Endovascular Repair of Thoracoabdominal Aortic Aneurysm

Announcer: Welcome to the Mayo Clinic Cardiovascular Continuing Medical Education podcast. Join us each week to discuss the most pressing topics in cardiology and gain valuable insights that can be directly applied to your practice.

Dr. Bell - Welcome everyone again to another in our series of interviews with the experts. I'm Malcolm Bell, and today we are going to be talking about the endovascular repair of thoracoabdominal aortic aneurysms. And my guest today is Dr. Bernardo Mendes, who's a consultant in vascular surgery and endovascular surgery here at Mayo Clinic Rochester. He's also an Associate Professor of surgery and is the Associate Program Director for their fellowship training program and residency. So Bernardo, thank you so much for joining us today.

Dr. Mendes - Thank you very much Dr. Bell. Thank you for the opportunity to be here and for the invitation. It's a pleasure.

Dr. Bell - Yeah. So maybe we'll just start with just a general question, perhaps. Maybe just give our listeners a sense of how much endovascular repair of these aneurysms has taken over from open repair in the last, you know, one to decades.

Dr. Mendes - Certainly. I would say that this is really something that is, something that continues to evolve, but it has been really the primary modality of treatment for, particularly, for thoracoabdominal aortic aneurysms here at Mayo Clinic and in many of the leading institutions in the country and even more substantially, I would say, outside of the United States. For instance, in European countries or in South America, most of these aneurysms are repaired endovascularly. As you know, the endovascular revolution for aortic aneurysm treatments started in the infrarenal aorta, then progressed to the thoracic aorta. That's in the 1990s, early 2000s. And it's really taking over the paravisceral segment of the aorta and including the thoracoabdominal aorta over the last 15 years. And now finally reaching the, what we call, the final frontier, which is obviously the aortic arch. So I would say that here at Mayo Clinic, probably about 80% of the aneurysms that we fix currently are performed endovascularly, and that includes all types of aneurysms from the subclavian artery to the common iliac arteries.

Dr. Bell - So there's clearly been lots of advances, and maybe you, perhaps you just give us a sense of what have been those advances that have made this possible to, you know, I mean almost replace open repair in these, and, maybe, as you answer that, maybe just make a distinction, if needed, between elective versus emergency repair.

Dr. Mendes - Absolutely. That's is a great question. I would say that the advances, and this is one of the very, one of the very exciting points of being part of this practice, is that we, we not only see but we participate in the evolution of the techniques, the understanding of how these patients do. What is the best repair for them and everything that comes with it? But I would say that the

majority of our advances over the last 15 to 20 years, thanks to several of our pioneers, include advances in preoperative imaging and the way that we plan these procedures. And I will develop on that in a second, intraoperative techniques, of course. As we continue to learn how to do these operations, they're becoming more and more streamlined, more and more straightforward, quicker, faster, and, therefore, translating into better outcomes. And imaging technology, preoperatively, meaning the type of imaging that we have access to in the operating room has changed completely how we do it, and the protocols for postoperative care. So I would say going back in preoperative imaging and planning, we now have different options for devices, whereas in the past we kind of had to make it up in a way, the way that we would incorporate these visceral vessels. Nowadays we know that we can use fenestrations, branches, which are different ways of incorporating those visceral vessels. And we know that certain anatomies, and I don't think we need to go into a comprehensive description of which anatomy is benefiting from which device designs, but we know that certain anatomies benefit more from a fenestrated stent graft, whereas other ones will benefit more from a branched stent graft.

Dr. Bell - So maybe just before you go on, because some of our listeners may not be familiar with some of these terms. So when you talk about fenestrated grafts, and obviously we we're talking about protecting side branches, but..

Dr. Mendes - Right.

Dr. Bell - But can you maybe sort of make that distinction between the fenestrated and these branched stents?

Dr. Mendes - Absolutely. So we have to think about if you have a repair that is incorporating from the thoracic aorta and into the abdominal aorta. So think about a thoracic stent graft, a TEVAR graft, is basically a tube with a metal structure, which is the stent and the graft, which is the fabric structure that will cover effectively that aneurysm. Same thing for an infrarenal EVAR stent graft, except it's a bifurcated device that, like I tell my patients, looks like a pair of pins. If you think about a thoricoabdominal repair in which you have to start up in the chest and go across the paravisceral segment, you have to incorporate those visceral vessels into the repair in a way that the blood will flow inside these stents and stent grafts and no longer flow in the aneurysm unless there are endoleaks of course. But the objective is for the blood to flow only inside these stent grafts, including the visceral vessels. So to incorporate these visceral vessels, originally, it all started with fenestrations, which are basically small holes in the graft that are reinforced by a metal ring in general. They're different designs on that, but it's reinforced with a metal ring. And that can be either custom-made manufacture, patient-specific by an industry manufacturer, meaning it can be performed, done by Cook Medical in Australia. They will analyze the anatomy that you send to them, you will make the measurements, and they will make the stent for you. Or you can actually make a device. You can do what we call physician-modified stent graft in which you make those fenestrations and reinforce with a metal ring. Those are ideal for patients that have, let's say, a parallel aorta at the level of the paravisceral segment. More for juxtarenals or perineal aneurysms, in which you don't have a very wide aneurysm gap at the level of the visceral vessels. Branches are essentially little cuffs that are

sewn into the main stent graft. Again, they can be custom-made and patient-specific manufacturer devices, but can also be devices that are made by the surgeon or physician-modified stent grafts, or there is yet another category, which are called the off-the-shelf stent grafts, which would be a quote unquote one-size-fits-all type of graft. They have four branches that are standardized based on a relative predictability of the anatomy of these patients. The branches are usually, with few exceptions, they're usually downgoing in these branch devices, and they have something between 16 and 18 millimeters in length. And the objective is that you are going to put a stent that will anchor in this branch instead of anchoring in that reinforced fenestration and go into your visceral vessels that you are trying to incorporate in the repair. And these are all, this is all technology, again, that has been developed over the last 15 to 20 years and continues to evolve and progress. So certainly that is one of the main contributors to this being more and more utilized in our outcomes improving.

Dr. Bell - And you emphasize the importance of imaging in your pre-procedure and planning. And I don't think we need to go into the details of that, but obviously that plays a major role here, and in terms of sizing and your technique. Is there a distinction between those patients who have thoracoabdominal aneurysms that are degenerative versus syndromic or genetically-mediated? Endovascular repair is still useful in the non-generative population or not?

Dr. Mendes - That's an excellent question and also something that is becoming more and more fluid over the last few years. I would say that, in general, as, uh, I would say as a general guideline, we still recommend that patients with connective tissue disorders, genetically-triggered aortic diseases is a better term, like you mentioned, such as Loeys-Dietz, Ehlers-Danlos, Marfan's, ACTA2 mutation, etc. Those patients in general are still better served with an open repair. However, however, there are exceptions that we have been slowly venturing into, into these exceptions with endovascular techniques. The exceptions are in patients who have primarily a prosthetic proximal landing zone, such as a previous elephant trunk graft or a frozen elephant trunk graft, or a Marfan's patient who had a thoracic, open thoracic aneurysm repair, has a Dacron graft in the thoracic aorta, and now has a degeneration of the paravisceral segment of the aorta. Those are the patients that will be primarily, that would primarily benefit from an endovascular solution, because the risk of retrograde dissection, which will be the main concern for a patient who has a native thoracic or thoracoabdominal or arch aorta, that risk is much decreased in general or eliminated if there is significant coverage of that aorta by a previous graft. We understand that we have to use different techniques, different wires, different wire manipulation principles when we're dealing with these patients. Access is a big issue as well. Most of these patients are going to end up having a surgical access instead of a percutaneous access. The experience is still very limited. Probably here at Mayo Clinic we have treated, I would say by now, something between 5 and 10 patients with our combined experience, my predecessor, Dr. Oderich and myself, 5 to 10 patients that we performed a fenestrated or branched repair in a patient with a connective tissue disorder. All of them within these exceptions that I mentioned, and probably the global experiences in the one to 200 cases at the most. We know that they will have more complications, they will have more target-vessel-related endoleaks, but for those patients in which you are trying to avoid second, third, fourth time redo operations, as long as you have an anatomy that is compatible like I mentioned, it is acceptable. Although that is not the gold standard. So I am not promoting that.

Dr. Bell - Sure.

Dr. Mendes - But I am saying that, yes, there will be an increasing role for that.

Dr. Bell - So let's get back to the, maybe the bigger population, those who had degenerative disease and undergoing repair. I'm assuming that today we would accept that the morbidity and mortality associated with those procedures is an improvement on that we've seen in the open repairs. And, so, with that in mind, what's the durability then of these devices just in terms of, you know, long-term outcome, what late complications? I don't think we need to go into all the detail of those complications, but what's the frequency that we see in those?

Dr. Mendes - Absolutely. You're touching on the, really this is the key point about the, it is the key point about the comparison between open and endovascular repair of essentially any aneurysm. I would say that, without a doubt, your first comment of decreasing the perioperative morbidity and mortality has been accomplished with endovascular repair. In the right hands nowadays we have mortality that would vary between 0.5 and 2% of thoracoabdominal aneurysm repair, compared to 5 to 7% with open repair in a much older and sicker population for the endovascular group. Our major adverse events, including myocardial infarction, need for respiratory failure and need for the ventilator for over 72 hours, spinal cord ischemia, which is obviously the main concern, combined with mortality and acute kidney injury going on dialysis has been around the 15 to 20%, again, in our hands and in the hands of most of the experienced operators out there. And these are all, these will be probably in the order of 40 to 50% with the open repair series. So there is no question that on the perioperative period, we have surpassed that and that's the new benchmark for comparison. The long-term durability remains an issue and we will be always the, I would say, the Achilles heel of the technique. So about 30 to 40% of these patients will develop an endoleak. Either they will have an endoleak, there will be a primary endoleak immediately postoperatively that you will follow and continue to see with the follow-up imaging, or they will develop endoleaks down the road. Now these endoleaks have several different types, and I don't think we need to go into all those types of endoleaks, but there are certain types in which a re-intervention is almost mandatory and very, very much recommended, because those are high-pressure endoleaks that will cause the aneurysm to continue to expand and potentially rupture. This leads to re-interventions of course, and the number of re-interventions within three to five years, which is really the most of our series are within the three to five year long-term outcome, which is still not as much as we have with open surgery, given the open surgery has been the time-honored treatment since the 1970s. But that's about the 30%, I would say, at 25 to 30% of patients will require re-interventions. The main outcome that we want to avoid, of course, is aortic-related mortality. A patient that dies of a aneurysm rupture after the aneurysm has been repaired, for instance, or a patient who died of an aneurysm-related death in the perioperative period. That number is in the three to four percent of the population. So ultimately, ultimately still probably the curves, there are no direct comparisons with thoracoabdominal aneurysms, but probably the curves would continue to converge with time. So for those patients who have quite a bit of longevity, of course, in which some of them, we include the ones with the genetically-triggered diseases. It's very logical that

the curves will eventually converge. There are more and more, there is more and more research now to try to improve and try to optimize this durability, stent graft design, what type of stent we're gonna use as a bridge for the visceral vessels. What is really the ideal follow-up regimen? How often should we see these patients? Is it every six months? Is it every year? All of those things are kind of open, which is a very fertile soil for research, thankfully. But I think the durability overall has been improving. We have, our understanding of it has been improving, but it's certainly not as good as it will be eventually.

Dr. Bell - I mean, I think it's really important for people to understand that and thanks for outlining that, but I sense that you, we can expect to see advancements and improvements in the future. And so maybe just to finish up here, you know, just maybe just got a minute here. You mentioned, you know, the arch, the aortic arch, and I'm assuming that's where, sort of, a lot of the challenges remain. And I think for the purpose of this discussion, we're not talking about the the ascending aorta at the moment. That's very much a sort of open repair, at least for today. But maybe could you just give us a very brief glimpse of what's happening in terms of repairs involving the aortic arch? And obviously we talk about the great vessel protection.

Dr. Mendes - Absolutely. So the aortic arch is really what we call the our final frontier. Perhaps the final frontier will be the valve and the ascending and the coronaries of course, but the arch, the experience is increasing, particularly in Europe where they have access to all these devices, because there are still a number of the arch devices, the devices that are, that are designed for a total endovascular arch repair is still not available, widely available, in the United States. They're available through some investigational device exemption protocols. But in Europe, this experience is increasing with some of the most experienced operators, which I had the pleasure to visit in the last few years, have over 150 of those operations, total arch repairs, each of them. So it's really growing. What we have in the United States, first of all talking about devices, what we have approved in the United States currently, is a single retrograde branch device by WL Gore called the Thoracic Branch Endograft, which is designed and approved specifically for zone two repair. Mainly a repair that starts at the level of the left carotid artery, left common carotid artery, and has a retrograde branch for the left subclavian artery, in order to perform a repair of the zone two of the aorta without having to perform any cervical debranching, meaning carotid-subclavian bypass. The results of that device have been encouraging. It has been FDA approved. We are using it frequently. We're expanding its indications, using it for other pathology, not only aneurysm, but dissection, a few coarctation cases here at Mayo Clinic, but that's off IFU. And then if you keep going proximally in the arch, you start to run into a little bit more challenge of course, because you have to incorporate additional vessels. They nominate, the left common carotid artery, therefore the risk of stroke increases, the risk of retrograde dissection, which I mentioned before, it's present. So the ideal patient, the ideal patient, is a patient who has an ascending prosthetic graft. They had the replacement for any reason, either a dissection or an ascending, a root replacement for any aneurysm, you need to have a, in whom you have a proximal landing zone for that stent graft to incorporate the supra-aortic trunks. Other challenges include the mechanical valves, patients who have a mechanical valve, you usually would have to cross that with the wire and potentially even with a nose cone of a device, which can be very traumatic, and in general is an exclusion criteria for these cases. And everything in the arch is a little different. The morphology of the arch is different. The motility of the arch is

different, the dynamic forces and the pressure in there is very different. So I think we still have a lot to learn for arches. I think those cases are very stressed. Every time I have a case that I'm getting closer to the, closer to the, the closer I get to the aortic valve, of course, the more nerve-racking the case is, the risk of stroke obviously goes up quite a bit. And we have to remember that the results of open repair, frozen elephant trunk, total arch repair, are excellent in the right hands. So really this technology will need to improve a lot and our experience needs to increase tremendously for us to hit that benchmark, so that we can start to compare ourselves. But I think it's a matter of time. It will continue to improve, and eventually institutions like Mayo and others will have to have expertise in both open and endovascular, so that we can really use whichever is the best option for each patient, because there will be always a role for open surgery. And that's the same for thoracoabdominal aneurysms.

Dr. Bell - Well, I think we should probably stop here. Just to remind our listeners, you're listening to Dr. Mendes, a vascular and endovascular surgeon here at Mayo. This is a very complex area and you're giving us, I think, a real sense for how complicated it is in the arch, as you're getting closer, closer to the aortic valve, as you said. And I think I would really like to have you back on the program and we can maybe just, you know, talk about that in more detail. That is exciting to hear that you're getting closer and closer to that. So I very much appreciate you spending the time with us today, Bernardo, and, as I said, love to have you on the program again in the future to expand on some of the things we brought up today. And maybe even just talk about, you know, the open versus endovascular approaches, particularly in those emergency cases in selected patients. So thank you so much and thank all of our listeners today for joining us.

Dr. Mendes - Absolutely. Thank you very much, Dr. Bell. It was a pleasure and I look forward to coming back.