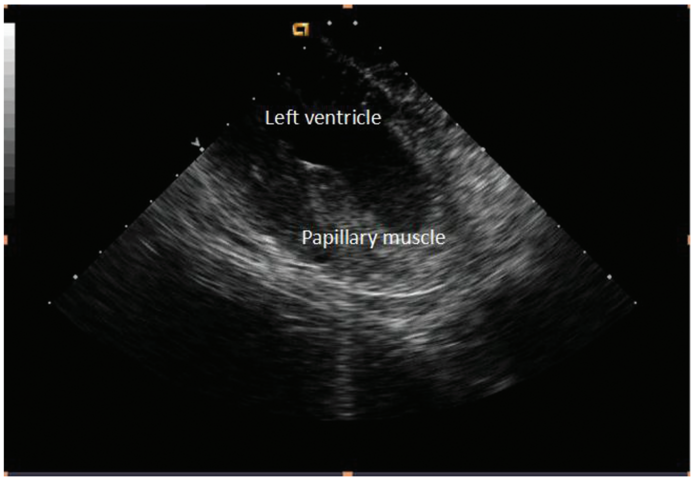

Figure 5. Left ventricle.

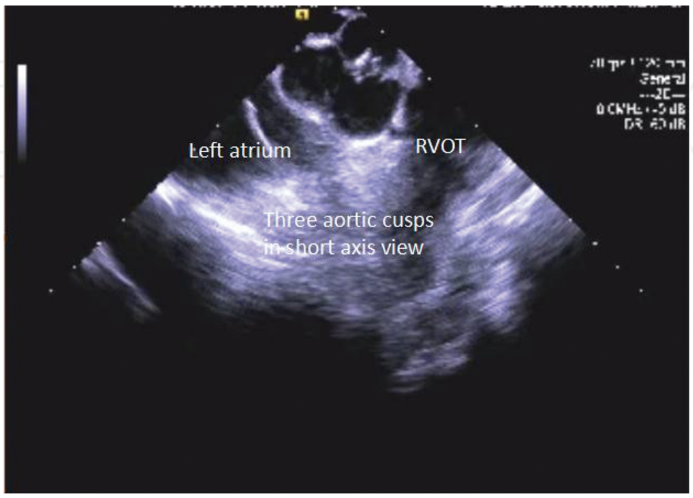

Figure 6. Aortic cusps.

nary cusp will be adjacent to the right ventricular outflow tract and left coronary cusp will be adjacent to the left ventricular outflow tract. In this view, one can also visualize left atrial appendage. In between the left coronary cusp on the left atrial appendage, we may be able to see left main coronary artery or left anterior descending artery. Further clockwise rotation over here will bring the aortic valve and ascending aorta in long axis (**Figures 5** and **6**).

8. How does one use ICE catheter to avoid complications during electrophysiological procedures?

Ice catheter can be used to monitor the catheter contact with the tissue. This helps us to make sure that they are ablating the right structure. It also helps us to maintain a better stability during respiration or with cardiac motion. With the help of the near field lesion visualization, one could avoid over ablating a region. Steam pops can happen during ablation secondary to high temperatures in the tissue. Impending signs of steam pop like increased echogenicity and microbubbles can be seen using ice catheter and hence avoiding imminent complications including perforation. Ice catheters also help us in negotiating through the valves safely without getting entangled in the valve apparatus. During ablation, continuous monitoring of the pericardial space can identify an early pericardial effusion thereby avoiding a less optimal outcome for the patient.

9. Conclusion

Imaging using intracardiac echocardiography has led to significant improvement in the safety and efficacy of the complex local physiological procedures. In addition to this, less dependence on the fluoroscopy also produces the occupational hazards for the physicians and the patients.

Author details

Umashankar Lakshmanadoss

Address all correspondence to: drlumashankar@gmail.com

Louisiana State University Health Science Center, Shreveport, USA