

**TRACY WONG:** Good evening, everyone. Thank you very much for joining. Tonight, we're going to talk, have a real conversation about real patients. Our faculty have presented a couple of great cases for you where we're going to really talk about aortic valve replacement, including redo aortic valve replacements and considerations for that. So I hope you will enjoy the next hour.

My name is Tracy Wong. I'm going to be moderating this discussion. I'm a professor of radiology here at Duke University.

Let's do some housekeeping things first. So next slide-- you guys can go ahead and read that. And then let's go on to the next slide. Amy, you want to take us through the housekeeping--

**FEMALE** Sure. I'm happy to do so. Hey, everyone. Good evening.

**SPEAKER:**

Just so you know, everyone is muted by default to avoid any interruptions during the program. Please feel free to participate in the audience polling, and please use the Q&A function to submit any questions you might have. Our faculty will be responding to your questions and comments within the Q&A function during and after panel discussions.

Along with your question, please include your full name, city, and country. Thank you very much. The floor is yours, Dr. Wong.

**TRACY WONG:** Thank. We intentionally designed this to be an interactive program, especially interactive among our panelists. But we look forward to interactions with you all as well.

So please feel free to use the Q&A function. Dr. [INAUDIBLE] will be monitoring that function and submit questions, read all the questions. I'm joined by three colleagues that are excellent, and let me have them introduce themselves first. Vinod, would you like to introduce yourself?

**VINOD THOURANI:** Yeah, thanks. Thank you so much, Tracy. I'm Vinod Thourani. I'm a cardiac surgeon at Piedmont Heart Institute in Atlanta, Georgia, and really a pleasure to be here tonight.

**TRACY WONG:** Great. Thank you. Chris?

**CHRIS MALAISRIE:** I'm excited to be here tonight. Thanks, CryoLife. Thanks, Tracy. My name is Chris Malaisrie. I'm a cardiac surgeon at Northwestern Memorial Hospital and professor at Northwestern University.

**TRACY WONG:** Fantastic. And Hector?

**HECTOR MICHELENA:** Yes, Tracy. Thank you very much a pleasure to be here. Hector Michelena, professor of medicine at the Mayo Clinic, a cardiologist, and chair of research for equine structural heart disease.

**TRACY WONG:** Great. So looking forward to our discussion here. Let's get right into it.

And first, I want to thank Chris, Dr. Malaisrie, for providing a good chunk of the imaging and case reports here that we'll be talking about. He provided all three cases, and we might have a few extra bonus cases as well. So thank you very much.

Let's go with our first case. Excuse me. So we've got a 55-year-old gentleman here who had a tissue valve implanted 10 years ago.

Was a 23 millimeter Edwards valve. He now comes in with moderate to severe aortic stenosis. Not much past medical history, and there's quite a bit of information on this slide.

But generally, what you see here is that he's considered mostly lower risk for surgery, with an FTS score of 1.12%. And then there's some information on frailty here at the bottom right here that suggests that he's pretty active and not too frail. BMI is 28. Creatinine is 1.0 with the GFR that's nicely intact. He's got New York Heart Association class two symptoms. So when we go ahead and look at some of the basics like his EKG, what you see is he's in sinus rhythm, he does have a right bundle for conduction disturbance here, as you can see in the EKG here.

Let's take a look at the echo. And you've got the gradients on the right. But you can see that as noted on the left, the ejection fraction is pretty well preserved. The ABA is 0.9. The index 0.48. You've got moderate to severe AS, not much aortic regurgitation, and not much mitral regurgitation either.

**HECTOR** I think, Tracy, it's important to note there that the alignment of the cursor with the flow of the aortic valve is not appropriate. And therefore, this is likely a severe aortic stenosis which is underestimated.

**TRACY WONG:** Good point. Thank you. All right. Hector, do you want to continue to talk a little bit about this, the echo, the Doppler images?

**HECTOR** Yeah, I mean, I think it is important, number one to note that he has a preserved LV and RV function. And also, **MICHELENA:** when we have this type of-- I mean, you see the aliasing going through the aortic valve, which basically-- it clues you in into obstruction. But the critical thing with these patients is perhaps to take a look and make sure that it's not thrombosed and make sure that it's degenerated. And the best way to do that is either by TEE or CT.

**TRACY WONG:** Great. Here's the CT pictures. Chris, do you want to chat a little bit about those CT images here?

**CHRIS** And this is one of our-- this is a real patient, and the CT scan is taken for a couple of reasons. The first, it would **MALAISRIE:** be a reoperative ABR. So I like to get a CT scan to see anatomy for surgical planning.

But for this particular one, we're getting a CT scan to see candidacy for TAVR valve in valve. And a couple of things on this slide you can see-- that we know it's a 23 stented bovine pericardial valve. But with real dimensions there, the inner diameter is running 18 to 19.

**TRACY WONG:** Yeah, small.

**VINOD** Chris, I think this is important because a lot of surgeons, the most common valve put in by surgeons is a 21 **THOURANI:** valve. It's not really 21. A 23 is measuring 18 by 19. A 21 is measuring a lot smaller than that. So I think this is an important thing for people to appreciate by CT-- really that it's not really a 23 when you look at the dimensions by CT scan by-- the effective orifice area, that is.

**TRACY WONG:** Good point, Vinod.

**CHRIS MALAISRIE:** The instructions-- the reconstructions are pretty good. Volume rendering-- here are some MIPs. You can see the posts in relation to the coronary arteries, which are really important. You can see the bulges of the sinuses because there's got to be room for both the old surgical valve and the new transcatheter aortic valve if that's the route we're going to go.

**TRACY WONG:** Here are some of the heights, especially the left and right corner heights, which you might want to comment on as well.

**CHRIS MALAISRIE:** Yeah, and this is trying to determine what sort of risk of coronary obstruction with valve in valve this patient is going to face. So if you look at the coronary heights, there are eight and nine millimeters, a little bit lower than we would want. But there's going to be the next slide, I think, Tracy, that measures a virtual valve that is in the surgical valve and measuring from that frame to the coronary arteries.

And with these measurements, I think it's a little bit iffy, right? You have 5.1 millimeters to the left coronary artery and 3.3 millimeters to the right coronary artery. And Vinod is an expert in TAVI of course. Vinod, what sort of numbers are you looking at for these virtual distances from the TAVI valve to the coronary arteries?

**VINOD THOURANI:** I think this is very important, and these are a little bit on the shy side. I'm looking for a little bit more than that. But what's important is sinus and Valsalva diameter is 30.3 millimeters.

And so the post, it's not going to [INAUDIBLE] going to go much past that. So I think that even though the heights are a little bit on the lower side, I think your sinus and Valsava is actually nice, and I feel relatively comfortable moving forward with something on this patient if TAVR was the pathway that was being chosen all because of the SOV. If the SOV was in the 25 range, 25 range, I'd be very concerned about coronary occlusion. Hector, do you agree, or what are your thoughts?

**HECTOR MICHELENA:** I agree.

**VINOD THOURANI:** Yeah.

**TRACY WONG:** There's actually a great question from the audience. Why was this procedure 10 years ago not a [INAUDIBLE] or a mechanical valve? I think this is one that we also debated when we were going over this case before.

**VINOD THOURANI:** Yeah, that's a great question.

**TRACY WONG:** It's sounded like this patient had had a strong aversion to warfarin and so preferred a tissue valve at that time. But I think it brings up a good point. 10 years ago, this guy would have been 45, and confronted with many, many years ahead of him, tissue valve is probably not the best option for the patient given what we know to be the durability. But let's keep going here.

Oops, go back one. Keep missing this. OK, so just a quick look at the coronary angiogram.

Seeing some lumps and bumps, as you might expect, but consistent with his age-- nothing really that requires CABG per se. So let's get to our first poll question. And Justin, if you could line us up for the poll, I'd love to get a sense from the audience. What do you-- based on what we've presented so far-- and again, this is a guy with severe AS.

He's 55. He's had a bio prosthetic valve, 23, with the dimensions now that you're seeing on echo and CT imaging. What would you do next for this gentleman?

Would you do a trans catheter AVR valve in valve? Would you take the guy to the OR, redo his valve with a bio prosthetic valve or redo his valve with a mechanical valve or think about ABR with a homograft here? There you go.

See 61% of folks-- got quite a few respondents. So 61% of folks would prefer to do a redo surgery with a mechanical valve. And then the second choice was redo surgery with a bio prosthetic valve. And then 9% thought about doing transcatheter valve in valve. Let's open this up to our panelists. What do people think?

**HECTOR**

I personally think and dealing with bicuspid aortic valve and knowing that bicuspid aortic valve is so prevalent

**MICHELENA:**

that we have to be very clear in our shared decision making with the patients. Yes, it has to be a bidirectional communication with our patients. But we also have the responsibility of showing our patients what the data is and making sure that they can make a well-informed decision that is based not just on fallacies and opinions but that is based on data.

So I think this guy at 45 years old, when he had his first problem, he was done a disservice. Basically, he's now again for the same problem. And we have an opportunity to do a service for him.

**VINOD**

So I have a question for you Hector and also Chris. When you see something like this, when you put a tissue

**THOURANI:**

valve in them, what do you tell them their durability is going to be? I tell them that I plan to see you in 10 years.

I don't tell them-- I have some people that I've heard, surgeons say this at national meetings, when they go, I will see you back in 20 years. This valve is going to last you 20 years. And I do not tell them that.

If they are over the age of 60, I say 10 to 15 years. Under the age of 60, I say, I'll see you back in about a decade. And so I'm very honest with them, Hector, because I do think that people-- the patients are going to listen to you.

You're an authority. And so I think that you can guide that direction in a variety of different ways. I think we have to be very honest with the patients on what we think the tissue valve is going to last, especially under the age of 60 to 65.

**TRACY WONG:** Yeah, Vinod, I usually give them a range, and it's somewhere between 7 and 15 years.

**VINOD**

Yep.

**THOURANI:**

**TRACY WONG:** So-- and for some people, they may be quite unlucky, and you know, I refer them to a surgeon seven years later. And for others, the luckiest individual, will be 15 years. So 45 [INAUDIBLE] confronting surgery at 60 and possibly, if we do the same thing at 60, another one at 85-- no, sorry, 75. I can't do math. So at least three to four surgeries over the course of their lifetime.

**VINOD THOURANI:** Yeah, I mean, I would tell this patient 45 that they're going to have three to four surgeries, three or four interventions, however you want to call that.

**TRACY WONG:** Yeah. Oops. I don't know. Chris or Hector, do you want to weigh in?

**CHRIS MALAISRIE:** I just want to make a point that there's two big questions that need to be answered in clinic when this patient comes to you. The first is the valve choice. And I think the audience hit on it right there-- mechanical versus tissue.

And the second is the approach. And I think patients come to us asking the wrong question first. They come to us asking, should I have a TAVI or should they have surgery, when I think the first question that should be answered is, should they get a mechanical valve or a tissue valve because that determines everything else downstream.

**VINOD THOURANI:** Right.

**CHRIS MALAISRIE:** Because if the right answer is a mechanical valve, then it has to be redo surgery. You can't get a transcatheter mechanical valve. So only after that decision is made, mechanical versus tissue, then do we start talking about approach.

**VINOD THOURANI:** Yeah, I agree with that, Chris 100%.

**TRACY WONG:** All right, let's keep moving here. So Chris, what happened to this patient? It looks like as part of the evaluation, you also looked at some virtual valve imaging.

**CHRIS MALAISRIE:** Yeah, this is the advanced imaging that we get. And I think most people are used to getting this. It does require additional software to draw this virtual valve in. And I just have to make sure that everyone understands that aortic valve in valve for low risk patients is not currently FDA approved.

This particular patient was being considered under an investigational protocol. But here you could see the transcatheter valve drawn in and pretty good distances to the coronary artery. So we felt pretty good about enrolling this patient in an investigational trial.

**VINOD THOURANI:** Chris, did you model this also for self-expanding valves or only balloon expandable because it was part of a trial?

**CHRIS MALAISRIE:** It was only this particular valve as part of the trial. Right, right. Here's some additional images of what these beautiful CT scans can offer us here. You could see the silhouette of the valve there, Tracy.

**TRACY WONG:** Mm-hm. Nice pictures.

**CHRIS MALAISRIE:** And then this patient I think ended up getting A.

**TRACY WONG:** Oh, actually, you had an access picture first.

**CHRIS MALAISRIE:** Right.

**TRACY WONG:** Thank you. I talked a little bit about transfemoral versus other accesses. [INAUDIBLE] changed your mind.

**CHRIS MALAISRIE:** Right. I think Vinod remembers when we started TAVI about 10, 15 years ago that it was 50-50 chance you're going to get a transfemoral access. But now with sheath sizes down to 12 and 14 French, about 90% would be a candidate for transfemoral. And for these CT scans which have to be taken and looked at, this is a good transfemoral case.

**VINOD THOURANI:** So in the United States, when I looked at all the TVT data for 2020, 96% of patients in the United States are done transfemorally. And that was in 78,000 TAVRs in the United States. So it's now up to 96%, Chris.

**TRACY WONG:** It does seem like a great transfemoral case here. So Chris, you can tell us a little bit about follow up imaging here too.

**CHRIS MALAISRIE:** And we're actually pretty happy about a couple of things. With that right bundle branch block, it puts the patient at a higher risk for pacemaker. Didn't end up with a pacemaker.

The gradient's a little bit better than expected. Previous valve in valve trials show the gradients of about 17 or 18 after valve in valve. And this patient ended up getting a 16 millimeter gradient. Still not great but better than what would be expected, and it looks like it persisted--

**TRACY WONG:** Three years later--

**CHRIS MALAISRIE:** [INAUDIBLE]

**TRACY WONG:** Yeah, so that three year later the echo results from three years after the procedure was shown on the right. So it looks like you had some pretty decent, durable results too.

**CHRIS MALAISRIE:** Third issue there, we put the antiplatelets, anticoagulants here because one more thing that is showing up in the transcatheter valves is the risk of valve thrombosis. And Vinod, I forget the exact numbers for valve thrombosis for both valves.

**VINOD THOURANI:** Yeah, it's--

**CHRIS MALAISRIE:** You showed it in a couple of trials.

**VINOD THOURANI:** Yeah, there's not great data on the valve in valve nearly as much as it is for de novo. It's in the 20% and 30% range. But the only thing that I would do differently on this, at least for this component, is that we would put them on Coumadin and not aspirin-- I mean, I'm sorry, on not Plavix.

We would do aspirin and Coumadin for 30-- like three months of Coumadin therapy. The [INAUDIBLE] have not shown decrease in thrombus nearly as much as a full anticoagulation with Coumadin. Eloquis and the other ones have not shown it. So we're a little bit more proactive with Coumadin for these patients at least for the first three months. So that's the one thing we would do differently with that.

**HECTOR** Yeah, so you know, it makes you wonder-- and I want to ask Vinod and Chris. You know, with these patients, how many valves can you put in inside a 23 millimeter valve, and what's going to happen to the future of this valve in valve? But before I ask you that--

**VINOD** [INAUDIBLE] I'll show you later.

**THOURANI:**

**HECTOR** OK, perfect. But in the meantime, I just want to say a couple of things because everybody has opinions. But the bottom line is that it's what you think you know for sure that gets you in trouble.

**MICHELENA:**

So if you can go to the next one, in the-- and you can bring them all down. In the area of TAVR, there are some facts, and there are some misconceptions. There is increased popularity of bio prosthesis.

Patients don't want to take Coumadin, but they misunderstand Coumadin. Like, for example, I have to change my diet to accommodate Coumadin when it should be the other way around. You should change your Coumadin dose to accommodate your diet.

For example, industry suggests that the third generation's bio prosthesis are perfect-- no warfarin, no clots. The cardiovascular community has accepted as a given that valve in valve is the long term solution. And then the partner three trial in low risk patients showed initial outcomes better with TAVR than with SAVR. Let's go to the next.

With that being said, of course, you can see that for all age ranges, the use of mechanical valves in patients 50 to 70 years has decreased. Let's go to the next. And I just have to show you here a 56-year-old two year status post-aortic valve replacement with a bioprosthesis coming due to thrombosis and having had to have the valve redone.

Let's go to the next. And the truth is-- that's going to-- and the truth is that bicuspid-- that bio prosthetics valve not only incur degeneration over time, but they also incur thrombosis. And we say, well, we'll put the patient on Coumadin for three months.

Well, it turns out that thrombosis can occur late in these patients. And this is very important to know. You can have a three or four patient-- three or four year out patient from the surgery or from the TAVR that comes with a completely thrombosed valve. Let's go to the next.

And I want to show you something very interesting. Go to the next. Yeah.

If you look at the aortic valve estimated incidence of bioprosthetic thrombosis in the aortic position-- this is about half a percent, huh? Half a percent. And I want you to look at the next slide and see that the same risk of thromboembolism of 0.5% is for the mechanical valves.

So there are two important lessons that we have to learn. Number one, thromboembolism and even by old trials has been proven to be the same with bioprosthetic or mechanicals. And the same has happened when all these big trials have compared endocarditis. The rate of endocarditis in mechanical versus bioprosthetic is the same.

Let's go to the next. And here's what has happened. And in this regard, I am very, very respectful of the partner group because they have come out with very, very clean and transparent data. And you can see here that the initial results that favored SAVR over TAVR in terms of death or disabling stroke in low risk patients are offset at the end of two years, noting a higher incidence of valve thrombosis in TAVR versus surgery with the result of increased gradients through TAVR valves and not SAVR valves.

And this is an important thing to note-- let's go to the next one-- because this is real data. When we look at valve in valve, evidently, it is a great solution, especially for older patients and high-risk patients. You better believe.

It can save a life. I mean, let there be no doubt. But if we look at the data a little further-- let's go to the next, to the previous. Yeah, so if we go and look at the data, we can see that there are issues with valve in valve.

One of the issues is the size of the prostheses itself, as my surgeon colleagues were mentioning. Note that there is a significant difference in survival that is related to having a large bio prosthesis versus a small bio prosthesis. Let's go to the next.

**TRACY WONG:** Sorry about that.

**HECTOR** And very important to note that mortality was very strongly associated with every millimeter of decrease of  
**MICHELENA:** internal diameter. And it was also associated with reintervention using balloon-expandable TAVRs. Of course, there's a call there for surgeons to implant valves that are more than 23, which I'm sure for Vinod and Chris, who are very experienced surgeons, it's not such a big deal. It's difficult but not such a big deal.

But I don't think all surgeons all over the place are well-versed in annular enlargement techniques that are easy for them to do. So you have to take all of this into consideration. And then I asked Vinod and Chris, so how many valving valves can you put in, number one? And number two, what is the risk that a valve in valve will give for future coronary artery interventions? How are you going to get into the coronaries with a couple of valve in valve when this guy comes with an acute MI?

**TRACY WONG:** Vinod, I think you're up. [INAUDIBLE]

**VINOD** So Hector, I think that you're absolutely right, and I agree with that. And I think that the data is out there for us  
**THOURANI:** to look at. I think we have to be-- we can't just look at the data that we want to see.

We have to look at all the data and be very honest with our patients about this. So I'm going to show you something because you're absolutely right, Hector. So here's a patient, 65-year-old, now comes in to me with a progressive dyspnea on exertion, bilateral leg edema for the last six months.

And he is young, 65, but he's COPD with a home oxygen, atrial fibrillation, diabetes, hypertension, bad PAD with prior stints, and a chronic anemia. At age 49-- Hector, at age 49, OK, this patient underwent a tissue AVR with a coronary bypass times 2. Patient then comes back later, seven years-- not 10, Tracy, not 15, not 20, OK?

Patient comes in seven years and says-- actually, at that time, 2012, I was at Emory. So he came to me after the first surgery wasn't done by us. And I ended up-- at that time, a home oxygen. He was in a bad shape.

He was in acute heart failure. We did a valve in valve on him with a balloon expandable valve. He did OK with that.

In 2017, he came back to me. Now his femoral access was completely gone, and he looked even worse. So we did a transcaval TAVR valve in valve in valve.

So the guy's got a surgical 23, a balloon expandable valve in valve. And we put in a core valve in valve in valve. Now he finds me.

I come back to Atlanta. I moved away for two years. I come back, and my God, he found me.

I'm not sure how he found me, but he found me. And now he comes to me like this. He's still smoking, by the way, a pack and a half a day. He just won't stop.

His EF now is 40% to 45%, severe AS, mean gradient of 43. And he also has some severe mitral regurgitation. We diuresed him.

We got him better. We got the mitral regurgitation down to moderate. Take a look at this, Hector.

So there's a tissue valve. There's a safety valve. There's a core valve.

And then we end up putting another core valve in him. So this guy at age 65 has two core valves, a balloon expandable valve, and a surgical valve. We had to do him as a redo transcaval, right?

So he's a redo transcaval TAVR valve in valve and valve in valve self-expanding THV. Mean gradient is 25. Valve area is 1, 1.

That was in April 20, 2001. I'm scared to get his echo in April of 2022. So he's symptomatically better, but in my opinion, he's not in a great situation. And I don't expect him to live more than one or two years.

**TRACY WONG:** Yeah, I think you bought him a little bit of time, but he's not helping himself. And lord knows if this guy comes in with a stemi, I feel sorry for whoever the interventionalist is.

**VINOD THOURANI:** Luckily, that's not going to be me because I don't do stemis and I'm not going to operate on them for coronary bypass. But Hector, your point is well taken. In my opinion, that patient in his 40s should have been coaxed as much as possible to going to a mechanical pathway, a mechanical valve pathway. And I think we need to do, as physicians, a little bit better job not talking about the glory of what we could do with valve in valve but also talking about these type of cases where we're struggling now on a 65-year-old that I don't think will make it to 67.

**TRACY WONG:** Great. Great case, Vinod. Thanks so much for showing that.

That was our little bonus case there. Let's go on to case two. Case two is a really cool case too.

So let's quickly go through it-- 48-year-old gentleman, moderate aortic stenosis. STS score of 0.38. And then let's see if I can advance to the next slide, I am controlling the slides. Let's see.

Whoops, go back one. All right, so you can see the gradients here. Calculated AVA is 1.6.

Index is 0.9. Again, might be underestimating here. EF is pretty preserved here. Hector or Chris, do you want to go over these pictures quickly?

**HECTOR** Well, I mean, you can clearly see on that echocardiogram that there's significant decreased mobility, systolic mobility, of that aortic valve. And you know, evidently, we know it's a unicuspid valve. And in that short axis, basically, the differential diagnosis would be between a right left bicuspid aortic valve fusion and the unicuspid valve. And it turned out to one unicuspid valve.

**TRACY WONG:** All right. Sorry, it's jumping ahead. I'm not sure what I'm doing differently.

But let's see if I can get back to where we want to be. All right, Chris. Here's the cardiac MR results, and maybe you can take us through the next few.

**HECTOR** The unicuspid valve was visible there on that cross section MRI. Looks like a toilet seat-- just one leaflet all the way around. Definitely be concerned about doing a TAVI in something like that's.

Worse than a bicuspid, I think. And the second reason that this is not a great TAVI case is that aneurysm there. And you could see it on that right panel.

Some rotational images-- mid ascending aorta is 5.2, the bicuspid. That's class two, recommendation for surgery just by itself with the aneurysm but definitely indication for surgery. If they've got aortic stenosis, you need to do something anyway.

We get some-- these are investigational MRs, time resolved MRs, 4D flow colloquially. And you could see the manner of the vortical flows and wall shear stress that we can measure there. Through the aortic stenosis that hits the aortic wall, we think that contributes to aneurysm growth on top of the BAV aortopathy.

**TRACY WONG:** That great picture is really showing why that aneurysm is [INAUDIBLE] asymmetric here. So what happened?

**CHRIS MALAISRIE:** All right, so this case, young patient, aortic stenosis aneurysm. The biggest question is what sort of valve they would have wanted, and that's where I always start-- mechanical versus tissue valve. And despite AHACC, European, Asian, Japanese recommendations to take a mechanical valve, the patient did not want to be on Coumadin.

So the patient would have received a tissue valve at 46 ascending aortic replacement. So that opens up, I think, a great option for this patient, which is pulmonary autograft, a Ross procedure. I think it's important for the general cardiologist and probably some cardiac surgeons to be able to explain what a Ross procedure is.

It's very difficult to send this patient for a referral if the referring physician can't even explain what a Ross procedure is. And there are some diagrams on the web. CryoLife has these diagrams that can be accessed through that website.

The next slide shows that the procedure involves taking the pulmonary valve and translocating it into the aortic position. So it's an aortic valve replacement using the patient's own pulmonary valve and root. And in the place of the pulmonary valve goes a pulmonary homograft.

So that's an allograft, a cadaveric homograft, from a cadaver. And that's used to replace the pulmonary valve. And the reasoning here is that you want something native, something autologous in the left sided valve.

And although the homograft is a substitute for the pulmonary valve, it's much more benign in the pulmonary position than in the left sided position. This particular one shows a full route replacement technique. There's a couple of techniques to the Ross procedure.

When Donald Ross first described it, he described it with a sub-coronary technique. So that's not a full route. It's just an aortic valve replacement sub-coronary suture line. I don't think people have to concern themselves too much with that.

Most people do it with a full route replacement. That means the coronary arteries have to be reimplant into the pulmonary autograft. So that's a couple more suture lines, takes a little bit longer to do.

I think the most compelling thing about the Ross procedure in young patients is the survival advantage. And you really saw some survival data that Hector showed for patients who get an artificial valve. And their life expectancy was not good-- 40% at-- I thought I saw five years, Hector.

So patients definitely do not return to expected survival after accepting an artificial valve. Still much better than living with aortic stenosis, though. They'll be dead in two years but not the same as the normal population.

And this *JACC* state of the art reviews shows and summarizes some of the data on the next slide showing 15 year survival-- not just 10 years, but 15 years survival-- of greater than 90%. So that's a lot better than a patient receiving either a mechanical or a tissue valve. And beyond that, the next slide shows--

**HECTOR** What's the reoperation rate, Chris?

**MICHELENA:**

**CHRIS** Yeah, the reoperation rate is better than having a tissue valve and almost as good as having a mechanical valve--  
**MALAISRIE:** - not quite as good as having a mechanical valve. The risk ratio was about 1.7 when you compare Ross with the mechanical valve but still definitely better than taking a tissue valve. Vinod already told-- I mean, I tell the patients the same thing. Tissue valve at 45 years old, expect to be back in less than 10 years for another procedure.

And this is the final slide that I think we'll show for the Ross survival in case people don't believe it. I do believe it. This is 25 year data now, and with the expected survival of 75.8%, that confidence interval you see in that panel is not statistically different from the general population. So the hypothesis that Ross procedure can bring people back to their normal life expectancy, I think, could very well be real.

**TRACY WONG:** And Chris, maybe you can speak to a little bit of the selection factors. Who are Ross candidates versus not?

**CHRIS** I think the hardest thing about getting the Ross procedure is finding a center that will offer that procedure and  
**MALAISRIE:** even finding a center that would talk about the Ross procedure. I think that first case, the person who got a tissue valve at 45, probably was never offered a Ross procedure at all. So I think that's the hardest part about patient selection.

In terms of anatomy, we get MRIs in order to look at the pulmonary autograft to make sure that also isn't bicuspid-- a lot of these patients are bicuspid-- and make sure there's no PR, PS. Just don't want any surprises. I mean, we can quickly change to a mechanical valve at the time of surgery, but I'd like to know these things preoperatively so we can counsel the patients.

**VINOD** Tracy, can I ask two questions of Chris?

**THOURANI:**

**TRACY WONG:** Of course. Go ahead.

**VINOD** Yeah, so when you say, Chris, that Ross procedures are going to be done in people who are relatively healthy,  
**THOURANI:** right-- you're not going to do it on a sicker patient who's on some home oxygen or-- so their survival curve automatically, by patient selection, therefore, makes them a little bit more likely to recover and take a hit of a larger or longer cross claim time. Wouldn't you say?

**CHRIS** Yeah, I think so. I think that was sort of the pitfall that we ran into 20 years ago was people were doing Ross  
**MALAISRIE:** procedures in risky patients, even patients with endocarditis. I'm not saying you can't do it in endocarditis.

**VINOD** [INAUDIBLE]

**THOURANI:**

**CHRIS** Those aren't the patients that you want to be starting out on. And the patient has to have an expected life  
**MALAISRIE:** expectancy of 20 plus years for the Ross procedure to be worth it.

**VINOD** Yep. And the second thing is, you know, to me, a major impact is going to be a [INAUDIBLE] trial that both Tracy  
**THOURANI:** and I are on the steering committee for it. And I think-- would that change if-- because I think that will change that bar. Hector showed some nice slides about bio prosthetic and mechanical valve.

If you said to the patient, I'm not going to give you Coumadin-- after 90 days, you can switch over just like we do for tissue valves or whatever, TAVR valve valves. We can switch over to a non-warfarin based therapy. Do you think that would change your decision? Would you do Ross's if that study becomes positive?

**CHRIS** I think the [INAUDIBLE] trial is going to be a groundbreaking trial. Tracy is going to talk about it at the end as  
**MALAISRIE:** well. The opportunity to have almost an ideal valve, right? So it's a durable valve that you don't have to be on Coumadin for but you will have to be on apixaban if the trial is positive is extremely, extremely attractive for doctors and the patients.

**VINOD** Yeah, agreed.

**THOURANI:**

**HECTOR** I think it is important to recognize that for the younger, healthy population, Ross procedure and bicuspid aortic  
**MICHELENA:** valve repair in the appropriate valve, leaking bicuspid valve with the appropriate surgeon--

**CHRIS** Yeah, it's a key part.

**MALAISRIE:**

**HECTOR** --procedures, the Ross and bicuspid aortic valve repair in young, low risk patients done by the proper surgeon  
**MICHELENA:** and done on the proper valve can give a patient a 20, 25 years of having their own tissue, having their own tissue, and not needing anticoagulation. And then there will come a reckoning moment where something else will happen. But I think that that is an important thing to know.

**TRACY WONG:** Great point, Hector. And Chris, you can take us home on what happened with this patient.

**CHRIS** And I'll have to Hector as well-- freedom from endocarditis of the autograft too. I think it's a powerful motivating factor for the Ross procedure. So this is the post op echo for this Ross. Deep implantation of the autograft-- you can see it's seated well in the LVOT. I think that protects the proximal suture line. Next slide--

**TRACY WONG:** And Chris, just a quick point about endocarditis-- do you do antibiotic prophylaxis after Ross?

**CHRIS** Right, I do. So we do prophylax Ross procedures but not for the autograft. We prophylax it for the pulmonary homograft. But even if they gets endocarditis on the homograft, which is on the right side, we know that's a lot more benign than having endocarditis on the left side.

**TRACY WONG:** So some more cool pictures for you to show.

**CHRIS** Yeah, those 4D reconstructions-- we followed it up with more 4D reconstructions afterwards. And the left sided panel, you'll see that the ascending aorta is completely replaced with a Dacron graft. So all that's left of the pulmonary autograft is 2 and 1/2 centimeters of the pulmonary valve.

So the autograft is protected proximally and protected distally at the STG to keep it from dilating in the future. Blood pressure control is also important for the first six months afterwards. And the 40 MR shows resolution of the wall shear stress and vortices of blood flow secondary to the aneurysm.

**TRACY WONG:** Hopefully predicts the durability too.

**CHRIS** And some more pictures here. The 4D MR previously also showed nice flow to the pulmonary homograft. We typically use a 28 or 30 millimeter homograft just so we don't get pulmonary homograft dysfunction afterwards, pulmonary stenosis specifically.

And I'm really excited for this patient. I think not doing the aneurysm would be a mistake. That wall shear stress is ominous. We're going to have more data correlating wall shear stress with aneurysm growth and probably aortic catastrophes. But just looking at that wall shear stress hitting the outer curve of the aorta makes us not want to leave that aorta alone. That aorta should be replaced.

**TRACY WONG:** Well, great case and really complex anatomy here, but great result. In the interest of time, since we've got about 12 minutes left. Let's move on to case three here. So this is a 58 year old lady who had Hodgkin's and underwent mantle radiation before-- and we all know that this is associated with thoracic pathology here-- who now comes in with severe aortic stenosis has an STS4 of 3.8%. [INAUDIBLE] is a little high. GFR is 55.

Let's take a look. This is her EKG. Not terribly concerned about conduction issues here. This is her echo.

Severe AS-- ABA index of 0.38. EF nicely preserved, although I suspect she'll have some diastolic dysfunction. Not much MR but a little bit of aortic regurgitation.

**HECTOR** Yeah, I think this is a beautiful echo for all echocardiographers. Present if you look at the left side on that [INAUDIBLE] alone, you see the typical appearance of radiation disease. It's almost pathognomonic when you see a calcified aortic valve and a tremendous, exuberant calcification of the aortomitral curtain going all the way almost to the-- a little bit beyond the belly of the anterior leaflet of the mitral valve.

And you can also see very importantly that in short axis as well, the calcification is exuberant such that this patient likely has calcification of the LVOT as well. And this is another category of patient that the STS doesn't cover well. I mean, that STS risk of three for a post-radiation patient is not true because these patients have damage to their lungs, their myocardium, valves, coronary--

**VINOD THOURANI:** [INAUDIBLE] all their [INAUDIBLE] are gone. yeah. Yeah, I can't wait to see the CT on this patient, Hector. I have to be honest with you.

**TRACY WONG:** It's concrete. It's a concrete wall.

**VINOD THOURANI:** There you go.

**HECTOR MICHELENA:** So I mean, again, I mean, there's calcium accretion on the left there all the way below the annulus of that valve. And that is something that a cardiologist imager cannot let go by without discussing with a surgeon because there are dangers to having this amount of calcification and doing TAVR. And I'll let my colleagues explain that.

**CHRIS MALAISRIE:** So this is native aortic stenosis. Radiation heart disease is bad. All the reasons that sway you away from surgery also leads to problems with TAVI.

So these severe LDO2 calcifications put the patient at risk for annular rupture at the time of TAVY. In fact, Venod, I don't think we enrolled any patients like this in any of those transcatheter TAVI trials that we did this past decade.

**VINOD THOURANI:** I think that's really important, Chris, to mention that is that Hector's showed some data on P3. And these are not the patients that are represented in those trials. And you showed that.

It's not representative. You have to look at the trial patients and equate them for real life. You can't just assume that these are the type of patients that are considered low risk. That's a very important adjunct about looking at randomized trials for your own specific patient population.

**TRACY WONG:** So heavily calcified coronary heights are shown here. You can see the sinus of Valsalva diameter as well. Coronaries-wise, small coronaries but fortunately nothing that looks bypassible.

So let's do a quick audience poll here. Based on what we've shown so far, so younger patient-- well, somewhat young patient-- mantle radiation, heavily calcified, including LVOT calcifications, severe AS. What would you like to do for this particular patient?

**CHRIS MALAISRIE:** Tracy, I think you listed all the potential options. I can't think of any other options that the patient would have to decide upon.

**TRACY WONG:** Yeah, let's see what the poll results show. So a little over half want to do a surgical AVR with mechanical valve. I have to say that I agree with that. There is some thought about surgical AVR with brood enlargement and maybe a tissue valve. I think the tissue valve, if we we're going to crack the chest, I probably would not favor a tissue valve given that this is a chest you don't want to get back into again.

**VINOD THOURANI:** Yeah.

**TRACY WONG:** And then TAVI is as an option here. What does the panel think?

**VINOD** Hector? What do you think?

**THOURANI:**

**HECTOR** So I think that these are very difficult patients, and my recommendation from seeing and having many patients, **MICHELENA:** many radiation patients, is that you have to pick the right time for surgery, and you have to try that that surgery is the only one that they have, as best as you can. So if you need to do the aortic and the mitral valve, you're better off doing it in one sitting because a redo operation in these patients is like-- behaves, as Chris was saying before, as a seventh reoperation because all the tissues are extremely scarred and calcified. And I also have to say to my cardiology fellows, colleagues out there, that it is critical in these patients to make sure that before you send them for whatever you're going to send them, look at their aorta. And echo is not very useful for that. You either have to do it by plain old chest X-ray or ideally by CT scan because some of these patients may have a porcelain aorta, which would put you in real trouble because then, the only thing potentially you can do is a TAVR or a more complicated operation with replacement of the aorta and the aortic valve replacement. So these are very tough cases.

**VINOD** Yeah, I 100% agree with that. I think that you've got one shot at this. Mantle radiation is an absolute bear, and **THOURANI:** you have no lines of demarcation within the chest. So I think, Hector, you have one shot.

You have one shot for this patient. You better take it. And it's going to be a very difficult operation because you have to debride a lot of that calcium. But you get one shot at it, and I think that's the appropriate spot is trying to do a mechanical valve once and be done with it.

**TRACY WONG:** Chris, any final words on this case?

**CHRIS** I think this brings up one topic that we should discuss is minimal invasive cardiac surgery. That's what MICS **MALAISRIE:** means for the cardiologist. Usually, these patients come in looking for a TAVI, and they're very disappointed when we tell them you're not an anatomic candidate for TAVI, just too much calcifications, and we take on a huge risk of rupture here. You're going to need open heart surgery. So then if we can offer patients minimally invasive cardiac surgery, either mini sternotomy or mini thoracotomy, I prefer mini thoracotomies. Then all of a sudden, that becomes a little bit easier to swallow for the patient.

**TRACY WONG:** Well, we've got four minutes left. So Hector, I'm going to turn this over to you to kind of give us a little bit of a recap here.

**HECTOR** Yes, and again, you know, I mean, we all speak about prosthesis and biology versus mechanical. And we believe **MICHELENA:** those facts. But what does the real data show?

And there are many studies. Let's go to the next. And I just want to show you a couple of them, you know? First, the two big randomized trials that began a long time ago-- one is the Veterans Affairs, which the follow up-- no, no, that's good.

And this was, of course, bio prosthesis versus mechanical. And you can see that what turned out happening is that actually, survival was better in the mechanical patients. And somebody from a company might tell me that's because they used all bio prosthesis.

I don't know the answer to that. And clearly, of course, there was more bleeding with mechanical prostheses. And that's the final result of that study published in *JACC* in 2000.

Let's go to the next. They also noted that if you're less than 65 years old, the degeneration is quicker. And as you can see, the degeneration in these patients, as we have said, started occurring at eight, nine years, you know? That's where the business begins.

Let's go to next. This is the other Edinburgh randomized trial, which was a much smaller trial and again also showed no difference in thromboembolism or endocarditis between bio and mechanical.

And these were very young patients-- 45-year-old. Again, [INAUDIBLE] operation better with mechanical AVR. Death alone was not better, but death and reoperation was. This is-- yeah.

**TRACY WONG:** Sorry [INAUDIBLE].

**HECTOR** That's OK. [INAUDIBLE]. Please, please, please. And this is just one to show you.

**MICHELENA:**

This is now an observational study with many patients, but it is very appropriately prospectively matched. And you can see that the survival between mechanical and bioprosthesis in 50 to 69-year-old is about the same. Let's go to next. And basically, the difference is reoperation in bio prosthesis and major bleeding in mechanical.

Let's go to next. This is an important one. This is a paper that was published in 2017 in the *New England Journal of Medicine* by Goldstone, 2017.

It's a retrospective study but very well prospectively matched and with inverted weighing and all possible statistical methods to try to make it as clean as possible. And you can see that the probability of death is larger in biologic valve patients, particularly in the 45 to 55 years of age. Let's go to the next.

Not very significant for older patients-- a little difference in the curve there but not enough. Let's go next. And again, very important-- the risk starts to begin or starts to increase when you are about more than 60 years old with bio prostheses. Let's go to the next. Therefore, I mean, I think it is important to recognize that of the 11 or 12 studies that are out there, some of which show equally nobody has shown that bio prosthesis are better in big outcomes, and most of them have shown that mechanicals are better, particularly for the younger people.

**TRACY WONG:** Yeah, and I think Vinod really alluded to this. I'm very excited to be part of this trial. And actually, all of us are. All [INAUDIBLE] faculty are involved in this trial either in the steering committee or as a site.

We think that this will be a big game changer for us because clearly, one of the biggest messages we're hearing from patients is that they don't want a mechanical valve because they don't want warfarin. And so if we're able to show that a drug like apixaban could be as safe as warfarin for these patients, then I think we really will change that very first decision that patients and their surgeons are making, which really changes the landscape of these redo conversations that we've been having a dialogue about tonight and in our practices.

So just a quick reminder-- the PRACT Xa trial is a randomized trial. It will take patients with an On-X valve. These are patients that many of whom are already on a lower INR target with the On-X valve.

But we are randomizing them to best warfarin-- so as FDA required, INR two to three versus apixaban 5 milligrams twice daily. And we are looking for non-inferiority as well as OPC criteria for thromboembolism and for valve thrombosis. We're currently enrolling.

We're at about 300 patients enrolled across 53 sites so far. And we hope to be able to complete this trial. We're trying to get to 1,000 patients and 800 patient years of follow up on each arm.

So stay tuned. And for those of you who might be with us in this trial, thank you so much. We just had a great site investigator meeting today, and we hope to really push up our enrollment now that we're seeing COVID hopefully behind us.

So I think that is our last slide for the night. I hope you've enjoyed these cases. We're a little bit behind 8 o'clock.

I really want to, again, thank Chris, Vinod, Hector for some amazing cases. I think I learned a lot from these cases. I hope you felt like these were instructive and helpful for context as well. I like these kind of case-based discussions where we're really talking about what decisions we're making as we're seeing the patients.