4-18-2024

How We Heal Little Hearts: The Piccolo Procedure Explained

Rania Habib

Toby A. Rockefeller

How We Heal Little Hearts: The Piccolo Procedure Explained

The Piccolo device is an innovative and minimally invasive way to close the Patent ductus arteriosus (PDA) in pediatrics. Dr. Rockefeller talks about how the Piccolo came to fruition, the benefits, and what else is on the horizon for the PDA closure world.

Featured Speaker:

Toby Rockefeller, MD

Dr. Toby Rockefeller is a board-certified pediatric cardiologist at Children's Mercy Kansas City with more than seven years of experience. He specializes in interventional pediatric cardiology with an interest in device trials and a focus on incorporating new technologies into mainstream standard of care. He is also board-certified in adult congenital heart disease (ACHD) and has an ACHD clinic at KU Medical Center. As a former Program director for Washington University's Pediatric Cardiology Fellowship program, Dr. Rockefeller has interests in teaching, subspecialty training, and institutional leadership. He received his medical degree from the University of Oklahoma College of Medicine and completed both his residency and fellowship training at Washington University School of Medicine/St. Louis Children's Hospital.

Transcription:
How We Heal Little Hearts: The Piccolo Procedure Explained

Rania Habib, MD, DDS (Host): According to the National Institutes of Health, the patent ductus arteriosus, also known as the PDA, is one of the most common congenital heart defects, accounting for 5 to 10 percent of all congenital heart disease found in full term infants. This is Transformational Pediatrics with Children's Mercy Kansas City.

I'm your host, Dr. Rania Habib. Joining me today is Dr. Toby Rockefeller, an Interventional Pediatric Cardiologist who serves as the Medical Director of the Single Ventricle Clinic. The Piccolo device is an innovative and minimally invasive way to close the patent ductus arteriosus in pediatric patients.

In this episode, Dr. Rockefeller discusses how the Piccolo came to fruition, the benefits, and what else is on the horizon for the PDA closure world. Welcome to the podcast, Dr. Rockefeller. We are so honored to have you with us today.

Toby Rockefeller, MD: Thank you. I appreciate the invitation.

Host: So let's begin with a refresher. What is the ductus arteriosus and what are the effects of a patent PDA on an infant?

Toby Rockefeller, MD: Yeah, so PDA just stands for Patent Ductus Arteriosus, which comes from the Latin roots for the words open pathway between arteries. So the PDA or the ductus arteriosus is a pathway or a connection between the pulmonary artery and the aorta. And the PDA is extremely important during fetal circulation while babies are developing inside mom. And the ductus arteriosus allows blood flow to go from the pulmonary artery to the aorta, down to the placenta. Because while babies are in the womb, their lungs aren't fully aerated, there is not much blood flow through the lungs. So everything that's ejected from the right ventricle, into the pulmonary artery; it has to go somewhere, so it goes across the ductus, down the aorta, to the placenta.

And then after babies are born, the umbilical cord is clamped, they take their first breath, the oxygen concentration in their arterial blood goes way up, and with the clamping of the cord, the circulating prostaglandins that keep the PDA open, those are all taken out of the circulation, and the increased oxygen content causes basically vasoconstriction inside the PDA.

Host: Hmm.

Toby Rockefeller, MD: And so that PDA should go away within 12 to 24 hours of birth. Pretty awesome how quickly that thing clamps down for most babies, but it can stay open. And if it stays open, we just say it's patent ductus arteriosus or PDA. The PDA, you know, if it's open, sometimes it's open but it's really small and it does eventually close on its own.

Host: Mm hmm.

Toby Rockefeller, MD: For other kids, it's really large and it stays open and poses some problems to their circulation. But for most babies, it closes within 12 to 24 hours. And the longer it's functionally closed, it does eventually turn into what we call anatomic closure.

Host: Okay.

Toby Rockefeller, MD: Where the internal lamina of that duct actually necrosis and is replaced with fibrotic kind of ligamentum tissue, and it becomes the ligamentum arteriosum. So there's always a physical connection between pulmonary artery and aorta, but it's not patent. It's not actually allowing blood flow through there.

Host: And so when we have a patent PDA, what are some of the main effects that we would see on the infant?

Toby Rockefeller, MD: Yeah, so in the womb, the flow through the ductus should be from the pulmonary artery to the aorta.

Host: Mm

Toby Rockefeller, MD: After birth, it depends on the gestational age of the baby, but if these are term babies, the pulmonary vascular resistance drops as the lungs are inflated and oxygen is in those alveolar spaces, the pulmonary resistance drops and now it's much easier for blood to go the other direction.

So from the aorta into the pulmonary artery and into the lungs. And so, when we see these PDAs, it depends on the size of the duct and the pulmonary vascular resistance, how much blood actually flows through the duct. And so I always talk to our fellows, the things that determine the amount of shunting or the amount of blood flow through the PDA,

is the size of the duct itself and then the downstream vascular resistance. So if you have normal pulmonary vascular resistance, it's going to be really easy for blood to go from aorta into pulmonary artery. And what that causes for the circulation is just an inefficiency. It's basically a short circuit.

Sometimes I'll use the analogy with these families to try to understand how the circulation can be inefficient. I say just imagine your air conditioner is trying to maintain a certain temperature, and it can do that, no problem, but then someone goes and opens the front door, and now your system is inefficient, and so the air conditioning has to work really, really hard to maintain the temperature you want.

But what if they open both doors and all the windows? Now the air conditioning is working really hard and it can't actually achieve the temperature you want. And so your circulation is, or your air conditioning is really inefficient. And the analogy is for the circulation in the PDA; when the circulation is that inefficient, babies have symptoms similar to heart failure.

And so those are the things we're looking out for in babies that have a PDA, do they have symptoms of heart failure? Is their air conditioning, so to speak, working too hard? Is their heart working too hard to maintain what their body needs?

Host: Thank you for that analogy. It was actually really easy to follow along. So when a PDA is suspected, what is the workup?

Toby Rockefeller, MD: Yeah, so PDAs are suspected more frequently in premature babies. So premature babies have a much, much higher incidence of PDA. Some papers would say, you know, if your birth weight is under 1200 grams or your gestational age is under 26 weeks gestation, you have an 80 percent chance of having a PDA. And so, for premature babies, we almost assume they have a PDA, but for older kids that you suspect a PDA, you know, you start this workup by really first thing we like to do as cardiologists is get an echo, you know, just say, do you have it or do you not?

The availability for echo has gone way up over the years, and so it's actually pretty easy to get echocardiograms in these newborn babies. And if the echo shows the PDA, then there's the answer. We often will get a, an echo, we see the PDA and we're still left with the question, is this hemodynamically significant?

Like, is it actually causing circulatory inefficiencies bad enough to warrant an intervention. And so after the echo makes the diagnosis, then we get other information to decide, you know, how bad is it? So one of the first things we do and often have done before the echo is getting chest x rays. The PDA allows blood to go from the aorta into the lungs. And this is blood that just came from the lungs. So the lungs are accommodating a lot of extra blood flow. And because of that, they're prone to pulmonary edema. So we get these chest x rays and sometimes you'll see pretty significant airspace opacities, pulmonary edema type patterns. In premature babies, you're like, well, they have premature lung disease, but they also have a component of congestion or pulmonary edema. Sometimes we will get blood levels of BNP. So the NT pro BNP something that goes up in volume loaded hearts that can help out. But the chest x ray is the primary indicator for how much pulmonary blood flow they have.

Then we look at secondary data. So if you have a really inefficient circulation and you have pulmonary edema, then what happens? These kids are really tachycardic. They are really tachypneic. They're breathing really hard and fast and they're not growing well. They're burning all their calories just sustaining the basic functions of life. They don't have enough calories left over to pack on the weight.

Host: Right.

Toby Rockefeller, MD: So when you have the secondary symptoms or the evidence of heart failure or circulatory inefficiency then that kind of tells us it's hemodynamically significant.

Host: So once we've determined that the infant now needs intervention, what are the treatment options for a PDA in an infant Dr. Rockefeller?

Toby Rockefeller, MD: Yeah. So for these babies that we think have hemodynamically significant PDA, the first thing we try is a medical treatment. Indomethacin, ibuprofen, and now Tylenol are all in the group of medicines that we try in the first two weeks of life to close the PDA and to stimulate the vascular constriction inside the duct to try to promote the natural closure.

But if that fails to work or the baby can't receive the medicine, either due to bleeding problems or kidney problems, then we're stuck considering an interventional technique. And historically, these were closed by surgeons. And surgical ligation was certainly done successfully for years and years, but the newer technology has allowed these devices to get much smaller.

And the first PDA closure in the cath lab happened way back in the 1960s, but it was in a, an adult. And so things have gotten smaller and smaller and smaller to the point that we are now able to close PDAs in the cath lab just accessing the femoral vein. And getting up and closing it with a device in the cath lab in babies all the way down, I think the case report of the smallest one is around 500 gram baby. So things have been shrunk down immensely. And so this less invasive technique in the cath lab has become our first line treatment in kids that either can't get medical treatment or failed medical treatment.

Host: I love the fact that, you know, you have all these different options based on the severity of the PDA and how healthy the infant is. The Piccolo device is unique in the fact that it was specifically designed for use in pediatrics. What is the Piccolo device?

Toby Rockefeller, MD: Yeah. So the Piccolo device has an interesting story, you know, it started its life as the Amplatzer ductal occluder type 2 additional size. So you know Amplatzer is actually the last name of the guy that invented the original catheter delivered ASD devices, Kurt Amplatzer, he was actually a radiologist by training and he invented these devices that can be placed in the cath lab.

And it really revolutionized what we were able to do in the cath lab. And so, they made PDA occluders, but they were used in older, bigger kids. Then they used a type 2 occluder, which was supposed to close different size or morphology of PDAs. But everyone thought, we really need additional sizes that would be more suitable for little babies.

And so they started making these additional sizes, and they were first being used in Europe and in Asia. And Evan Zahn, who's an interventional cardiologist out in Cedars Sinai in California, was on a trip, a medical trip in Taiwan, I think, or Thailand, and saw this device and was like, we need to use this in the U.S. for premature PDAs. And so then there was some pressure put on the company, on Abbott, to actually do a device trial in the U.S. to get this device available for premature babies here in the United States.

Host: And how did the Piccolo device come to fruition? Because I've heard it has a very interesting story.

Toby Rockefeller, MD: Yeah, And so once they started putting pressure on Abbott to bring it to the United States, the big question was how do you get through FDA approval? Device trials specific to pediatrics are very difficult. It costs a lot of money to put something through a device trial, and then you're going to be using it in a relatively small population.

So most of what we use in the cath lab in the pediatric space is actually off label. And we're using it because they're adult approved devices, we're using it off label in pediatrics. But for this specific situation, the FDA had changed the way they were doing device approvals, and there was a new expedited device approval process.

And the Piccolo was one of, it may have been the first device to go through their expedited device approval process. And so we started the trial, it was a multi center device trial in 2016, and the idea was to enroll 200 patients and get 100 babies less than 2 kilos and 100 patients above 2 kilos. And, we did this trial between 2016 and 2017, and then it was FDA approved in 2019.

Host: Wow.

Toby Rockefeller, MD: So from the company making the device and using it in Europe, to us finding the device, asking for a trial, and then going through the expedited device approval process into actual patients after FDA approval, you know, it only took like four years.

Host: That's

Toby Rockefeller, MD: Which is just remarkable, and really has gone through that process that fast.

Host: So that being said, what is, are there any safety concerns that have arised with the expedited approval from the FDA?

Toby Rockefeller, MD: So the, it was interesting, they gave for the device trial, they basically said you need to enroll a certain number of patients, prove that things were going smoothly, and then they would give permission to extend enrollment. And the extended enrollment was up to the 200. And so things had to go perfectly with the first few implants.

And so I could imagine, if things didn't go well with those first few implants, then it would have been shut down. But things continued to go very, very well. And in fact, the babies that were less than two kilos actually had the best procedural success, the fewer complication rate and seemed to do better.

And there's a lot of you know, after the fact, everybody looking back, with hindsight, why is it that the less than two kilo babies seem to do better? They have a more predictable duct that's a little bit longer and more tubular and the device seems to fit better in those PDAs.

Things that came out of the device trial that were of some concern was device sizing. Nobody really knew how to size the device. Like if the duct is this big, then you pick this device. And so we were all just making our best guess about what size device would go in what size duct, and that has evolved and so in the original trial, there were a handful of device embolizations where you put the device where you want it, you let go, and then it, it moves.

Host: Okay.

Toby Rockefeller, MD: So device embolization has gotten better since the device trial. And the other concern was the tricuspid valve. We have to work across the tricuspid valve. And for some of these babies, there was injury to the tricuspid valve. And so the process of crossing that valve has also evolved. And so the risks to that valve have gone way down since the device trial. So things have gotten better, and the device trial was a huge success. So things have gotten better since then.

Host: That's wonderful. So when we look at the Piccolo device compared to traditional methods of repair, what are the benefits?

Toby Rockefeller, MD: Yeah, the biggest benefit is just it's minimally invasive. Yeah. Surgery requires an incision between the rib space and getting past that left lung down to the vasculature to clip it. And there are rare occasions where they clip the wrong thing, clip the bronchus or the pulmonary artery instead of the PDA.

In cardiothoracic surgeons, it's extremely unlikely that they clip the wrong thing, but sometimes general surgeons are trying to do this procedure on teeny tiny babies in their NICU. So there's procedural complications. The recurrent laryngeal nerve goes right underneath the aortic arch by the PDA and there have been reports of up to 15% of kids having important recurrent laryngeal nerve injuries and long lasting vocal cord issues.

And then, some kids will have issues with pneumothorax or pleural effusions. Some will have asymmetric chest compliance and then chest growth resulting in scoliosis later in life. So, it's the fact that you can go through the blood vessel of the leg and close the PDA without any of those surgical issues, that was the primary benefit.

And then people have looked after we started doing this, people have looked at the post ligation syndrome, or, how does the baby tolerate losing the PDA in an instant? Either the surgeon clips it or we close it, all of a sudden the loading conditions on the left ventricle change, and how does the baby handle that?

And so, for kids that have surgical ligation, the post ligation syndrome seems to be more severe and lasts a little bit longer and their return to baseline takes longer. But for the PDA device closures in the cath lab, they don't have as severe a post ligation syndrome and they recover quicker.

Host: That's fantastic. So you have provided us with wonderful insight about the Piccolo device and PDAs. What are the exciting developments on the horizon in the PDA closure world?

Toby Rockefeller, MD: Yeah. So for the Piccolo device, the exciting future is that they continue to evolve the delivery system. That's not always the case for certain devices. Sometimes the company will make the device and let it do its thing but not continue to innovate and evolve the system.

And so for the Piccolo, we know we're getting into smaller and smaller babies. And even this really flimsy, floppy, flexible, 4 French delivery catheter is too stiff for some of the little babies. So they're working on the delivery system trying to make it even more accommodating to really fragile, very small, premature circulation, so that there isn't as much guesswork about how things are going to shift once we release it. So, it is exciting to see how the device and its delivery system continues to evolve and get better and better. Also, some people are starting to do this procedure at the bedside. So, one of the biggest frustrations is you have to move the baby from the NICU to the cath lab, and that can be a long trip, and you have to get them on the table, and then anesthesia, and the C arms. It is just a challenge to move these really fragile babies.

So, some places are doing them at the bedside entirely guided by echocardiograms. And so that's pretty impressive. Some places are actually thinking in the future they would travel to the babies. They would go to the referring nurseries and do this at the bedside there as opposed to transporting babies from surrounding NICUs or surrounding nurseries instead of having to transfer them to us.

So if you don't have to transfer the baby, you don't have to take them to the cath lab, you just do it at the bedside. And clearly that would be a revolution in how we treat PDAs in these really tiny babies.

Host: Absolutely and it increases the safety.

Toby Rockefeller, MD: Oh, for sure. I think the one downside to that and the reason we haven't immediately jumped to doing it that way is, you know, if things don't go right and you have some sort of issue and you're at the bedside in a rural NICU you know, who's your backup going to be? How are you going to transport the baby out of that situation to somewhere where you can intervene on whatever problem might arise?

Host: No, that makes a lot of sense, but it is exciting that you would be able to reach more patients and hopefully as the safety increases, you'll be able to really revolutionize those pediatric patients and not have to always bring them to the tertiary center.

Toby Rockefeller, MD: Oh, for sure. I think the limitation to getting babies treated initially was just not even knowing the device exists. So babies weren't being transferred because they didn't know it was an option. And I think the second step is once people know it's an option and they're transferring these babies, is do we have the bandwidth to accommodate all the referrals?

And then, like you said, if in the future state, we are going to the babies, then you could certainly increase the number of kids that could be treated. And if you treat them early, there are good papers that suggest that the earlier you get rid of the PDA, the less consequences of the PDA you have to deal with later, bronchopulmonary dysplasia, chronic lung disease. Those things may not be as bad if we're treating the PDAs definitively with device much younger.

Host: That's fantastic news for these kids and their overall wellbeing. As we wrap up, what is your final take home message for our audience, Dr. Rockefeller?

Toby Rockefeller, MD: Yeah, I think the take home message would be, you know, if you're a parent of one of these babies with a PDA, I think knowing that there are multiple options, and some are minimally invasive. I think it's nice to live in the current era where we have options. I think in the past where you had none, you're trying to medically manage heart failure; it could have been a terrible kind of overwhelming situation. So I think there's hope that we have multiple options for closing these PDAs. If you're a radiologist or a surgeon or a cardiologist, thinking outside the box, I think is a good lesson from this story because a radiologist became one of the greatest inventors in the pediatric cardiology space and his devices are still being evolved and used in smaller and smaller babies or different situations.

And just thinking outside the box, you know, for all of us can be extremely valuable. And then thinking about ways to treat babies and thinking about how do you prove that the new thing, the new shiny object on the shelf, is actually better than the old thing. And so, staying focused on just because something's new, you don't just immediately rush to putting it in everyone.

There are plenty of people out there that are trying to do randomized trials between surgical ligation and duct device closure. And, you know, staying true to the scientific drive to know is the new thing the better thing I think is a really important lesson for this because like you said, these expedited reviews, we can do things faster.

Technology changes pretty rapidly now, but we have to stop and think is the newest thing the best thing? And so I think that's where we're at right now is we have a new device, FDA approved just five years ago, and we're using it in a lot of babies. And people are looking with a critical eye. How much better is it than the old way? And how do we get better from here?

Host: I absolutely love that message. Be innovative, but at the same time, hold on to scientific integrity to make sure that it's actually the best option.

Toby Rockefeller, MD: Absolutely.

Host: Well, thank you so much, Dr. Rockefeller, for joining us today. This was such an insightful episode.

Toby Rockefeller, MD: Well, thank you for having me.

Host: Once again, that was Dr. Toby Rockefeller, an Interventional Pediatric Cardiologist at Children's Mercy, Kansas City. To refer your patient or for more information, please visit childrensmercy.org. to get connected with one of our providers. I'm your host, Dr. Rania Habib, wishing you well. This has been Transformational Pediatrics with Children's Mercy, Kansas City. Please remember to subscribe, rate, and review this podcast and all other Children's Mercy podcasts.