

**HEART RHYTHM SOCIETY'S REALITY EP SERIES:  
CATHETER ABLATION FOR PAROXYSMAL ATRIAL FIBRILLATION  
UNIVERSITY OF VIRGINIA HEALTH SYSTEM  
CHARLOTTESVILLE, VA  
May 1, 2008**

00:00:16

ANNOUNCER: Welcome to the Heart Rhythm Society's Reality EP series. Over the next hour you will see a live panel discussion featuring case footage of a catheter ablation for paroxysmal atrial fibrillation procedure utilizing 3-D mapping and rotational intracardiac echocardiography. This program is being broadcast out of University of Virginia Health System in Charlottesville, Virginia. OR-Live makes it easy for you to learn more. For more information on Reality EP programs or the Heart Rhythm Society, just click on the "request information" button or visit [www.HRSonline.org](http://www.HRSonline.org). Now let's join the doctors.

00:01:02

LARRY A. CHINITZ, MD: Hello, and welcome to the Heart Rhythm Society Reality EP series. My name is Larry Chinitz. I'm an electrophysiologist from New York University Medical Center in New York. And today we have a great program that will allow us to discuss the advantages and disadvantages and limitations of three-dimensional electroanatomic mapping, the risks and benefits of complex ablation procedures, and live prerecorded footage of an ablation procedure of a patient with paroxysmal atrial fibrillation. I am joined by my colleagues today, Dr. Michael Mangrum and Dr. John Ferguson, both who are electrophysiologists at the University of Virginia Health System. They truly are part of a spectacular EP program, have great experience in some of the concepts and new technology that we will be discussing today, and I'm quite sure that we will have a great program.

00:01:57

So I'm going to start off by a very brief overview of what the concepts are behind complex ablation of atrial fibrillation, why we do what we do, and introduce just a couple of concepts regarding some of the technology that we will be discussing in great detail during our footage. So let me begin with our slide presentation. So I think most of us do understand or at least accept the concept that atrial fibrillation is predominantly a left atrial disease. It's been over 10 years that we have accepted that triggers, myocardial cells, fire within the pulmonary veins and enter the pulmonary vein left atrial region to initiate and sustain atrial fibrillation. I think it's important to look at the left atrial pulmonary venous musculature carefully. In embryologic development, a common pulmonary vein is incorporated into the left atrial body. And the histology of the pulmonary veins in the posterior wall of the left atrium have the characteristics of vessel architecture, and these are interrupted areas of myocardium that present the perfect electrophysiologic substrate for the generation of arrhythmias. So in fact, we know that when we approach patients with atrial fibrillation, it's important for us to pay close attention not only to the pulmonary veins themselves but the left atrial musculature that surrounds the veins. A couple

years ago an important study was published in the *AJC* which shows that, in red, you can see the musculature of vessels, or the thoracic veins, and they are identical to the red musculature you see in the posterior wall of the left atrium, different than adjacent areas. So once again, our approaches to paroxysmal atrial fibrillation in particular must address not only the pulmonary veins but the left atrium itself. And when we use our CT images, it's important for us to distinguish between the ostia of the pulmonary veins, as shown in this CT image, from the true antrum and the musculature surrounding those veins, as seen in those blue dotted lines. So once again, we will use and show you various techniques to address this larger area of the left atrium.

00:04:07

So the first thing that we need to do is get into the left atrium, and that requires a transseptal puncture through the fossa ovalis. There are many techniques that can be used to do this. Some use fluoroscopy, some use ultrasound. Whatever technique that you do use, it's very important to realize that the fossa ovalis is adjacent to the pericardium, adjacent to the sinus of Valsalva. So the margin of error from crossing the septum and getting into the left atrium as opposed to the pericardial space or some other unwanted structure is rather small. So the tools that are available to us, again, is fluoroscopy. Some people will stain the intraatrial septum with a little bit of dye to ensure the location. Many are using intracardiac ultrasound, in which we can actually visualize the fossa and the needle going through the septum. And my colleagues will discuss this in great detail as we move along. It's also important to realize that the left atrial anatomy varies substantially from patient to patient. The location of the left atrial appendage, the number of pulmonary veins, the presence of common ostia, extra right and left pulmonary veins can occur in up to 30 percent of our patients. So the use of imaging to see these differences and know the location of the appendage as it relates to the vein and the rest of the heart is really very important. Some patients may have a left atrial roof pouch that may extend directly out of the roof that could create some problems with energy delivery. And the pulmonary venous anatomy, we are finding, can vary substantially. The presence of common left-sided pulmonary veins are very arrhythmogenic, and we need to understand its relationship to the left atrial body in order to adequately approach and ablate these areas. So the end result of this is that accurate and detailed anatomy is critical to the successful treatment of patients with atrial fibrillation.

00:05:58

We had initially the CARTO system, in which we began with three-dimensional electroanatomic mapping. And as much of our technology has improved, both with Biosense and the St. Jude NavX image, we have quite detailed images that are created with catheters of both the right atrium and the left atrium. And here you can see a CT image of the left atrium on your right adjacent to the created images that we have to help us define and accurately re-create the anatomy. The advantages of CT and MR are going to be discussed in great detail. Most importantly, it allows us to image the characteristics of the vein and the left atrium, knowing the differences between patients, looking at adjacent structures, helping us to deliver accurate lesions, and understanding morphological remodeling that occurs in the left atrium. The CT images show us so critically the location of the esophagus, which can vary from patient to patient to the right or the left side, and understanding location of the esophagus is critical when we deliver lesions in the posterior wall of the left atrium, whose thickness may only be 3 to 4 millimeters. It also helps us identify adjacent structures such as the pulmonary artery and the circumflex artery, which lie very close to areas that we ablate during these procedures.

00:07:17

We will be discussing in even greater detail the concept of image registration, not just using the CT image as a reference but actually merging it with our three-dimensional maps that we create so that we actually move our catheters in a registered CT image and place lesions directly on patients' individual anatomy. There are many issues that need to be discussed that Dr. Ferguson and Dr. Mangrum will elaborate on making sure that this registration is accurate and not misleading us into thinking that we have more. There have been many studies, animal studies, that have validated registration, and we will be hearing about some individual data out of the University of Virginia. The comparison of Echo and CT is very much expertise-driven. And the University of Virginia has a lot of experience in using intracardiac ultrasound, but you can see from these images, it takes substantial more expertise in seeing the nuances on Echo than it is visualized in a CT or an MR.

00:08:18

And finally, lesion delivery is something that requires great technology and experience. We need to be able to deliver lesions that are effective and transmural but do not create problems such as overheating, thrombus, char, or perforation. We use many tools like contact, temperature, impedance, electrogram reduction to help us in lesion delivery, but each of these are imperfect tools. Amplitude reduction during radiofrequency ablation, as can be seen here, may be one of the clearest signs that true energy is being delivered and a transmural lesion is being created, though this, too, has limitations. Many of our procedures organize atrial fibrillation into these regular tachycardias. And post-ablation left atrial tachycardias, both reentrant and focal, turn out to be a very significant issue post-ablation and require very careful management.

00:09:14

So you can see that nowadays we approach atrial fibrillation both for paroxysmal patients and patients with structural heart disease. And you can see from this slide that there can be quite extensive ablation required in the septum, in the mitral annulus, around the antrum of the pulmonary veins, within the coronary sinus. And suffice it to say that in order to achieve this degree of energy delivery, we are reliant upon good anatomy, good lesion delivery, and a full understanding of technology to accomplish this task. And this is pretty much the theme of what we will be discussing today. And I'd like to introduce my colleague Michael Mangrum again to talk to us about the video we will be seeing.

00:09:55

**J. MICHAEL MANGRUM, MD:** Thank you very much, Larry. It's a pleasure to be here, and I would like to thank the Heart Rhythm Society for sponsoring or supporting us on this program. If I could have the first slide of the case, please. This is the case that we have the footage for. This is a 52-year-old male with a history of paroxysmal atrial fibrillation. His history is that he had intermittent palpitations which began in 2006. He described these as fast, irregular, and lasting less than one hour. Then from January '07 to September of '07, the episodes continued. He made a couple of trips to the emergency room. And on one of the trips, there was documentation of atrial fibrillation, which you can see on this particular slide. His AF course after diagnosis was that he had a sleep study as part of his workup for atrial fibrillation and was started on CPAP for treatment. His episodes continued and in November of '07 he was started on antiarrhythmic drug, Flecainide with Metoprolol. After being on the medication for a bit, he had another episode. And because of that additional episode and his desire not to be on long-term suppressive therapy, he was referred for an ablation. His past medical history includes hypertension, hyperlipidemia, and a sleep apnea, as I mentioned earlier. His medications include flecainide, metoprolol, simvastatin, aspirin, fish oil, and the CPAP. On his physical exam he had a normal physical exam. His blood

pressure and pulse were normal and his physical exam otherwise was normal with a normal cardiac exam. He underwent an echocardiogram in December. This showed his left atrial size was 4.1 centimeters, which is at the upper limits of normal. He had normal LV function, and the rest of the structure of his heart was normal. He did undergo event monitoring. During that event monitoring phase, there was no atrial fibrillation documented, but there were PVCs.

00:12:10

So that is our case today. We have the footage broken up into seven segments. And we will be discussing each segment separately. The first segment will be the segmentation. The second will be access and transseptal. The third will be looking at the anatomy with intracardiac echo. The fourth will be catheter geometry, then registration, then the ablation, and then an alternative way of doing registration with intracardiac echo. And to start the footage, I'd like to turn this --

00:12:50

LARRY A. CHINITZ, MD: Can I interrupt you just one second? I just want to remind the audience that you have email access to us so that if any questions come up during the course of our presentation, we encourage you to email those questions and we'll do our best to answer them properly. Sorry, Mike.

00:13:03

J. MICHAEL MANGRUM, MD: Yeah. No. Thank you, Larry. And I'd like to turn this over to Dr. Ferguson, who will start the program.

00:13:10

JOHN D. FERGUSON, MDChB: Good. Thanks, Mike and thanks, Larry. And again, thank you to the Heart Rhythm Society. We're excited about education in treating patients with atrial fibrillation. So Larry has shown some magnificent three-dimensional images of the left atrium. Could we get the first segment running? And what I'd like to do is start talking about some of the practicalities of taking images and incorporating and integrating them into catheter ablation. So at UVA, we use both CT and MRI scans to image the left atrium prior to ablation. Our preference is MRI simply because we can avoid exposing the patients to significant radiation. And what is absolutely crucial for whatever imaging field is going to be chosen is a good relationship with the radiologist. And we are very fortunate to have a cardiologist here that has a special interest in both MR and CT, and we get very detailed information. So what we try and do is get the scan performed during the same kind of loading conditions that we would perform the ablation. So typically we do the scan the day prior to ablation and at the same time and the same fasting conditions, where at all possible. And we certainly find that doing the scan in sinus rhythm gives us better imaging, we are able to gate to 70 percent of the RR interval. And with tachycardia patients, we typically will give them a small dose of beta blocker. So here you can see David Wiggins, our EP tech, working to segment the image. You can see in some of the panels there are the axial slices of the MRI scan and then there's the 3-D image, which is generated from the pixels chosen within the left atrium. So the skill of this is to include all of the left atrium but exclude adjacent structures. And this is a skill where there's a bit of a learning curve and it's certainly worth taking a very close look at the individual anatomy of the patient. And once the three-dimensional image has been generated, we can then go through and have a look at various actual slices to make sure that they're correctly chosen. So we're going to be talking about fiducial points in a little while, but the ostia and the pulmonary veins, the mitral valve annulus, and the left superior pulmonary vein, left atrial appendage ridge are all extremely important in trying to choose accurate fiducial points. So here you can see there was an error in selecting or combining the left superior pulmonary vein and the left atrial appendage, and David

is just correcting that manually on the scan. We'll be having a better look at the three-dimensional image in a short while once we start with the registration process. And you can see that this patient had conventional superior and inferior veins on the left side, but then had more of a common ostium on the right.

00:16:55

So what I would like to do is just to pause briefly here, and if we could turn to the next slide, and I'd like to present a little bit of data from a study that we've done here at the University of Virginia. So when we're combining an image of the left atrium with a catheter geometry of the patient, you have to remember that the image is a static snapshot of the left atrium at whatever point in the cardiac cycle is chosen, and this was 70 percent. But we asked the question, how much does the left atrium change in volume during once cardiac cycle and how do various regions within the left atrium move? So we looked at 30 patients with paroxysmal atrial fibrillation, and they all underwent a detailed cardiac MR prior to ablation. And all of them were in sinus rhythm at the time of the scan. And so left atrium volumes were measured by stacking axial slices, and volume was collected at 25 different points during the cardiac cycle. And here are some of the results that we found. So on the horizontal axis is the percentage of the RR interval, and on vertical axis is the change in left atrial volume. So if you take a look at the black line in the middle, which shows the median change of volume through the cardiac cycle, you can notice a number of interesting points. So firstly, alpha is the maximum left atrial volume and measured about 170 ml compared to the minimum left atrial volume, which is right at the end of the black line at 100 percent of the RR, which was only just over 50 ml. And so the ejection fraction was really quite significant. The average ejection fraction, the total ejection fraction maximum minus minimum left atrial volume measured 47 percent. But importantly, the maximum left atrial volume occurs at 40 percent of the RR interval and not immediately prior to left atrial contraction, which is indicated by beta. Maximum volume is immediately prior to mitral valve opening. And then there's a passive emptying phase as blood is sucked through the mitral valve into the left ventricle. A plateau phase, and so possibly choosing 70 percent of the RR interval to scan is a reasonable place to scan. And then there's more contraction. And if you just take a look at some of the individual curves, you can see the slopes vary quite significantly and absolute volumes vary quite significantly. And we take time to present this information because the change in volume is very important to consider when combining the CT scan with the catheter map. Now, let's have a look at some of the regional change in wall displacement. So we looked at in-plane displacement of points on the posterior aspect of the left atrium. So the first four columns of this histogram showed displacement in millimeters of the left and right-sided pulmonary veins. And you can see that the posterior aspect of these veins moves less than 3 millimeters in the majority of cases. In contrast, the anterior left atrium, mitral annulus, and left atrial appendage are extremely mobile. And so one needs to bear in mind that we probably get more stable fiducial points in the posterior aspects of the left atrium than around the mitral annulus. So we're now going to move on to the case. So I'm going to hand it over to Mike.

00:21:06

LARRY A. CHINITZ, MD: So John, may I just say that, first of all, I congratulate you on being so careful at obtaining CT scans so close to the time of the ablation. But it's probably true to say that the importance of this is when true registration is being done. If one is using the CT image purely as reference with your CARTO or NavX image, that correlation may not be as important. Is that true?

00:21:29

JOHN D. FERGUSON, MDChB: I think that's exactly right. So many of us have used side-by-side images, and having a road map of the CT next to your catheter map gives you a very good idea of where the pulmonary veins are, whether there's a common origin, and how the images correlate with the ultrasound or catheter movement. But size probably does matter for registration.

00:22:00

J. MICHAEL MANGRUM, MD: Okay. Thank you. So we will start the case now. And this is a segment that we are calling "Access and Transseptal," and I will set the stage on what we're seeing. The patient is on our procedure table. I'm gaining access in the femoral veins. Dr. Ferguson is working towards the head getting subclavian vein access. And the subclavian vein is usually where we choose to use to put a coronary sinus catheter in. We use the coronary sinus sometimes for mapping, but for this particular case, we were using it as a stable reference catheter. So I'm currently gaining access in the left femoral vein. And earlier today, we were having a little discussion, me, John, and Larry, about anticoagulation. And I thought maybe we could discuss that a bit. The protocol that we generally use is the coumadin is held three or four days in advance to the procedure, whereas I think, Larry, your experience has been very positive for continuing the coumadin.

00:23:15

LARRY A. CHINITZ, MD: Yeah, Mike. We had some trouble post-procedure when we tried to bridge with lovenox, creating a lot of femoral hematomas and injuries and pseudo-aneurysms. So along with several other colleagues, we started to experiment with not stopping the coumadin before the case and continuing it with an INR in between 2 and 3. And this obviates the need for bridging with lovenox before and after. And so far we've had a good experience. We certainly are frightened about a terrible complication that may be exacerbated by full anticoagulation, but so far things have worked out well. And as you know, there is a publication out there from Cleveland Clinic suggesting the safety of this approach. So I do think we're evolving in this concept.

00:23:54

J. MICHAEL MANGRUM, MD: Yeah. Thank you. What you see here on our footage is the -- we're pulling out the sheaths that we will use for the transseptal puncture. These sheaths are steerable. We use -- we will frequently use steerable sheaths, and the reason for the steerability is that we generally have found that using intracardiac echo, particularly if it's nonsteerable, that this provides an extra imaging plane that we did not have without the steerability of the sheaths. And the other thing is that I do think it helps with manipulation of the ablation catheter. So we're prepping the sheaths. The flush we use is heparinized, and I think that's important. One thing that we'll see shortly, and I will pause just to highlight it shortly, is the importance of heparin in the flush and overall sheath management in the case. We wanted to illustrate the steerability of the sheath. As we'll see later, when we use intracardiac echo, we have a circumferential but perpendicular plane that we're imaging. So the steerability of the sheaths provide more imaging capability. The other thing I wanted to point out here is the staff that is involved with an atrial fibrillation ablation. In this case, we did this case under general anesthesia. We have the anesthesiologist in that area that I just circled, and off to the left we have the nurses, who help monitor the patient. And the patient's under conscious sedation, they give medications. And we have a radiology technician that is at the foot of the bed to help with the in-lab procedure along with helping with sheath management. And then in a separate control room, we have a technician that helps with the recording system.

00:26:08

LARRY A. CHINITZ, MD: You know, Mike, we have a question from the audience asking how long it takes to set up a laboratory like yours or how much expertise is required for electrophysiologists and electrophysiology laboratory to do this kind of a procedure well.

00:26:22

J. MICHAEL MANGRUM, MD: Well, that's a very good question. For labs that are new, that are just starting out, it can be quite a challenge because of all the different tools and the imaging that is done simultaneously. In general, I think if a lab has had experience with less complex cases first, then I think taking the next step to learning an a-fib ablation or the tools makes it easier. But still, even then there hopefully at one point will be opportunities that they can observe labs and be able to pick up points. But the exact time -- John may have some comments on that, too, but the exact time I'm not quite sure. It really depends on the staff.

00:27:15

JOHN D. FERGUSON, MDChB: Absolutely. And I think it's a matter of ongoing training. The equipment is evolving so quickly that this requires motivated and efficient personnel. So maybe we can pause here and Mike can talk us through the transseptal.

00:27:33

J. MICHAEL MANGRUM, MD: Yeah. We just placed a sheath up into the superior vena cava. And if we could just continue to roll the footage, please. And we will use two separate punctures -- yeah, two separate punctures with two separate sheaths. And if we could pause right here, please, the footage. Advance it just a hair. Yeah, thank you. One thing I wanted to show is that as we put the sheath within the body, we immediately will flush the sheaths and pull back. But what you see here is a tiny clot. And that is very important because obviously this could embolize in a case. But you want to make sure with large sheaths that there is flush continuously going through the large sheaths and there's constant flushing. And we can go ahead and roll the footage, but I wanted to illustrate that particular point there, that sheath management is of prime importance in these cases.

00:28:45

JOHN D. FERGUSON, MDChB: And maybe that goes back to the issue about lab personnel, that we depend on the lab personnel to flush the sheaths, make sure that the heparinized saline doesn't run dry, make sure that there's never any air that can produce air embolism. And unfortunately, we've had to learn this the hard way, through some air embolism and problems with flushing of the sheaths. So one of the educational things which has been useful for the cases is we set timers during the case to prompt the staff to measure ACTs, to flush the line, to check on urine output. And there's a whole myriad of observations that need to occur during a case.

00:29:34

LARRY A. CHINITZ, MD: Yeah, I think that illustrates the point that I think of all the procedures that we've been involved in, there's no other one that requires such a team approach with the buy-in from every aspect: anesthesia, nursing, and all others. You're absolutely right.

00:29:49

J. MICHAEL MANGRUM, MD: So what we see here on the footage is we're getting the second sheath prepped and we'll be advancing that into the SVC. I may have mentioned that we use both groins, both the left and right groin. We have just found that having access in both sides, there's less interaction with the sheaths as they're being manipulated. And so I'm advancing the sheath in the right groin. Dr. Ferguson is starting to prep the intracardiac echo probe. And on fluoro what

we're seeing is we're advancing the guide wire up to the SVC and then we will get the sheath up in the SVC and then flush.

00:30:46

LARRY A. CHINITZ, MD: So for the whole case, Mike, you'll have two transseptal sheaths for ultrasound and other catheters and one coronary sinus catheter going in from the subclavian.

00:30:55

J. MICHAEL MANGRUM, MD: Yes, exactly.

00:30:56

LARRY A. CHINITZ, MD: So there's a lot of variance in that. Many labs have many more catheters, but you probably don't require any more.

00:31:02

J. MICHAEL MANGRUM, MD: Yeah. And we -- and I know other labs will put the coronary sinus catheter from the femoral vein to save subclavian or an IJ stick. We have personally found that the subclavian gives us the greatest stability with the catheter. John, do you want to comment on the ICE prep here?

00:31:22

JOHN D. FERGUSON, MDChB: Right. So what you can see is with the rotational ICE probe, there is some preparation of the catheter that is required before inserting it into a sheath. And the catheter comes packed with the acoustic chamber at the end of the catheter is air-filled. And that means the air needs to be flushed out and the chamber needs to be filled with sterile water. And that's just what I'm doing here. So there is a metal transducer which rotates inside this catheter, and this should be surrounded by the sterile water. And this process is a little bit of a fiddle, but it's important that it's done correctly because air bubbles will reduce the quality of the picture. So there you can see the plastic plug at the end of the acoustic chamber and you can see the metal transducer. And the needle will be passed through a little opening in the distal end of the catheter. And the air will be flushed from the chamber through a lumen and out the back of the catheter. So this catheter is not a steerable catheter. And we've already shown you the deflectable sheath, which we found extremely helpful. And so, Mike, I think you had some slides you wanted to show about the ICE catheter.

00:32:52

J. MICHAEL MANGRUM, MD: Yeah. We'll finish this prep here. Thank you. This slide here illustrates just the history of intracardiac echo. We wanted to sort of digress just a moment to talk specifically about the imaging that we will be using today in this case. And this intracardiac echo really got its origin in the early '90s with the marriage of IVIS, which was used by the interventional cardiologists to look at atherosclerotic lesions, and the use of TEE or TTE in the EP lab to help guide ablation. So the first use in the EP lab of echo, or intracardiac echo, was in the early '90s, and at that time there was the identification of structures, particularly in the right atrium, the use of ICE in sinus node modifications, and over the last five to ten years, there has been increased use of ICE for transseptal catheterization as well as for pulmonary vein procedures. Now, the ICE catheter that we will be using today is a rotational ICE. The image that we will get is circumferential and is perpendicular to the shaft. The size is 9 French. It has a very good near field resolution, but the depth of view is limited to 5 to 7 centimeters. This is different than the phased array catheters, in which you get a wedge-shaped image and has a greater depth of view up to 12 inches. A closer look at the ICE probe shows an acoustic window and the transducer in which it is rotating, and that's the reason Dr. Ferguson was prepping this with the sterile water. The image that you get is perpendicular to the shaft and is circumferential. And

where we're positioning the ICE is in the right atrium as we start the transseptal puncture. We will pull the ICE back to where it's at the fossa ovalis, and we will see a very thin structure. And then after that we will be pulling back the needle and the transseptal sheath to see the image of the fossa as well as the needle. Now, this is the image that we will be looking at. Again, this is a 360 degree image. The right atrium is located here, the left atrium here, and the fossa is located in the middle of the screen. As we pull the needle from the SVC to the fossa, one very important component is that you see tinting of the fossa. Just to orient you, this is the fossa where I have the arrow pointed along with the needle, and then this is the posterior wall of the left atrium. And we'll see some images later of the posterior wall more clearly. After there is tinting of the fossa, the needle is advanced and it's popped into the left atrium. And in this image here, you can see the sheath. This is actually in the left atrium. So that's what we're going to be seeing, and if we can go back to the footage of the case. And we will pick up from where we had left off. Now, the ICE was prepped by Dr. Ferguson, and now it's positioned at the fossa. We have a sheath in the superior vena cava and we're advancing the dilator with the needle into the superior vena cava. Note very carefully that once the dilator becomes at the tip of the sheath, the sheath is retracted back over top of the dilator and the dilator is not advanced forward. That's a very important point that that footage just showed.

00:37:18

LARRY A. CHINITZ, MD: Why is that, Mike, just to avoid damage by advancing [unintelligible]?

00:37:20

J. MICHAEL MANGRUM, MD: Exactly, exactly. So we're now clocking the sheath and pulling back, and you'll see a drop of the dilator needle into the fossa right there. That was in an AP view. This is the intracardiac view of that same pull-back, and you see the same needle, which is located in this area here. But that's not a good place to cross. You want to make sure you have tinting, which you will see as we pull back slightly and rotate it even a little bit more posterior, you will see better tinting, and that is a safe place to cross right there. And just as an aside, this is the esophagus right here. So that's posterior. But that's a perfect image of tinting the fossa. So here we've tinted. We're now going to advance the dilator and needle apparatus. We're also monitoring the pressure through this. I forgot to mention that earlier, but we advance the needle and then the dilator over the needle, and then we're now placing the sheath over top of that apparatus and pulling back. So we're pulling back, and once we get that out of the sheath, we will flush. Now, here we have the ICE probe. We reposition the ICE probe in the sheath that we did the first transseptal and we're going to image through that sheath. And we're taking the second transseptal. So we're pulling the needle down and it will fall into the fossa. Because of the steering mechanism of this particular sheath, it does make it more challenging to see the tinting, but you have to sort of advance and pull the ICE back to see the imaging. But you can see it, and then just like before, the needle is advanced, you would feel a pop, you would see pressure change on the hemodynamic monitoring, and then the dilator needle is across and the sheath is in, advanced over that.

00:39:35

LARRY A. CHINITZ, MD: Mike, do you make any efforts to create some separation between the two sheaths as to where they cross or is it just random?

00:39:43

J. MICHAEL MANGRUM, MD: Well, it's somewhat random where it falls, but in general, we find that the more anterior you cross, the more challenging it is to get to some of the pulmonary

veins. So if it does fall anteriorly, we will try to make an effort to reposition that either in the middle of the fossa or more posterior.

00:40:05

JOHN D. FERGUSON, MDChB: And certainly we find with the PFO, often that should be very high on the septum. And that takes you a long way away, especially from the right inferior pulmonary vein. And frequently we choose still to do a puncture with a [Brackenburg] needle than use a PFO.

00:40:23

LARRY A. CHINITZ, MD: Yeah, I think that's a really important point. We used to be so happy when the PFO was present that we could avoid the transeptal puncture, but its location can clearly make it a more difficult procedure. Absolutely. So we can move on to the next segment, right?

00:40:35

J. MICHAEL MANGRUM, MD: Yeah. So if I could have the nice set of slides. What we want to talk about now is anatomy with intracardiac echo. So where we are in the case, we have now crossed into the left atrium and we're starting to visualize structures. Throughout this case, we use this intracardiac echo a lot, so we wanted to put together a few slides just to show the image that you will see. The image you see on the screen now is of the left atrium, which is here, what's in red. The esophagus is in green. The pulmonary artery is in blue at the top. Now, these are structures I'm pointing out on this CT scan, but we will see those on the ICE. The other structure, I can't really see it, but just on the other side of the left superior pulmonary vein is the appendage, and the other structure that we will be seeing is the superior vena cava here. Now, what we have here is the intracardiac ICE probe within the left atrium, in the body of the left atrium. And with this view, you can see a lot of adjacent structures. Very prominent is the structure here. That is the esophagus. And you can appreciate the proximity of the esophagus to the posterior wall of the left atrium. The other structure, if that's posterior, then opposite of that would be anterior, and there's the aortic valve. Again, further orientation. The mitral valve is located here. And this structure here with the red arrow is the coronary sinus. What we have here are some CT scans which show the relationship to the adjacent structures and how the relationships of the adjacent structures can help orient you with a circumferential ICE catheter. So in this particular case, this is a CT scan of the left superior pulmonary vein. What is adjacent to the left superior pulmonary vein is the appendage and the left pulmonary artery. So with that in mind, this is the ICE probe within the left superior pulmonary vein, and you find that you have this relationship. You have the left atrial appendage, the left pulmonary artery, and the ICE probe is within the ost or right at the ost or just beyond the ost of the left superior pulmonary vein. So much like there are those relationships, the relationships with the left inferior pulmonary vein is this structure here, which is the descending aorta. And because, again, of the view, you catch this longitudinally, and so the descending aorta is here and the left inferior pulmonary vein is where the ICE probe is located. If we look at the right superior pulmonary vein, the relationships we have here is the superior vena cava and the right pulmonary artery. The SVC is an anterior structure. We will know that this is the SVC because of our decapolar catheter that we have going down the SVC to the coronary sinus from the left subclavian vein. And we can see the catheter here, the shadowing of that. And then over in the 2:00 position is the right pulmonary artery.

00:44:36

LARRY A. CHINITZ, MD: I just want to add about the proximity of the phrenic nerve in that location as well.

00:44:39

J. MICHAEL MANGRUM, MD: Very good point, Larry. That's exactly right. And finally, the right inferior pulmonary vein.. The relationships that we have to that are none. And so there is no other structure that's next to that that you can identify.

00:44:56

JOHN D. FERGUSON, MDChB: Mike, just to interrupt, the one exception is that we occasionally and in the minority of cases see the esophagus right behind it. And in fact, we may see that a little bit later on.

00:45:10

J. MICHAEL MANGRUM, MD: Yeah, that's a very good point. And so if we -- shall we go on to the case?

00:45:17

LARRY A. CHINITZ, MD: Yes. Roll the video.

00:45:19

J. MICHAEL MANGRUM, MD: All right. Let's go to the video, please. Okay, we're back in the case again. We're in the left atrium. We're starting our identifying the structures. You'll see on our -- the constellation of images that we have to help navigate us: our fluoroscopy, the mapping system, the intracardiac echo, and then the three-dimensional mapping. This fluoro image shows the ICE probe, and that is the image within the body of the left atrium. The structures that you see: the aorta, which is here, and you can start to make out as you move it, the esophagus is located here. The coronary sinus is there. And we'll be manipulating the ICE, moving it to different locations, and this is one way of knowing exactly where the esophagus is on real-time. And we have found that to be very useful. And we did use a temperature probe in this particular case, and you can see the temperature probe right here within the esophagus. But if we were to ablate in this area, that's away from the temperature probe, but clearly the edge of the esophagus is right there. So we think that is one advantage of having the ICE probe right in the left atrium next to it. You can certainly see the structures very well. So this is the ICE within the left superior pulmonary vein, and this is the segmented image of the left superior pulmonary vein. As a live case, you will see the adjacent structures that we saw earlier. The appendage. We know that's the appendage by how it [flops]. And you can see the trabeculation often within the appendage, and then the pulmonary artery is located here. We'll be pulling back the ICE. And at that view, as you pull back the ICE, we see sort of the antrum of the pulmonary vein as it then drops into the left inferior pulmonary vein. That fluoro image we see now is within the left inferior pulmonary vein. This is the segmented image of the left inferior pulmonary vein. And this is the ICE image of the left inferior pulmonary vein. Again, like before, we know where we are just by its relationships that are next to it. This is the descending aorta, which is located right there. And as we pull back slightly, we come into sort of the antral component of the left pulmonary veins. And as we'll see later on, and maybe we can discuss this, where to ablate. Do we ablate in the antrum or do we ablate at the ost? And in this case, we did a combination of this because of the esophagus. And we'll see that later on.

00:48:37

LARRY A. CHINITZ, MD: You know, some people would just be using three-dimensional mapping, other people just using ultrasound. I think you'll be discussing pretty soon the value of using both is truly the validation of both techniques.

00:48:48

J. MICHAEL MANGRUM, MD: Yeah, that's right, Larry. That's really good. And they're complimentary. We could use either to validate where we are. And we get complimentary information, I believe, with the different imaging tools.

00:49:00

JOHN D. FERGUSON, MDChB: And certainly having these three-dimensional images has helped us interpret these very difficult ultrasound images.

00:49:09

J. MICHAEL MANGRUM, MD: So we're now positioning the ICE in the right inferior pulmonary vein. And the CT scan. Again, there are generally no adjacent structures, with the exception of many times, or sometimes, the esophagus. And we can actually start to make out in this particular case the esophagus. And that did play a role in where we decided to ablate in the right inferior and right superior pulmonary veins. So we have a pretty good idea of what the left atrial geometry looks like. We had the MRI scan, we had intracardiac echo images. And now we're ready to start with the catheter geometry. So Dr. Ferguson, should we play the tape?

00:50:04

JOHN D. FERGUSON, MDChB: Let's do that.

00:50:11

J. MICHAEL MANGRUM, MD: Okay, one thing we did, after we -- when we created our geometry -- and, John, you may want to comment on this -- is what catheters to use for geometry creation.

00:50:26

JOHN D. FERGUSON, MDChB: One of the differences between the St. Jude and Biosense system is that most people using the St. Jude system collect many points during each second, and the points are not gated to the cardiac cycle. And we find that the number of points, and actually the regional density of points that we collect within any geometry, is important in helping us get an accurate map. And previously we only used an ablation catheter, which we put inside the pulmonary veins, and pull that back and sweep it around the pulmonary veins. We use ultrasound to help mark the ostia of the veins. But more recently, we've joined many other people in using the lasso, which helps us to collect a greater density of points, and more quickly. I know some people use the lasso for collecting the geometry of the pulmonary veins. We find that it does distort and stretch the veins somewhat. And we've not had as good results with our registration using the lasso. But being meticulous about collecting microannular points and the ostia of the pulmonary veins, we found those particular points we've used an ablation catheter. I don't know what your experience has been, Larry.

00:52:06

LARRY A. CHINITZ, MD: No, I think there is distortion. What I'm curious is, John, are you simultaneously visualizing with ICE as you create your NavX map and then sort of saying, okay, this is the ostia of the vein confirmed on ICE, mark it at that point?

00:52:19

JOHN D. FERGUSON, MDChB: Absolutely. But just at the minute you'll see that we've just got the lasso and ablation catheter in. And we're doing the body of the left atrium first in this particular case. Once we start doing the anatomy of the veins, we use the ICE to find the ostium of the veins. And the way in which we do that is we advance the ICE catheter and out distally in the vein, and then we pull it back. And when you're in the vein, there's a complete circle. And as you move in towards the ostium, the circle becomes discontinuous, and that's the ostium of the vein. And the difficulty is defining where does the ostium begin and the antrum end. But with

ICE, we can notice a very different caliber of diameter as we pull back from the distal vein. The other thing which we make a careful note of is when there are proximal branches in the vein within the first 2 centimeters or so of the ostium of the vein. We find those branch points are extremely useful for subsequent registration. So this is just collecting the left atrial appendage anatomy. And this is using a circular mapping catheter which we can change the diameter of. And we find that's very noninvasive for collecting the appendage and anatomy.

00:54:01

LARRY A. CHINITZ, MD: How long do you usually spend on creating this anatomy?

00:54:05

JOHN D. FERGUSON, MDChB: Well, I think it really depends on the procedure that you're planning to do. And if you're doing a registration of a full geometry like this, I think it is worth getting a detailed catheter map. And so we probably spend between 10 and 15 minutes making sure that we've got all the idiosyncrasies of this specific anatomy. This is a good -- can we just pause here for a moment? Mike, you might like to point out, so Mike's got the mapping catheter, so I think this is now in the left inferior pulmonary vein. And it's a circular mapping catheter. But you can see that the vein is oval and not round. And on the anterior and posterior aspects of the vein, there is good apposition to the wall, but on the upper and lower aspects, it's maybe a centimeter or so away from the lasso catheter. And so I think that's an interesting point to consider when only using the lasso catheter to ablate around the pulmonary veins. Probably some other form of imaging catheter would give us better contact. We can play on.

00:55:24

J. MICHAEL MANGRUM, MD: Those are excellent points. And as we saw coming in and out of the plane, at a point that was a slight bit distal, there was good apposition, but right at the ostia, you're exactly right. So the rest of this, we created the geometry and we marked where the ost, the pulmonary veins. We're confirming that with intracardiac echo and placing a shadow of the circumferential catheter at the ost on the NavX imaging, another example of a circular catheter in a pulmonary vein without good apposition. So one could get deceived that there was no electrograms there if there's no apposition, so I find that that can be valuable at times.

00:56:12

JOHN D. FERGUSON, MDChB: So Mike, you've only recently started making these shadows of the lasso catheter. And do you want to explain your rationale for doing that?

00:56:20

J. MICHAEL MANGRUM, MD: Well, I find that it's helpful after the ablation to reposition the catheter back in the same area to confirm that, one, that's where we think the ostia is, and two, when we put the catheter back for confirmation, that we've isolated the vein, I feel pretty confident I'm at the same location. So I have started doing that.

00:56:53

LARRY A. CHINITZ, MD: I was just going to say the variable radius of this circumferential mapping catheter can be very helpful to make sure that you in fact have tissue contact. I think some of the fixed diameter catheters can be problematic, making you think that you have no activity or even isolation when you could be missing a section of the vein. Again, another advantage of having multiple technologies at your disposal.

00:57:14

J. MICHAEL MANGRUM, MD: Yeah. Good point. Okay, why don't we go ahead and -- shall we go to the registration?

00:57:23

JOHN D. FERGUSON, MDChB: Okay. All right.

00:57:26

J. MICHAEL MANGRUM, MD: So we will cut off the fluoro -- not the fluoro, sorry, the case right now, and I'll turn this over to Dr. Ferguson, who will talk about registration and the role of registration.

00:57:42

JOHN D. FERGUSON, MDChB: Okay. Thanks. Can we go to the slides? And just before we go onto the practicalities of registration, and we want to just comment on what we think is the role of registration. And Larry has shown some beautiful images of the left atrium. And these CT three-dimensional images can show remarkable anatomical detail, and particularly of the branches of the pulmonary veins and the junction between the appendage and the left superior pulmonary vein. So there's no doubt that 3-D images can display the complex and variable left atrial anatomy in intricate detail. The plan is for integration of these images in the catheter procedure to increase the accuracy of navigation and lesion placement. And I think that this is certainly possible, but is it a foregone conclusion that that's the case in every single patient that we use navigation? And I've put a question mark next to this because I think it all depends on how good the registration is and how accurately we perform it. There is a potential to reduce fluoroscopy. We choose to do MR scanning prior to the ablation so that we don't offset the same fluoroscopy during the case with the x-ray exposure that you get from the CT scan. We're not sure that there's widespread reduction of procedure time. And I think to do the registration accurately, we do need to spend a little bit of time doing it. And once you know the anatomy, we do find that it's faster to then work around the anatomy. And we hope that we are producing better lesions and hopefully going to produce better results. But as yet, there is only very limited data about procedural outcomes of registration in reducing atrial fibrillation in these patients.

01:00:00

There are many challenges to registration, and these include the fact that I've alluded to already, that the 3-D image is a static model of a very dynamic left atrium. And there's also potentially major shifts in the left atrial volume. And unfortunately, we have very little data on this. People allude to it frequently, but there's very little hard evidence. So we think that different volume loading conditions, possibly irrigated catheters and the volume that you give with irrigated catheters may change the volume of the left atrium. And we know that certain catheters distort the left atrium, and you can sometimes see that on ultrasound. The timing and the cardiac cycle is important, and I've already shown how the volume changes during the cardiac cycle. And of course, the rhythm is important. And the volume probably changes significantly when patients go into atrial fibrillation. So when thinking about the accuracy of registration, there is an inherent inaccuracy of all mapping systems. And there is some difficulty in choosing fiducial points. Some patients have very nice anatomical landmarks, but other folk have landmarks which are very difficult to find. And so using ultrasound or something to confirm your landmark can be helpful. And then I think there are a number of algorithms which are used by the software of these mapping systems which make certain assumptions which possibly aren't always physiologically correct. And respiratory movement can be a major problem, both in anesthetized and patients who have conscious sedation. And algorithms to compensate for respiration certainly have made a difference to us. And then of course with both CARTA and the NavX system, patient and catheter movement can create problems.

01:02:10

So many of you would have used the CARTA system and been familiar with this, but the EnSite Fusion version of registration has only been launched more recently. And it's currently FDA approved in the USA for registration with CT scans. So these are the steps that are required. First, there's a segmentation of the axial images of the scan, which we've shown. And then there's a generation of a catheter map. Then there is field scaling. Then there is registration. We're going to talk more about that. And then there's subsequent adding of electrical information to this three-dimensional anatomy. So field scaling is a correction algorithm that St. Jude have made. You can see on the left hand catheter image that the pulmonary veins are somewhat distorted. And this is created by the change in impedance between the catheter being inside the heart and inside the lungs. And what one would notice if there was an ablation catheter there is that the distance between the electrodes of that catheter would increase as the catheter is advanced distally in the pulmonary vein. And the simple algorithm is to input the measurements of the intraelectrode distance in the catheter into the EnSite system, and then the EnSite system will compensate for this distortion. So this first image is prior to field scaling. Not in this case, but this is a case from Australia. And here you can see after field scaling, the left atrial body puffs out and the left-sided veins look far more proportional.

01:04:25

So something which we really want to emphasize with this case is whatever form of registration is performed does require chemical validation. And so the ways in which we will validate the accuracy of our registration -- and firstly, once the registration is complete, is to move the catheter within the 3-D shell. And so once you move back to the left-sided veins, does a catheter remain inside the geometry or does it float outside of the geometry? Then we want to look at the electrograms. So a good example of that, is there a difference between the left superior pulmonary vein and left atrial appendage electrograms? So these locations may be only a few millimeters apart, but invariably we get very different electrograms. And on the St. Jude system, there's a proximity indicator, and that is helpful. And then something which we'll show you we use frequently is the ultrasound to confirm that the catheter, which may look like it's touching a wall on the geometry, we want to confirm that on ultrasound before we deliver a lesion. And then in development are both pressure and contact sensors on catheters. And this is a very interesting subject. And I know Larry's been doing some animal work, and it's certainly going to play into how we deliver energy to the left atrium. So all these forms of validation need to be repeated throughout the case. Catheter shifts, volume shifts, changes in impedance can all change the accuracy of registration later on in the case. And so just because you've got a good registration at the beginning of the case doesn't mean it's going to be good throughout the case. So I feel that registration is a little bit like having a GPS system, that you still need to keep your eyes on the road. Certainly don't just follow the map. We need to use all the electroanatomical information that we have.

01:06:55

And then I'm just showing one slide of results of some of the animal validation that we've done at UVA looking at the fusion system. And so we performed implantation of freshwater pearls on the outside, or the epicardium of all four chambers of 16 swine. And we then closed the chest and a week later did a CT scan and did segmentation of the CT scan and marked exactly where those pearl markers were. We then did registration of the CT scan and targeted these markers of the pearls for ablation. No fluoroscopy was used during ablation. And so the results were I think very promising. It's a difficult protocol, and I think that this kind of accuracy could very well be

repeated in clinical practice on a routine basis. So the mean registration, the distance from the lesion to the marker was 2.5 millimeters in the left atrium and 4.7 mm in the left ventricle.

01:08:18

So just looking at that data and thinking about some of the data that we have with CARTA, what accuracy is really required for registration? And I think that depends on what catheter you're using and what procedure you're performing. But I think that any of us who do mapping using electrograms either for accessory pathways or focal tachycardia know that we need to frequently be within just a few millimeters. And so we certainly want it to be in that kind of range. And we want it to prevent injury to the esophagus and we certainly want to prevent damage to the phrenic nerve. And so again, we probably won't be within just a few millimeters. And then we want to be able to do successful linear ablations, where we know that adjacent ablation lesions are overlapping. And if you think of an ablation lesion being at minimum around about 4 to 5 mms, you want to have that kind of accuracy in the accuracy of the system. And so it's my opinion that you need to consistently achieve an accuracy of less than 5 mm with registration. And I think that if we pay attention to detail, we may be there, but not in every case at the moment. I don't know what your opinion is.

01:09:59

J. MICHAEL MANGRUM, MD: Thank you very much, John. Let us go back to the case, if you would, please. And so just to kind of recap where we are in the case, we've now done -- we've constructed the geometry, we have confirmed that there are potentials in each of the pulmonary veins, and we're starting the registration in the lab. And we won't see the entire registration, but John, do you want to comment on the field scaling in this case and maybe the registration?

01:10:36

JOHN D. FERGUSON, MDChB: Sure. The field scaling has actually already been done in this particular case. And we -- I think we spent a little bit more time than usual doing the catheter geometry in this case, and it ended up being very close to the real anatomy. And so now what -- after the field scaling is completed, what we're doing is we're looking for fiducial points on the CT scan and wanting to select the corresponding points on the catheter map. So you'll see that with this system, once we click on usually the catheter map first, we'll get a little yellow dot. And then once we complete a fiducial pair by clicking on the corresponding point on the CT scan, we'll get a yellow spring. And that represents one fiducial pair. So the interesting thing about the St. Jude algorithm is that it treats the 3-D CT scan, or MRI scan, in this particular instance, as a static and immobile image. However, the catheter geometry can be warped to fit the particular MRI. So if there's a minor change in the volume of the two images, you can squeeze the catheter geometry into the CT scan. And the assumption is that you will squeeze it in in a proportional manner and it will still be accurate for navigation. So here with the time that David's taking, you can see that he's very carefully looking at not only the smooth surface of the catheter geometry but also the three-dimensional points. And there you can see the first yellow spring. So once we have three fiducial pairs, you can get computer registration. And once you have more than three, so four or more points, you start getting warping of the catheter geometry inside the CT shell. And we'll see that David uses that in a stepwise approach to achieve a good registration. So he's going to compute the registration in a moment, and then what we'll see is -- there you go, that's the initial registration. And the initial registration is not too bad, but you'll see that the catheter geometry veins stick outside some of the CT geometry veins. And so what we can do is go ahead and we can correct for that and choose more fiducial points, bifurcations in the vein, to bring them into line. And so typically for a registration, we'll be using somewhere between 20 and 50

points to get a good registration. And again, the accuracy of the registration that you strive for probably depends on the level at which you're ablating. So Larry, I don't know what your opinion is, but there's always this tension between spending a lot of time doing a very accurate registration versus having a half-hearted anatomy but spending less time in the left atrium.

01:14:31

LARRY A. CHINITZ, MD: Yeah, John, so that's worth elaborating on as we watch the video. You know, we feel strongly that the more time you spend upfront, the fewer problems you're going to have later on. So the more accurate a creation of anatomy and validation of that anatomy that you do at the beginning, the less wandering around you'll do later in the case trying to find some areas. But as you stated, you know, that becomes really important when you're doing chronic atrial fibrillation and you're making multiple lines in various parts of the heart, maybe less so when you're just treating a paroxysmal patient in which you're just concentrating on the antrum. But I think the general theme that you create is really a good take-home point. It's worth spending some extra time upfront to avoid the problems later on. And it looks like you've done a really excellent job here at simulating the CT image.

01:15:20

JOHN D. FERGUSON, MDChB: Well, I think the locations, the specific anatomical locations which you find to be extremely helpful are certainly the ridge between the left atrial appendage and the pulmonary veins. And that tissue is often really pretty thick and quite challenging to get good catheter stability. And so spending some time looking at the separation between the left atrial appendage and the pulmonary veins we find is helpful. And so what David's doing at the moment, I'll just point out, is he's registering some points on the mitral annulus. And although there are more stable fiducial points on the posterior aspect of the pulmonary vein, those are ones which we tend to do first. The mitral annulus is a long way anterior, and getting some kind of registration, albeit not perfect registration, is very important for the orientation of the case.

01:16:35

LARRY A. CHINITZ, MD: It also shows you here how important it is to get that CT image in close proximity to the day of the procedure. If this volume was off by 20-30 percent, you'd be in big trouble over this.

01:16:46

JOHN D. FERGUSON, MDChB: Precisely. Now, one of the other points about the landmarks is that I think many people still consider their coronary sinus to be a perfect approximation for the mitral annulus. And that's not always the case. Often the coronary sinus is as much as 15 millimeters from the mitral annulus. So operators need to bear that in mind. It's not always perfect. So Mike, I think you had some slides about this case.

01:17:23

J. MICHAEL MANGRUM, MD: Well, let me ask you this one question. How many fiducial points do you think is necessary, or what do you find is sort of an average?

01:17:33

JOHN D. FERGUSON, MDChB: It does depend on how much time you spend doing the catheter geometry, but I think on average somewhere between 20 and 45. And some people are doing 60 or 80 if they're very obsessive, but I think that's only necessary if you do fairly distal ablation of the pulmonary veins.

01:17:55

J. MICHAEL MANGRUM, MD: Okay. So we've now, just to put this in a framework, we now have registered our image and we're now set to ablate. So if we could go to our first slide, please.

Now, this slide here is just to illustrate where one could ablate. What is shown in the red are ostia, where I would suspect is the ost. The antrum would be where the purple is. So in this case, we will do the antrum in the left veins and then closer to the ost in the right veins because of the location of the esophagus. So what does the task force recommend with regard to ablation? And I wanted just to show this. The ablation strategies which target the pulmonary veins or the antrum are really the cornerstone of most AF ablation procedures. And that if these are targeted, the goal should be complete isolation of the pulmonary veins. And that can be refined as a reduction in amplitude, the elimination of potentials or disassociation of potentials or even exit block. But even within the task force guidelines, it does recommend that careful identification of the pulmonary vein ost is mandatory.

01:19:21

This is a slide just to illustrate isolation. You see here in the first part of this slide the pulmonary vein potential. We're pacing from the distal coronary sinus, which separates the two nicely, and then ablation, which eliminated the pulmonary vein potential. And that's the goal of the ablation. We do monitor various things throughout the ablation, and we all do: the catheter location; ways to identify that we are forming lesions, by the catheter tip temperature, the impedance measurements, electrogram amplitude, or contact; and we are also monitoring for complications. So in this case, we placed the lasso catheter into the left superior pulmonary vein, and we see the nice sharp potentials from the lasso in the left superior pulmonary vein. We also will see that in the right inferior pulmonary vein.

01:20:25

So we can go now to the case at the ablation, and we'll start the ablation procedure. Again, we'll do the left veins initially, or first. I should mention the catheter we're using in this case. We're using a 5mm tip standard ablation catheter. We have the settings 35 watts, 54 degrees, and for 40 seconds the lesion. Again, this is a standard ablation catheter. I think more commonly now, the irrigated tip catheters. But in this particular case, we used a standard ablation catheter. So we used ICE to identify the antrum, or the opening of the left pulmonary veins. We're monitoring the temperature. And with ICE we have real-time guidance with ICE. Here is the tip of the ablation catheter. You get a nice echogenic shadowing from the tip of the ablation catheters so that you know exactly where the tip is, and it corresponds to the NavX image, the NavX-registered image that we had spent some time on earlier to achieve. So we're performing a lesion in the antral area. We're on the posterior wall here.

01:21:54

LARRY A. CHINITZ, MD: It's so important to state here, Mike and John, that it's the time that you took and using multiple technologies to create the image that you're guiding your catheter on that gives you the confidence to ablate in those areas. A much quicker created three-dimensional image not validated, we all can think that we're someplace that we're really not, and I think that's where all the problems can occur.

01:22:16

J. MICHAEL MANGRUM, MD: Yeah. And here we know that we've got good tissue contact, we're looking at various things, we have good electrograms, we have ICE showing good tissue apposition, we had the marker displayed on the 3-D image. So we're using multiple ways of knowing where we are. And I do think that's important.

01:22:40

LARRY A. CHINITZ, MD: Yeah, from an anatomic basis, I think this is really just spectacular. But you know, the one piece we're assuming is that we do in fact have good contact and we are

delivering good lesions. I just think that our current technology now limits us a little bit in knowing how much energy, how long to stay on. What's the biggest parameter that you use to tell you how long you stay on that pedal?

01:23:02

J. MICHAEL MANGRUM, MD: Well, we would like to see electrogram amplitude reduction. We will occasionally use a larger tip catheter, an 8mm catheter. And in those cases, you can't see -- or it's very difficult to see an amplitude reduction. But in the smaller tipped catheters, the Thermocool type catheter or irrigated tip catheter, or even a 4 or 5 mm tip catheter, it's not uncommon to see amplitude reduction.

01:23:26

LARRY A. CHINITZ, MD: Now, some people report being able to see lesion formation on ultrasound. Do you see it?

01:23:30

J. MICHAEL MANGRUM, MD: Yeah, you can. We could almost see it there. And you have to sort of get accustomed to looking at that. But what a lesion would look like -- you see this right here? You see how it's slightly more echogenic? So that's a lesion right there. And you can get some thickening. That's another advantage I think of this particular ICE is that you can see in many cases the lesion form, you can see some thickening of that area. And in areas in which there's contraction, you can actually see no longer contraction of that area. And here we've gone back to the left pulmonary vein roof area. This is an image of just manipulating the catheter. Manipulating catheters is a skill that you learn through fellowship really, and then throughout your whole clinical career. And many times these cases require not only steering the catheter, but we've found that moving the sheath, if it's a steerable sheath, I think that's an advantage. If it's not, it's rotating that sheath counterclock, as you know, Larry.

01:24:55

LARRY A. CHINITZ, MD: You know, Mike, one of our audience asked whether you allow residents and fellows to assist in ablation cases of atrial fibrillation.

01:25:02

J. MICHAEL MANGRUM, MD: We do. We feel strongly that one of our missions is to educate next generation of EPs that go out into the community so they can be proficient at these complex ablations. And so we will train fellows, and they get a lot of hands-on experience doing this. What do you guys do, Larry?

01:25:25

LARRY A. CHINITZ, MD: Well, you know, we're evolving, Mike. You know, our fellows are always part of atrial fibrillation ablation procedures. We've been a little reluctant to allow them to be primary catheter manipulators during the course of the actual ablation. They certainly help with the map creation and other aspects of it. You know, we believe that we're just still learning on this, and the margin between success and failure and complications is so small that I guess we want to take the hit by ourselves. But the more and more we do and the more confidence we have in the technology, like what you're showing us today, I think fellows will clearly take a more important role.

01:25:59

J. MICHAEL MANGRUM, MD: If we could pause the clip right here, and let's go back to the slide. We have now moved our catheters into the right superior pulmonary vein, but right before we did this, we mapped, we put the lasso catheter back into the left superior pulmonary vein and we have eliminated the signals in the left superior pulmonary vein. We then have done this to the

left inferior pulmonary vein, and you can see there's disappearance of the signal. So this area was isolated. And we can go back to the case, please. And then one thing I should have showed is the signals from the right superior pulmonary vein, which I'll get to next. But so in this case, we can see here the temperature probe in the middle of the fluoro. And one thing that drove our decision on where to ablate here is the location of the esophagus, which will be more obvious as we start with the right inferior pulmonary vein. But this is the right superior pulmonary vein. We're going around the ost fluoroscopically. You can see it fell off the ost there. We will then go to the -- use ICE to navigate and confirm with 3-D mapping. We have a nice electrogram here on the ablation catheter down here, placing additional lesions. And this is what I was showing earlier. That's the esophageal temperature probe right there. The tip of the ablation catheter is very echogenic. You can see the shadowing. Right in this area, there were some side branches you can see as the ICE probe is pulled back. Again, we're monitoring the temperature, or the electrograms, during the case.

01:28:08

JOHN D. FERGUSON, MDChB: So Mike, do you ever take an acute narrowing of the vein into account, and does that worry you?

01:28:17

J. MICHAEL MANGRUM, MD: Yeah, yeah. I think if we see narrowing, whether it's -- I think a general rule is certainly if you see some narrowing more than 25 percent, that's a time to be careful, and you may want to pull back further into the antrum in those cases or maybe hold up on the ablation even.

01:28:39

LARRY A. CHINITZ, MD: So in fairness, if you truly are in the antrum, we should not see acute narrowing, right?

01:28:43

J. MICHAEL MANGRUM, MD: That's correct, yeah.

01:28:45

LARRY A. CHINITZ, MD: But in practicality, sometimes you do need to dip a little inside or closer to the ost to get your results.

01:28:50

J. MICHAEL MANGRUM, MD: Yeah. And the other aspect, and John has done some studies on this, is looking at the translational movement of the ablation catheter during not only the cardiac cycle but with respiration. There's a great translational movement in and out of the ost of the pulmonary vein. Even if you think you're in the antrum, many times it does dip into the ost. And that particular case we just showed is -- here if we were to go out into the antrum, we would have been right on the posterior wall right on the esophagus, so again, we chose to go closer to the ost in this particular case.

01:29:27

LARRY A. CHINITZ, MD: You know, one of our questions from the audience asks that if you're going to avoid the esophagus, in most cases you're not going to apply energy at areas that you'd really like to ablate near the antrum and some of the areas. Do we just take the sacrifice on that, not go there? Are there any other tools that we have to get around that?

01:29:44

J. MICHAEL MANGRUM, MD: Well, I would be curious on what everyone on the panel here does. I do find that -- and here's a good example. Here's the esophagus right here. It's right adjacent to the wall. The thickness of the myocardium right there is no more than 2 millimeters

thick, so in those cases, I will say I will actually deliver energy monitoring the esophagus, as we are here, and for short periods of time, enough to where I think we can get an adequate lesion that's 2 mm thick but not so much that it's driving into the esophagus.

01:30:21

LARRY A. CHINITZ, MD: Yeah. And I agree with that very strongly. We try to limit lesion delivery to 20 seconds, the hope being that with a short delivery of energy we're not going to transmit as much temperature to the esophagus and avoid injury even when we're real close. But again, there are a lot of variables to that that we just don't know.

01:30:38

J. MICHAEL MANGRUM, MD: So we're placing the lasso catheter back in to confirm isolation of the right pulmonary veins, and we can go to the slides here to just illustrate that, if we could. So the right superior pulmonary vein -- I'm sorry I forgot to show that prior to the ablation. There was a nice potential there. The right inferior pulmonary vein there. And then post-ablation, there's loss of potentials in there also, in the right inferior pulmonary vein. You'll see that shortly. Okay, and shall we go to the last segment?

01:31:30

LARRY A. CHINITZ, MD: Yeah, I think the last segment's important because it shows a unique utilization of ultrasound as it relates to registration.

01:31:42

J. MICHAEL MANGRUM, MD: So what we're going to demonstrate here is an alternative way of registering the image that hopefully may one day show that you can eliminate the geometry creation. And what we've done is to place the ICE catheter into the left atrium, and with ICE and the tip of the ablation catheter, we know exactly where we are on a real-time. And if we take that image, the 3-D image, and place a fiducial point at that area, we should be able to hopefully register with good accuracy that CT image. And then the idea is that that would potentially avoid having to create an entire geometry. And so what we've been working on is identify key areas and a limited number of points where we can create a registration that is valid that would save a significant amount of time for geometry creation, and that's what you're seeing here. We're going into each of the ostia of the pulmonary vein, marking two points anterior, superior, inferior, posterior points on each vein as well as antral points. And then we're fusing. And then subsequently, prior to using a scan like this, we would validate, meaning we would reposition our catheter, confirm where we are with ICE, and make sure that it's registered adequately on the 3-D image. And that's what we're seeing here.

01:33:19

JOHN D. FERGUSON, MDChB: I think one of the big challenges with registration is that if it's taking a long time to do a full catheter geometry, by the end of that you often have such a beautiful catheter geometry, do you really need to register the CT image? And so I think the search for modalities that expedite anatomy of the left atrium, whether it's registration or catheter geometry, are certainly going to be crucial as we move forward.

01:33:55

LARRY A. CHINITZ, MD: That's very true. So I think we can wrap up the video for right now. And I just want to state congratulations to Dr. Mangrum and Dr. Ferguson and the University of Virginia. This was a spectacular showcase of the technology we have and the kind of accuracy that we can potentially development in ablation of atrial fibrillation. So maybe I can ask Mike for some final comments before we go.

01:34:21

J. MICHAEL MANGRUM, MD: Well, I think the integration of all these imaging modalities are complementary to one another, and I think they can actually help significantly in the case. And that is this whole integration of imaging from different modalities. And we get good catheter location, and I think it helps in planning the procedure beforehand and executing it in the lab. John?

01:34:48

JOHN D. FERGUSON, MDChB: I think there are three important issues here. I think attention to detail and really trying to understand physiology are crucial to getting this accurate and getting this right. And I think the second point is that once you've done a registration, we need to validate it clinically, either on ICE or by moving our catheter around. And we've got to be very wary of any shifts that there might be. And then thirdly, and probably most importantly, is there's only very limited data on how this affects procedures, reduces procedure times, and ultimately improves patient outcomes. And that's what we need to strive for.

01:35:30

LARRY A. CHINITZ, MD: I think that's really -- I'm sorry, did I interrupt you?

01:35:31

JOHN D. FERGUSON, MDChB: No.

01:35:32

LARRY A. CHINITZ, MD: That's a very important ending point. You know, I think we who spend so much of our time now involved in procedures like that in the treatment of atrial fibrillation recognize more than anyone that this is a work in progress, that we're much better than we were several years ago. Our intent is to continue to improve and get better. We don't present this technology as an end result but rather as a beginning to deliver more accurate and more successful procedures. And as long as we all maintain our energy, we could probably be in this process for quite some time. The partnership with our technicians and nurses and fellows and industry is so critical to what we do. So again, I thank the Heart Rhythm Society for giving us the opportunity to present this program today, and again, congratulate the faculty and staff of the University of Virginia and thank you for your time.

01:36:30

ANNOUNCER: You have been watching the Heart Rhythm Society's Reality EP Series featuring a catheter ablation for paroxysmal atrial fibrillation. Viewers seeking CME or CE credit may now take the post-assessment survey by clicking the button on their webcast screen. This Heart Rhythm Society program is supported by an educational grant from St. Jude Medical. [end of webcast]