[MUSIC PLAYING]

WILLIAM KATZ: My topic is mitral valve anatomy and echo evaluation of mitral regurgitation. How common is valve disease? Well, it certainly gets more common as patients get older. And if you look at this graph, it's actually about 10% of patients over the age of 75 have mitral valve disease, which actually exceeds aortic stenosis.

And any patient with moderate or severe valve disease has a worse survival compared to those who do not have moderate or severe valve disease. So it's a very important topic. And I'm going to go over the anatomy, the causes, the pathologies of mitral regurgitation, how we quantity mitral regurgitation, and how we can use imaging to choose and guide appropriate therapy.

This is a slide you're probably very familiar with that shows the mitral valve apparatus. The mitral valve is not simply an aortic and a posterior mitral leaflet. It's attached to an annulus. There are chordae. There are papillary muscles. And those are attached to the ventricle. These all work together for proper mitral valve opening and closing. And a problem in one of these areas can lead to mitral regurgitation.

So let's look at the mitral valve as if we're sitting in the left atrium. We can see that there is an anterior mitral leaflet and a posterior mitral leaflet. And these leaflets have been given in some geographic nomenclatures-- the anterior leaflet, A1, A2, A3-- posterior leaflet, P1, P2, P3. And the posterior leaflet actually can have separations that are called slits that would be normal, not really class, although we use that term sometimes. The anterior leaflet should be totally intact. And we have a trigone, a fibrous trigone, and an annulus here.

Looking at the mitral valve in another way from the under surface, we see the chordal attachments. And these chordal attachments come from the papillary muscles. We have an anterolateral and a posterior medial pat muscle. The anterolateral has chords going to A1, A2, P1, P2. And the posterior medial, A2, A3, P2, P3. You can see in the center here is a relatively chordal-free zone. And this gets important for a topic that's going to be covered at the end of my talk and the next speaker where we can take advantage of this, and put a mitral clip, and avoid these chordae to treat mitral regurgitation.

So looking at these chordae from sort of a side profile, coming from the pat muscles, we have primary, secondary, and even tertiary chordae. The primary chordae go to where the leaflets coapt. That coapt area's called the rough zone.

The secondary chordae go to the undersurface of the mitral leaflets. And the tertiary chordae, which actually only go to the posterior mitral valve leaflet, they come directly off the free wall. Why is this important? Well, if you have a lengthened secondary chordae, this can lead to prolapse and billowing. This is our mitral valve prolapse. If we have a rupture of a primary chordae, then that coaptation area is disrupted. And this is what we would call a flail mitral valve.

The mitral valve opening, a normal valve is at least four square centimeters. And again, this is also important in the era of structural interventions, so keep that in mind. So not all mitral regurgitation is the same. We kind of break it down into a primary mitral problem, which is generally a leaflet or chordae abnormality. And this is called degenerative disease. Sometimes there's confusion about what all these things mean, but these are equal. Primary equals degenerative.

Secondary MR is generally from ventricular remodeling, either from ischemic heart disease or some other cardiomyopathy. It's a ventricle problem. You can also throw into this category annular dilatation from things like atrial fibrillation. So this secondary MR is called functional. There's really nothing wrong with the leaflets. It's the ventricle or the annulus, so primary or secondary.

So Dr. Carpentier is a surgeon who is famous for development of mitral repair. He looked at these different pathologies and came up with this classification. Today we're going to focus on his classification of type 2, type 3 where type 2 is basically our primary, our prolapse, our flail leaflets. Type 3 can be broken down to A and B. A is the rheumatic, which I'm not going to talk a lot about. That's chordal shortening. The 3B is the ischemic and the cardiomyopathies, which leads to tethering and poor restrictive leaflet motion for closing.

So echo is, as we all know, fantastic for looking at the structure of the heart and looking at the left ventricle and the mitral leaflets. So here's our Carpentier class, dilated cardiomyopathy, annular dilitation type 1. Type 2 is our prolapse patients, excessive leaflet motion. Here's our rheumatic-- I'm not going to focus on that-- and ischemic where we have tethering of those leaflets.

So echo, besides looking at the mitral leaflets, other very important things is looking at LC size and function, RV function, LA size, pulmonary artery pressures, and, again, the mechanism and severity of a mitral recurge. If the echo transthoracic's not good enough, we have TE to fall back on to.

Now let's go back to these pathologies. Mitral valve prolapse, it's the most common cause of mitral regurgitation in the developed world. And there's really two major types. There's Barlow's disease, and fibroelastic deficiency, and sort of a fusion of the two, but I'm going to focus on Barlow's. What is Barlow's disease? This is excessive exogenous tissue resulting in thick, redundant, billowed leaflets and elongated chordae.

It's generally a bi-leaflet, multi-segmented prolapse problem. It's diagnosed in younger adults and commonly needs surgery in the fourth to fifth decade. Fibroelastic deficiency, this is an abnormality of connective tissue resulting in either localized prolapse, like a single scallop, elongated chordae, or a flail leaflet due to a ruptured chordae. This is a disease of the little-bit-older patient, patients in the sixth decade who have a shorter history of MR, because this can be a very abrupt presentation.

So here we can see some images comparing these two types of mitral valve prolapse. On the left is the Barlow's multi-leaflet prolapse. And TEE with 3D imaging really has been a great way for us to look at all of these scallops all in one image. And this, again, is an example of the multi-leaflet prolapse.

On the right is the fibroelastic disease. This is a flail P2 scallop and characterized very well with the 3D TEE. The secondary, probably the second most common, is the ischemic MR. And this is due to asymmetric tethered leaflets. And I emphasize leaflets, because a lot of times, we think it's just the posterior leaflet, because it's associated with the inferior posterior abnormality. But it's actually also the anterior leaflet, but to a lesser degree. And this leads to a very eccentric posteriorally directed jet.

Looking at this by TEE, we can see a very tethered posterior leaflet. And again, the anterior leaflet's also tethered. And this is shown by this geometric model where the blue represents all of these tethered segments. And this disease ischemic primarily involves the medial portion of the mitral valve where the P2 P3 scallops are.

So talking about mitral regurgitation quantification, this table, I'm going to focus on column 4, which is what is defined as severe mitral regurgitation by our quantitative methods. We have color flow jet, pulmonary vein flow, vena contracta width, EROA-- Effective Regurgant Orifice Area-- regurgant volume, regurgant fraction. So what is considered severe is if you have a central jet that's large, more than eight squared centimeters or more than 40% of the left atrium, or an eccentric jet reaching two pulmonary veins-- pulmonary vein systolic flow reversal, a vena contract more than 0.7, EROA more than 0.4, regurgitant volume more than 60, regurgitant fraction more than 50%.

So these are some things I'm going to go over how we measure and some of their limitations. Importantly, what does mitral regurg do to the left ventricle? Well, early on, the left ventricle loves it. We'll see a hyperdynamic function, but over time, the ventricle is going to start to dilate. And that's in order to maintain forward stroke volume, but at the expense of further dilatation and eventually LV failure. We don't want to get to this point. So echo is very helpful for following LV size over time.

And this slide shows a probability of LV dysfunction after mitral surgery if your LV and systolic diameter starts to reach 50 millimeters. So you don't want to get to this point. It's maybe too late to help the LV to intervene on the mitral valve at this point.

So color Doppler, several characteristics that we look at-- flow convergence, vena contracta, jet area, jet direction. On the left illustrates the flow convergence. We have acceleration of flow as we reach that orifice that's causing the regurge. This flow convergence, we are maybe familiar with the term of PISA radius. This is what we use to get the PISA radius. The vena contracta is a way to try to measure the orifice that's causing the regurge.

And finally, the jet area-- we look at how big is that Doppler signal. Over on the right here, we see mild central regurge. There's not much of a vena contracta. There's not much flow convergence. The central jet-- mild.

Here's a central jet. Most of the left atrium, we can see that there's flow convergence. And you can measure that vena contracta. Over on the right, it's a little bit more tricky, because of an eccentric jet. We can't really use jet area. So we can see that there is flow convergence. We could we could measure a PISA. And you could measure a vena contracta.

So these are the things that we get from the Color Doppler. The vina contracta, more than 0.7, severe-- that can be very tricky to measure accurately. The pulmonary veins-- this is really a strong thing to try to get on the transthoracic. We always do a part of TEE, but we're looking for patterns.

A normal pulmonary venous flow is systolic dominant. As we get more and more mitral rigurge refluxing up into those pulmonary veins, we get less and less systolic forward flow to the point when we have severe, we get reversal. This would be shown as flow below the baseline. So this is a very strong sign of severe mitral regurge, to see the flow reversal and pulmonary veins.

Now, we all have heard a lot about PISA. And it's a way to quantitate regurgitant volume, regurgitant fraction. But there is some very important limitations, though, that we have to keep in mind. First of all, this assumes a whole of systolic, meaning the entire part of systole of regurge. Hemispheric, that it has the shape of a half of a circle. And the orifice is circular.

These things are not always true. You may not know what I'm talking about just yet. But this would be a good one to do PISA on, because it's hemispheric, and it's holosystolic. We can see by the Spectral Doppler. So PISA should work pretty accurately on this kind of a patient.

But not all MR is holoasystolic. For example, mitral valve prolapse may have just late systolic flow. PISA will not be accurate in those mild, mild-to-moderate mitral regurge, because you're assuming it's holosystolic, which in this case, it's not. So you're going to overestimate by PISA or mitral valve prolapse with only late systolic regurge.

Cardiomyopathies with a left bundle may only have early systolic mitral regurge. Again, it's not holosystolic, so we would tend to overestimate MR if we're using PISA. So we've got to keep that in mind. All right, I mentioned that the orifice shape for PISA to be accurate should be circular. If we have a LV short access view on a trans thoracic echo, the primary disease, the MVP patients, they will generally have a circular orifice. So PISA will work as long as it's wholly systolic. So this is good, circular and hemispheric.

The Type twos, the schematic and the cardiomyopathies, though, if you look at the short axis mitral valve, the regurge has this elliptical appearance. And you'll see when I show you some epochal views, it's not hemispheric either. So PISA may not work so well with these secondary MRs. So when we're looking at these MR cases, we've got to keep in mind what's the underlying pathology and what would we expect the MR jets are going to look like.

So here's again an example of mitral valve prolapse. This patient, if you look at the color doppler, you say, oh, that looks like a pretty big jet of MR. But if you look at the spectral doppler, it's really only late systole. So again, this would be a problem for overestimating if you use PISA.

And here is the pulmonary veins, which are clearly systolic dominant. So you can't just go by the color. And you can't always rely on PISA. Pulmonary veins, though, pretty strong. I think I misspoke. This is mitral inflow here. But this would be one to look at the pulmonary veins, for sure.

All right, here's a dilated cardiomyopathy. Now, dilated cardiomyopathies generally will have symmetric tempting or tethering of both the anterior and posterior leaflet. And this generally will lead to a central jet of MR. On the short axis, here again, we have one of these elliptical orifices unlike the primary, which are circular. So this is elliptical.

And now, look at the flow convergence, which we would use for PISA. On the three chamber, it's pretty narrow. But on the two chamber, it's very broad. So this is not a hemispheric. And this would be one that PISA probably would not be very accurate for that because it kind of goes against the principles of what PISA is supposed to be looking at.

All right, so what can we do? If PISA is not going to be accurate, how else can we measure regurgitant volume, regurgitant fraction? There's a couple of different methods I'm just going to mention briefly.

One would be to use what we're used to with aortic stenosis is looking at the LV outflow tract flow, which is simply from the diameter and the pulsed wave doppler. We can calculate flow through the outflow tract. And then we can use a four chamber view to measure the mitral annulus at mid diastole to measure that as a diameter. And then get the mitral pulse wave doppler at the annulus, not at the tips, but at the annulus, same place where you're measuring diameter and measure of the flow through the mitral valve. And then we can subtract mitral flow minus aortic flow would be or regurgitant volume. And then you could also calculate regurgitant fraction.

So this seems like a great technique, very hard to do accurately, though. You've got to make sure you're measuring the mitral annulus and the outflow tract diameters very accurately, or you're going to get a lot of error because these numbers get squared. But it is a method.

Another method would be instead of measuring the flow across the mitral valve, would be simply measuring with biplane Simpson's, the LV volumes and the stroke volume from the LV volumes. So that would be your forward flow. And then you subtract from that-- well, this would be the flow that the ventricle is creating, either back to the left atrium, or across the aortic valve. Then you subtract the flow across the outflow tract.

So this is legitimate. It takes some time. It's not always easy. Probably if you're doing 3D echo, which most of us don't, this could be very accurate.

All right, so putting this all together, what should you be looking for to say that there's severe mitral regurge? This is from the guidelines looking at chronic mitral regurge. In this box here, not sure anyone can read it. But we're looking for, of these six criteria, at least four to say that it's severe MR.

And I'll just read it. Flail leaflet, being a contract of more than 0.7, PISA radius more than one with an Nyquist limit 30 to 40, central large jet more than 50%, pulmonary vein systolic flow reversal, enlarged LV with normal function. So these are things that we routinely get. And if you have four, then, OK, severe MR.

If you don't have four, what can you do? You can do some of these quantitative methods to calculate the regurgitant volume, regurgitant fraction. If none of that seems to help, we have other methods, which would be to do TEE to try to get the same information or cardiac MRI, which is very accurate for measuring mitro regurge.

So for TEE, besides all the things that I've just mentioned, with the 3D technology, which is really just tremendous, we could actually look at the vena contracta and measure it. Here's primary. So this is circular.

So you measure that circular color doppler jet right where the regurge is, or secondary, again, we expect that it's going to be somewhat elliptical. You can also trace that area and come up with the EROA. OK, so this can be very accurate. It takes a little bit of learning how to do it. But it's another method for EROA.

And here is a brief summary of what MRI does. Basically looks at LV volumes, stroke volume, and looks at the flow across the aortic valve. So it sounds very similar to what we do in echo. This is very accurate.

Finally, another thing that can be done when you're not quite sure would be a stress echo. And that would be to look at the EROA with exercise. This is not easy to do. We generally try to do it, if we do it at all, with a bike echo. But the main thing we look at is, does the pulmonary artery pressures go up? Because as you have more severe mitral regurge, PA pressures will rise at rest even and even more so with exercise.

And here is just an example of how the ERO increased with exercise. So again, MR is not such a good thing to have. Fortunately, Carpentier pioneered mitral repair surgery. And he has this quote, "Understanding the anatomy and pathology of the mitral valve, along with excellent surgical exposure of the mitral valve by using large incisions in patients to patient's chest while to visualize the heart. This is key to successful repair." Well, back when he started doing this, all we had was m mode. And big incisions, who's going to volunteer for that? Not these days. So we've come a long way, imaging and surgical techniques.

My next couple of slides basically look at the algorithm for primary and secondary MR, what do you do? Well, primary MR, thanks to Dr. Carpentier and others, can generally be repaired. If you look at the guidelines, it's repair, repair, repair, repair. They can fix the leaflets. They can fix the corday.

Secondary MR, there was a push to also do repairs for secondary MR, doing the angioplasty rings, along with bypass surgery. Recent studies, though, came out last couple of years that show the mortality and the recurrence of MR with doing mitral repair for the functionals actually doesn't work out so well.

OK, so for primary, the MVPs, repair. Not everyone's a candidate for repair. Thank goodness the mitral clip came out and showed that patients who get the mitral clip actually do really well.

What about the functionals, the ischemics? Well, there is a very important trial, the co-ap trial that compared mitral clip with goal directed medical therapy versus goal directed medical therapy. And this is really impressive. The study looked at patients with grade three and four mitral regurge. And by the follow up, 24 month follow up, I can't see it so well. All the mitral clip patients were down to grade one and two. And the goal directed medical therapy, there was actually some improvement. But very impressive results with the clip.

And bottom line is bottom line. Look at mortality, a huge separation over 24 months between those patients who got the clip and goal directed medical therapy, which also includes CRT versus just goal directed medical therapy. So now, we have an option for the functional patients for mitral clip as well as for the primaries who are not surgical candidates.

So what I want to finish up with real quick here is we get a lot of referrals now for mitral clip. And I want to just put a little plug in to everybody here who does echoes and reads echoes. And by the way, in the back, there some guidelines from the American Society of Echo, real nice here that Abbott has several of these if anyone wants to pick these up.

So what we need to look at is the color doppler flow characteristics from a good parasternal long axis, the LV size, the short axis. So we can get that mitral valve area. We need to start with more than four squared centimeters. We need to see where the jets come in through those leaflets. Is it circular? Is it eccentric?

From the fourt chamber views and the other epochal views, everyone should try to make an attempt at at least measuring the PISA radius, showing us the duration of the MR, getting the pulmonary veins. OK, TEEs, we get a lot of TEES sent to us. And what's really helpful for us is this kind of long access view, like 120, 130. We call this the grasping view So this is really helpful for seeing where we're going to try to put those clips. Remember that cordal free zone between A2P2. This is what we're looking at for most of our patients.

The 3D, extremely valuable. We can look at all the scallops. We can see where the regurge is coming from. We can measure the mitral valve area this way as well and do all the other quantitation. The bicommissural view, this is also a very important view for us. So I know I went through this real fast. But Abbott has these guidelines and also some other things about mitral clip that emphasizes these very important views.

So hopefully, I've built up a lot of enthusiasm for mitral clip. But you know what? Not everyone is a candidate. For example, this was actually somebody we just did this week. But interest of time, we see so much mitral annular calcification. This a patient who clearly has a lot of mitral regurge, tons or mitral annular calcification. The valve area is only 39. The main gradient is nine. We need less than six to do a clip.

So what do we do? So we're going to hear from Dr. Smith what do we do. To summarize-- no pressure, Conrad, no pressure. Imaging has become highly accurate for defining the mitral path to anatomy. Accurate connotation of MR severity is necessary to identify patients who need intervention. Degenerative patients should primarily go for repair. Functional MR, replace. And this will provide best outcomes with surgical correction. Advances in percutaneous techniques in combination with real time imaging allows for targeted repair of the mitral valve in selected patients who are not candidates for surgery. Thank you for your attention.

[APPLAUSE]