[MUSIC PLAYING]

JEFFREY FOWLER: My name is Jeff Fowler. I'm one of the interventional cardiology faculty here at University of Pittsburgh. I'm the Program Director for the Interventional Cardiology Fellowship Program and the Director of the Cath Lab at VA Pittsburgh Health System here in town as well. So thank you for having me today. My talk is going to be on percutaneous valve treatments in 2023. So I have no disclosures for this talk.

So our outline today-- we're going to talk a little bit about percutaneous aortic valve treatment. I'm not so much going to go over the TAVR platform so much. I think we're all pretty familiar with that. But I do want to focus on what's new in TAVR. Then we'll transition to the mitral valve and talk a little bit about mitral TEER, or Transcatheter Edge-to-Edge Repair, as well as a little bit on TMVR. And then the same thing in the tricuspid space with TEER and tricuspid valve replacement.

So let's start with the TAVR story. The TAVR story is probably a long and storied procedure at this point. Many of the TAVR is, and I've referred many patients to this. All the way back in 2002, Alan Cribier performed the first in-man TAVR. That led to further innovation in this space and expansion of the platform to different risks of patients, initially starting with inoperable and high-risk patients. That was FDA approved in 2014. And then to intermediate risk patients. And then finally, low-risk patients in 2019.

And I'll briefly review the low-risk patients and how that has led into what we think about in 2023 when we think about TAVR, which is not just innovation of the platform and the procedure itself. But the buzzword in TAVR in 2023 is really around lifetime management. And we're going to talk about what that means and how we think about who gets a TAVR device in 2023.

So let's first start with the low-risk trials-- the newest randomized controlled trials within the TAVR space. These are now several years old, both coming out in 2019. The PARTNER 3 trial for the balloon expandable device, and then the Evolut Low Risk trial, which is for the self-expanding device.

And both of these trials, their combined primary endpoint of death, stroke, or rehospitalization showed a significant improvement in the primary outcome with TAVR compared to SAVR, or Surgical Aortic Valve Replacement, even showing some signs of superiority with TAVR. And so this led, as I mentioned, to the FDA approving TAVR in low surgical risk patients as well.

And so I like to show this graphic. It's getting old now, but I'm going to modify this graphic here. We used to think of TAVR really, when it started, in its infancy, in the extreme surgical risk patients based on an STS, or Society of Thoracic Surgeons, risk score for surgery. And then as the CoreValve extreme risk in PARTNER I B transitioned to the CoreValve high risk in PARTNER I A trial, we started to expand TAVR into that high risk. And now we say it is at least equivalent and probably even superior to SAVR in that patient population.

And then as the SURTAVI and PARTNER II A trials came out in the intermediate risk population, and then, finally, as we just mentioned, the Evolut low-risk and PARTNER III trial are really the landmark trials that have expanded TAVR now further and further down that risk assessment to the low-risk patients. And is at least equal, may be in some cases superior, to SAVR in this patient population. And so what we really are focused on now is trying to think about who should get a TAVR, and who should still get a SAVR, and really, what that looks like for the lifetime management of the valve in each individual patient.

So as these trials have come out, it's no surprise that TAVR has actually exceeded SAVR in the number of procedures being performed here in the US. You can see the red line being TAVR has exceeded the light blue line somewhere around 2016, 2017, as these intermediate trials came out. And now low risk has continued to cause that to expand.

This has followed suit with the guidelines. The most updated US guidelines are the 2020 ACC and AHA combined valvular guidelines, and I'll just highlight a couple of these panels here. It is still the case that for high or prohibitive surgical risk patients with a life expectancy of greater than one year that TAVR is the class I indication in these patients. So SAVR is not the class I indication. It's TAVR in these high-risk patients.

And then probably the more important cut-out here is as we look at the different ages of patients, which is a predominant part of their risk score, we can see that if you're over the age of 80, it's a class I indication even in a low or intermediate surgical risk patient to have TAVR as opposed to SAVR, which is only a II A indication. And if you're between the ages of 65 and 80, it's a class I indication to either have SAVR or TAVR, and that's really the population I want to talk a little bit about-- lifetime management in these patients, and how do we decide between TAVR and SAVR.

And then we still think that under the age of 65, SAVR is still probably the better intervention because of the mechanical valve and the durability for somebody who needs several decades of life out of their valve. So that goes to speak to the TAVR valve and trying to understand how durable are these TAVR valves.

So as we start to expand our offering of TAVR valves to low-risk populations, which include patients who could go down to the age of 65 or so, and need them to last, we need to know how durable these valves are, and are they equivalent to at least bioprosthetic surgical valves?

And so there are some challenges in understanding the durability of TAVR valves. One is that these valves keep going through iterations-- structural iterations-- every couple of years to help improve the device. And because of that, the long-term data that we have is not really equivalent to the current generation devices that we have. And so we're lacking some longer term data on our current generation devices.

The other challenge is that the earliest TAVR trials, those extreme and high surgical risk trials, because of that patient population being so high risk with other comorbid conditions, many of those patients have died from noncardiac causes. And so we really don't have long-term durability data on the valve because these patients are no longer with us.

And so the best data that we have was actually just recently released within the last month at the European Society of Cardiology Annual Meeting in Amsterdam. This was a presentation of the NOTION trial, which is the first 10-year data that we have on the original core valve. And you can see the numbers are relatively small as we get 10 years out. But the durability is actually at least reassuring here.

All-cause mortality compared to SAVR is nonstatistically significant. And most importantly, bioprosthetic valve failure on the right-hand panel, again, is nonstatistically significant here. And maybe even some trends here, as we get further out, that the TAVR valve has a little less valve failure than the surgical valves. So I think even though these are small numbers and this is the original core valve, this is still at least encouraging to suggest that the TAVR valves do have reasonable durability as we start to think about placing these in lower risk patients.

And so, as I mentioned, the buzzword now in 2023 surrounding TAVR is really lifetime management. When we place a TAVR valve, this is likely not going to be the only intervention that a patient needs in their lifetime, especially when we're talking about a 65 or 70-year-old.

And so we're no longer talking really about a definitive correction that's a one and done for that patient, but more akin to a palliative approach-- or a palliation in therapies, where we have one therapy that lasts for a period of time, but we need to think about what is the next therapy that they're going to be a candidate for.

And so you can imagine several scenarios here. I've listed a couple. If you have a 70-year-old who's still actively working and wants to stay functional in their job and doesn't want to undergo a major sternotomy and the rehab time of a surgical aortic valve approach, do we do TAVR now? Do we think that maybe they have surgical options in 10 more years or 15 more years when they're in their 80s? That is possible.

What about a 70-year-old who has a large annulus? So we can put a large TAVR valve in. Maybe we could do TAVR now. And then if that fails, do another TAVR, or a TAV in TAV, as we like to say, later on.

Or do we choose in a 70-year-old who's low risk who has both options to start with a surgical valve now, with the hope that when that surgical valve fails and they're in their 80s, they can have a TAVR valve inside of that SAVR valve, and whether that valve is large enough to accommodate that and the other anatomical considerations around that.

Those are the nuanced discussions that we're having right now is the lifetime management of these patients, and not what their first procedure is going to be, but how we do their first procedures so that we are thinking towards what we are going to be able to do in their second procedure.

And if you think about a second procedure, you're certainly older at that point and likely have more comorbid conditions. So if you're going to need surgery at some point, do we do it preferentially when you're in your 70s because you can tolerate it better rather than your 80s? Maybe. That is perhaps a good way to think about these things.

When we start to look at patients who are in their 60s and 70s who have severe aortic stenosis, we're usually talking about a slightly higher proportion of patients who have a different etiology of aortic stenosis than just calcific degenerative aortic stenosis. Maybe we have more bicuspid valves in this population that are failing early. And so that also changes our approach because we know that there are some challenges still with TAVR and bicuspid etiologies.

And so this really takes a comprehensive heart team discussion with, of course, shared decision-making with the patient. And it's a very nuanced discussion. It's not just patient preference, although that certainly does play a role. But we look at certain caveats to the different therapies that we're going to offer.

So anatomical caveats, like small annulus and the size of valve that it will accommodate; a bicuspid etiology; if they have concomitant or maybe only severe aortic regurgitation as the primary pathology of the aortic valve, and how a TAVR valve potentially would see in that.

When we think about their next procedure or their next operation, there's issues surrounding putting a valve inside a valve, whether it's a surgical valve that we put a TAVR inside, or a TAVR valve that we put a second TAVR valve in place. We have to worry about coronary obstruction, the need for anticoagulation. I already mentioned the size of the valve and what we can place inside of it.

You can see on this right panel, we're already developing procedures to try to prevent some of these. This procedure is demonstrating a basicila procedure, where we actually use an electrified wire to slit the leaflet of the prior aortic valve. So when we put another valve in there that those leaflets aren't propped up and block the coronary ostium causing coronary ischemia. And so we're developing both procedures and devices to help to deal with some of these issues on a second procedure that may ensue after the first one comes in.

And then if we put a TAVR valve early, and we have to go to surgery and explant that valve and do a surgical aortic valve replacement, that certainly we know carries a significant mortality/morbidity-- a very big surgery they have to undergo. And so really, TAVR-- the buzzwords in 2023 are around lifetime management, thinking about what the second procedure may hold, what are the anatomical and patient-specific variables or caveats that would make us lean one way or the other.

And so I'd encourage you, as you see these patients in your clinics and are referring them for that discussion, try to be careful about how hardline you take on what therapy they might be best suited for because it really takes a very nuanced discussion and understanding their anatomy and what their options are that we do in our heart valve clinic. And so we're happy to have those discussions. And that's really where our head's focused on in TAVR in 2023.

So let's leave aortic valve behind now and talk-- and transition about-- to the mitral valve. So we like to talk about TAVR and aortic valve disease, and we see that a lot. But I just want to lay out some prevalence data for you here.

If you look at aortic valve disease in the pink line, and then look at mitral valve disease, there's actually a very significant prevalence of mitral valve disease. And so we've had a lot of discussion about TAVR in the past, and we have this great therapy for it. I want to make sure that we're spending a good amount of time talking about what are the valvular interventions that we have that are catheter-based for the mitral valve. You can see as the population ages here, the expectation is that mitral valve disease prevalence is only going to go up from here.

So let's first level-set and talk about what are the types of mitral pathologies that we can treat with catheter-based options. So really, we're talking most significantly about mitral regurgitation. And when we think about MR, or Mitral Regurgitation, there's really two types or two etiologies of MR.

The first one is primary or degenerative MR. This is really mitral regurgitation that's related to the valve itself-- either the leaflets, chordae, papillary muscles that cause that valve to leak significantly. And this can range all the way down from just classic fibroelastic disease, all the way up to Barlow's, where we have multiple prolapsing segments with redundant tissue that causes leaking.

And when we have a valve that has all this redundant tissue and may have a tear in the papillary-- or excuse me-- the chordae that's attached to the papillary muscles, you can see in this echo what it would look like for those leaflets to billow past each other and no longer have a competent plane of coaptation that will seal the valve.

This is an TE image of a mitral valve. And that anterior leaflet is billowing past the posterior leaflet, and you can imagine where the leaking would be coming through there. And we're going to look at some echo pictures here I'll try to orient you to them as we go through, so it can help to understand the pathology that we're talking about.

So that's primary degenerative MR. The other etiology is secondary functional MR. This is not necessarily related to the valve itself, but the surrounding structures, mainly the ventricle that is pulling or tethering the structures of the mitral valve and causing it to leak. So the most common is an ischemic cardiomyopathy, or perhaps a nonischemic cardiomyopathy. We have dilation of the ventricle that pulls on the chordae that then tethers the leaflets causing a coaptation gap and leaking to occur.

As you can see in these echo images up towards the top of the screen, the leaking goes backwards causing mitral regurgitation. We also can see this in something we call atrial functional, which is where it may not be that the ventricle is dilated, but as patients who have chronic atrial fibrillation, the atrium will dilate significantly, which causes dilation of the mitral annulus, and by that same mechanism, stretches the coaptation plane and causes leaking to go.

And so the treatment of choice here is to treat really the problem, which for secondary MR is revascularization-- trying to improve the pump function of the ventricle, guideline-directed medical therapy, cardiac resynchronization therapy to help to improve the function of the ventricle and improve the mitral valve.

So mitral valve disease is a very morbid condition. If left untreated, it will continue to lead to heart failure and then eventually death. The primary fix or primary MR is surgery.

However, of the patients who are referred for surgery, almost quarters of them are not getting valve replacement. Many of these are denied because of the risks associated with surgery. It's a difficult procedure to get through. It's a major open heart procedure. Most patients are elderly. We can see as patients age, their risk for surgery goes up, and the decision not to operate then because of those surgical risks become more significant.

And so you can see when you're into your 70s, over 60% of patients are not being offered mitral valve surgery because of the surgical risk associated, and that's close to 85% when you're in your 80s. And so this field is really just primed for a catheter-based intervention that can treat this disease and minimize the risks and allow patients to then have more fulfilled lives here.

And so the most common one that we talk about is Transcatheter Edge-to-Edge Repair, or TEER. There are currently two FDA approved devices for TEER. On the left-hand side of the screen, you can see the Abbott MitraClip. This is FDA approved for both primary degenerative and secondary functional MR. And then on the right-hand side screen, you see the Edwards Pascal device, which is also a clip-like device that is currently FDA approved for primary degenerative MR.

Now, the whole concept behind the clipping devices or the Transcatheter Edge-to-Edge Repair devices is that you clip the anterior and posterior leaflet together causing a double orifice valve that really mimics the prior surgical repair called an Alfieri stitch on these valves. And by approximating the anterior and posterior edge of the mitral valve, you can reduce the leaking through that valve. And yet, still maintain inflow through those double orifices into the valve.

So let's look a little bit of the story of TEER and then talk about how it's expanding into 2023. So if we go way back to the EVEREST II trial that was released in 2011, which looked at MitraClip compared-- randomized MitraClip and surgery for primary patients. Now, the challenge here was this was really first-generation TEER, and we had some challenges in clipping these valves.

So of the MitraClip patients, 23% of the MitraClip arm continued to have three to four-plus residual MR. And 10 patients were not able to have clips placed at all. And so we had challenges sort of getting surgical-like results with the MitraClip.

So in this trial, clearly surgery was the preferred therapy in these patients to provide more durable with less mitral regurgitation. But what this really helped to establish in the early phase of TEER is the safety profile of MitraClip, that these patients had similar clinical outcomes if you had a good result in reduction of MR, and there was significant safety improvement compared to surgery.

So this did lead the FDA to approve MitraClip in primary MR patients in 2013 for patients who are high risk for surgery. So still, surgery is the-- is still the gold standard repair for primary MR. But if you're high risk for surgery, and you have no option for surgery, then TEER is a good option, and FDA approved this.

And with that approval, we've been able to do a lot of TEER procedures in patients who otherwise had no options. And this has led, as it often does in this space, to innovation in the design and the offering of the MitraClip. And so you can see over the years, we're now on the fourth generation of the MitraClip with multiple different sizes, with improvements and iteration to the clip itself and the grasping mechanism that allows us to maneuver the clip better to grab the leaflets independently.

And so as we move beyond EVEREST II, where we had trouble really with generation-- the first generation of devices of actually getting the clip on, we can move from a standard anterior/posterior grasping. So this is a 3D en face look. We call it the so-called surgeon's view. If you opened the left atrium and look down on the mitral valve, this is what the surgeon view would look like. This is a TE image.

And you can see that clip is right in the middle of the valve approximating the anterior and posterior leaflet. And that was really sort of first-generation clipping ability is all we had. But as we-- now we're in the fourth-generation device, we can really use this device to pinpoint the clip over the pathology. And so in this case, the pathology is all on the right-hand side of the valve, the medial commissure of the valve.

And so there's two clips over there in the medial commissure. So we don't have a double orifice. It's a single orifice valve, but we have clipped right at the pathology. And we can even get so creative and so specific that we can put a clip on both the medial and lateral commissure. And instead of causing a double orifice, we have here a triple orifice valve. And so this fourth-generation device has really expanded our ability to pinpoint the pathology and get surgical-like results in these patients.

And so when we look at the EXPAND G4 registry, which is looking at how we're doing at reducing MR with this fourth-generation device, you can see that we're able to get 91% of patients to 1 plus or less MR. And nearly 96% of patients to less than 2 plus or less MR.

And if you go over to the right-hand side of the screen with the EVEREST II trial, you can see we were really achieving that in only about half the patients or even less. And now, with fourth-generation devices, we're achieving this in nearly 96% of patients. And so really, a marked improvement in these patients and the ability to really pinpoint the device, get surgical-like results. And what we've seen is that with that, we're able to really make a very significant improvement in patients MR and in their quality of life.

And so I want to just take a minute and show you a case of a TEER device in a high-risk patient who wasn't offered surgery. So this is an 86-year-old man who had prior coronary artery bypass grafting. He had some dementia, and he had mitral valve prolapse with severe mitral regurgitation. And despite appropriate medical therapy, he was still having NYHA functional class 3 symptoms.

So let's look briefly at this TEE. I know a lot of you don't look at TEEs every day. So we've seen this top left-hand panel view of the mitral valve. And we can see the color flow that's heading up towards the top of the screen as the mitral regurgitation.

As we move to the top right panel, we can assess the pulmonary veins. And that flow below the orange baseline that we see is reversal of flow in the pulmonary veins, which is indicative of severe mitral regurgitation.

And then we see that 3D picture that I showed you previously. And you can see in this patient that the pathology is predominantly on the right-hand side of the valve, the medial commissure and the posterior leaflet, which is the leaflet that's on the lower side of the screen.

And the bottom right-hand panel shows the color flow coming up towards us from that exact area where we can see that billowing leaflet coming out at us. And so this is a case where we don't want to put the clip right at the middle of the valve, but we do want to target over towards the right-hand side of that valve, or the medial commissure, to get the pathology and stop that leaking.

And so we were able to put two of the NTW clips-- that's one of the smaller but wider sizes of clips. And you can see, that clip now is on the anterior and posterior leaflet. It's holding those leaflets together, thereby decreasing the regurgitation. You can see on the 3D view where we're targeting over on the right-hand side of that valve, and the marked improvement in the leaking that we were able to do.

And so this is really what we're able to do with the mitral clip in an 86-year-old patient with prior heart surgery with dementia, who otherwise would have no other option, no surgical option here. And so really able to provide a really great result with a minimally invasive approach with TEER here.

So we've seen that TEER does a really nice job with primary MR patients. But it's right now only FDA approved for high surgical risk patients. But with this fourth generation, is it time, just like the TAVR story, to start thinking about expanding the offering of TEER to lower surgical risk patients, at least maybe intermediate risk? And then maybe consider low surgical risk patients as a viable alternative to surgical repair?

Well, we're studying that right now. So we are part of the REPAIR MR trial. This is a randomized controlled trial randomizing primary MR patients who are intermediate surgical risk to either surgical repair or the mitral clip. You can see the primary and secondary outcome listed below.

And so the hope is here that we will show that MitraClip is at least as viable, maybe even superior, to surgical repair in intermediate surgical risk patients. And just like the TAVR story, where we moved from high surgical risk down into the lower surgical risk patients for these catheter-based devices, that we can offer this to patients as a good alternative to a major open heart surgery. So stay tuned for that.

We are currently enrolling at this site as well in this trial. And so this is an exciting thing that we can offer our patients here who otherwise would only have a surgical opportunity.

So that's primary MR. Let's switch gears briefly to functional MR. Does TEER work well in secondary functional MR, where the pathology is not necessarily the valve, but the surrounding ventricle and the challenges that it places on the valve?

Well, that was answered in the recently released COAPT trial. So the COAPT trial looked at doing TEER in patients who had severe functional MR and had good guideline-directed and device therapy and still had persistent, symptomatic MR, and putting the TEER device compared to medical therapy alone.

And what we saw here was a very significant improvement in the combined-- the outcomes of all hospitalizations for heart failure on the left. And then even a mortality benefit with all-cause mortality on the right here, with a number needed to treat of just under six to show an improvement in patients.

And so this led to the FDA approval in 2019 to provide TEER for patients who have moderate or severe functional MR after optimal medical and device therapy has been instituted and they still have symptoms. And so we've been doing this now.

And the question is, if the valve isn't the problem, but the ventricle is the problem, and the ventricle continues to deteriorate, is this TEER device going to hold up? And just this past year, the five-year COAPT data was released and showed consistent improvement in the outcomes. You can see on the top are heart failure outcomes. And then on the bottom panels, we see death from any cause. And then a combined death and heart failure hospitalization.

And so the COAPT trial has shown significant benefit even out to five years, and patients are getting significant improvement in their symptoms with this device. So both primary and secondary have wonderful results with TEER, and we're looking to expand this therapy.

So what about the PASCAL device? All of that data so far has been with the MitraClip device, while PASCAL is the newer kid on the block. This was the Edwards developed device, which was meant to compete with the mitral valve. There are a few different iterations to this device that are felt to be improvements to the MitraClip.

Although, as I'd mentioned, the MitraClip has also iterated the device over the years to make improvements to that as well. But PASCAL was studied in the class 2 D randomized controlled trial, which was released in 2022. And they compared primary MR patients to getting either the PASCAL device or the MitraClip and seeing how these two devices compared to each other.

And we've seen this graphic of sorts before, where we look at the reduction in mitral regurgitation. And you can see that both the PASCAL and MitraClip was able to achieve a 2-plus or less MR in high 90% of patients. And it looks like the PASCAL device is at least equivalent to MitraClip in its ability to achieve these great surgical-like outcomes. And this did lead to the FDA approval this year, in January of 2023, to the approval of PASCAL as a second device of choice in primary degenerative-- excuse me-- yeah, primary degenerative MR who are still high risk for surgery.

So before we leave TEER or edge-to-edge repair, I want to just switch gears for just a second and talk about tricuspid valve. Can we use the clipping device in the tricuspid valve and do tricuspid TEER? And the answer is yes. Let me show you some of the data that's currently being studied and out there.

So tricuspid valve is another surgery that has a high morbidity and high mortality associated with it. And because that surgical risk is high, patients are often not offered surgery, even when it's indicated, because of the surgical risk. And this is one of those types of valves where the medical therapy is actually quite limited. Guideline-directed medical therapy towards tricuspid regurgitation is limited to SGLT2 inhibitors and diuretics.

And so as we start to think about could we use the clip device in a similar way that we use it in the mitral valve in the tricuspid valve to improve the leaking and improve patient outcomes. So the tricuspid valve-- you can understand just in the naming of the valve is a more complex anatomy. So the mitral valve has two leaflets, the tricuspid valve by-- right in the name, has tri, or three leaflets associated.

And what we've seen is that of patients who have these leaflets, only half of them have three actual leaflets, and the other half of patients have multiple leaflets-- or multiple scallops and leaflets. They can have a scallop in each of the anterior or posterior or septal leaflets.

And instead of having a trileaflet valve, may have a quadricuspid or quinticuspid valve, which as you start to think about clipping the valve and trying to reduce the leaking, it becomes that much more challenging to place a clip, or multiple clips, to try to reduce that leaking.

And so it's a much more difficult procedure to do, but we have been studying this within the TRILUMINATE study, which is a randomized controlled trial of 450 patients who have symptomatic severe tricuspid regurgitation who are high risk for surgery. And they're randomized to either TriClip or medical therapy, which is really the only therapy available to them with that primary outcome, as you can see.

And this data was actually just released this past spring at the ACC National Conference in Chicago. We can see that the TRILUMINATE study did actually improve its primary outcome, which was predominantly driven by improvement in patient-reported symptoms in the KCCQ score, as you can see there on the far right.

And so currently, the FDA is reviewing this data. We do not currently have an FDA approval for this device at the time. They're still reviewing this data and will make a decision on that. And so right now, we are still able to offer patients tricuspid TEER, but it falls within the TRILUMINATE continued access registry.

And so we're one of the sites that help to randomize patients for this trial and still have the ability to use the TRILUMINATE-- or the TriClip in the continued access registry. And we've been doing that in anticipation that the FDA will approve this device shortly for commercial use.

So we've seen TEER works really well in primary MR, secondary MR. We're even seeing that it's showing a lot of promise in tricuspid regurgitation. So does this mean we just can do TEER for everybody? We're going to start transitioning to TEER for all? Well, not so fast.

There are still a lot of challenges with TEER. As we mentioned, this clipping device, there's complex mitral anatomy or tricuspid anatomy that makes this very difficult. Specifically, if you have a small annulus with high resting gradients or mixed mitral stenosis and regurgitation, if you have thickened leaflets or cord, you have a lot of calcifications, or multiple jets or clefts or large coaptation gaps, you can imagine that the clipping device is that much more difficult to place and to get surgical-like results.

And even if there are challenges in some patients with visualization with our TEE-- Transesophageal Echo-- it may be difficult to get a surgical-like results. And so it still does really require proper patient selection to make sure that we're choosing the correct patients who will benefit most from TEER.

And so what about patients who are high surgical risks and maybe have this complex anatomy that TEER is not the device of choice? And so that leads us to our next transcatheter valve option in the mitral space is TMVR, or Transcatheter Mitral Valve Replacement. And these devices right now are currently under clinical trial. There is no commercially approved or FDA approved device right now.

And so as we study the different devices that are coming out, what we would really like to see in a TMVR device is a device that's agnostic to MR etiology, whether it's primary or secondary, that would perform well in real-world anatomy, especially as we discussed where TEER may struggle to provide adequate results.

And then we'd like it in the least invasive form, which would be a venous transseptal delivery system. And so that means we have to have large enough valve sizes that can be packaged into reasonably sized delivery catheters to deliver to the mitral valve. And so there's really a lot of innovation and a lot of clinical trials going on in this space.

I'll show you just one graphic that shows a handful of devices in this space. And this is not meant to be a comprehensive list of the devices. But what I really just wanted to emphasize is for you guys to see the different designs, the different engineering of the devices that are trying to make sure that we can develop a device that not only is going to fit in the space, so adequate sizes, but will anchor and seal without leaking around it. And so there's a lot of different innovation going on in this space to try to find a device that will work.

And as we have been evaluating these different TMVR devices in real-world anatomy, we're finding that we have to get much better with our planning of these devices, using these great CT-- structural CT images to overlay a virtual valve and see how it interacts with each patient's specific anatomy, where there could be areas of obstruction, or sizing challenges, or other anatomy that gets in the way. And so we're improving on our structural imaging and planning and trying to understand who gets what device and how each device will look in each patient before we get into the implantation process.

Now, with this planning, what we've seen is that a lot of patients have anatomical issues that preclude them from getting a TMVR device. And so the screen failure rate of these randomized controlled trials is actually very high, which is making it difficult to get patients into the trial and evaluate these devices because we're seeing 2/3 or 3/4 of patients who are screen failing out because the device won't fit with their particular anatomy.

And so we have to continue to iterate on the devices, understand how they interact with the other structures, and continue to see how this field will advance.

So I think there's a lot of hope for TMVR. And despite the challenges and the different designs, the engineering, the deliverability, and wide-scale applicability of these devices, there are a lot of patients that stand to benefit here who are high risk for surgery, may not have anatomy amenable to TEER, and really would benefit from a TMVR device.

And so it's on us all to really continue to iterate these devices and to randomize our patients to the clinical trials to evaluate them and understand who will benefit from which device. And I will say that the current generations of devices that are under clinical trial, if you're able to be randomized to a device, they are providing high-quality solutions.

This is just a look at some of the different devices that have been placed and the data that's already out there showing excellent reduction in MR in the 90%-- high 90% range, even out to two years in some of this data with a well-seated TMVR device. And so a lot of hope for the randomized controlled trials coming out.

So I want to show you another little case vignette of a patient that we recently enrolled in one of our TMVR trials here. So this is a 76-year-old male. He had an ischemic cardiomyopathy with an EF of 30% and severe functional MR. He was fully revascularized on good therapy. He continued to have persistent symptoms.

And so we randomized him into the SUMMIT Randomized Clinical Trial with the Abbott Tendyne device. This is a device that's delivered to the apex of the heart. We're able to reposition the device and then tether it to the apex with a apical patch.

You can see his TEE images here showing the valve leakage, the catheter that's going up through the apex to deliver the valve. We extrude this valve out, reposition it under TEE guidance, tether it to the apex. And you can see, he has a wonderful result here with no MR. And so we can see here at the one-year follow-up, he continued to get great results from this.

The tricuspid space is the other space we're looking at developing different devices for tricuspid valve replacement. I won't belabor this point. There's a lot of challenges still with tricuspid valve. There's a lot of devices that are currently under clinical trial similar to the mitral space. So stay tuned here for more going on here.

In conclusion here, there is a lot of innovation going on in the percutaneous valve therapies. There's new devices and technologies that are coming out. They're constantly being iterated.

The pipeline is promising both for TMVR, TTVR, tricuspid TEER. We need to continue to enroll patients in clinical trials. And a lot of challenges still exist in these high-risk patient populations. They really need an evaluation at a comprehensive valve center like ours, where we can talk about lifetime management. We can talk about different devices, and what randomized trials may be available to each patient.

So I'll stop there. I want to thank you for your attention. Please contact me if you have any questions in this space. Thanks