

THE BLOODLINE WITH LLS

A PODCAST FOR PATIENTS AND CAREGIVERS

Episode: 'Diagnosing Acute Lymphoblastic Leukemia'

Description:

Join Alicia and Lizette as they speak with Dr. Mohammad Maher Abdul-Hay, a hematologist and bone marrow transplant physician in New York, New York who is affiliated with multiple hospitals including NYC Health and Hospitals, Bellevue, and NYU Langone Hospitals. On this episode, Dr. Abdul-Hay defines and explains how acute lymphoblastic leukemia (ALL) is diagnosed and the risk factors and symptoms of ALL. He also stresses the importance of patients and families asking questions along their treatment journey to ensure that they feel comfortable with their healthcare team.

Transcript:

Alicia: Welcome to The Bloodline with LLS. I am Alicia.

Lizette: And I am Lizette. Thank you so much for joining us on this episode.

Alicia: Today, we will be speaking with Dr. Mohammad Maher Abdul-Hay, a hematologist and bone marrow transplant physician in New York, New York who is affiliated with multiple hospitals including NYC Health and Hospitals, Bellevue, and NYU Langone Hospitals. Thank you much for joining us, Dr. Abdul-Hay.

Dr. Abdul-Hay: Thank you very much for having me.

Alicia: On this episode, we will be chatting about symptoms, risk factors, and diagnosis of acute lymphoblastic leukemia, known as ALL, but before we get into that discussion, are always interested in knowing what brings doctors to their field of medicine. So, what brought you to the field of medicine, specifically hematology/oncology?

Dr. Abdul-Hay: So, you know since high school, I have always been fascinated by blood disorders. So, I always wanted to do medicine just to get into the field of blood disease. So, during my medical school, after second year medical school, I got to be exposed more to hematology and I loved it; in particular leukemias. You know, it's very fascinating. It's, we all carry this blood, the red blood cells, the white blood cells, the platelets that we need them; and then when they misbehave, it's just fascinating. It's a challenge and I always loved a challenge. For me to understand these diseases, and to know how to tackle them, and to have an impact on a patient's life, for me, that

was all I needed. It's fascinating and the relationship I noticed during my medical school that a relationship that a physician, especially a hematologist, has with his patient is completely different than other specialties. I like to have this relationship with a patient. They become part more of a family. And, in addition, for the disease being so fascinating, and trying to understand the disease, and making an impact, that meant the whole world for me. So, that's why I ended up doing hematology.

Alicia: And you know what, it is so interesting because a lot of doctors we speak to, most of them say the same thing saying that, you know, it's a different type of relationship with their patients. And I think it's a beautiful thing to hear, you know, doctors have that outlook when it comes to treating their patients because they are already in such a challenging time. So, to hear more doctors say this is a special relationship, this is a familiar relationship, it's a beautiful thing.

Dr. Abdul-Hay: Yes; that's true. And to tell you, like when someone is diagnosed with high blood pressure, for example, you know, that life doesn't stop or change completely, but when you are diagnosed with acute leukemia, your life, at that moment, changes. It changes forever. So, I like to be involved and I like to have an impact to make sure that your life goes back as normal as possible and, I believe, this is so great in the field of hematology, and the patient doesn't become just a patient. They become truly like a family member. You care about them. You monitor them. I mean, when, God forbid, they relapse after putting them in remission, it's just how heartbroken you are like them. It's just fascinating. It's beautiful.

Alicia: Right; right. And I always refer to this quote, it says "a good doctor treats the disease and a great doctor treats the patient".

Dr. Abdul-Hay: That's a good quote. I am going to use it.

Alicia: Feel free; feel free. A lot of times, the question will come, you know "what did I do to get this? What is the cause of ALL?"

Dr. Abdul-Hay: We always get that question actually. This is probably the most question we get asked about. So, to give you a brief about ALL, so as you mentioned, ALL is acute lymphoblastic leukemia. It's the second most common acute leukemia in adults. Roughly, in the USA, there's about 6,500 cases a year. The characteristics is genetic and chromosomal abnormalities. So, most of these ALL are associated with a chromosomal abnormalities and genetic alteration in in their differentiation and their cells. Why do they acquire this genetic abnormalities or chromosomal abnormalities, it's really not always known? There are some factors that have been shown to be associated with, like exposure to radiation, for example; pesticides have been associated with some genetic alteration and that leads to ALL. Some syndromes actually have been associated with ALL, for example, Down syndrome, Fanconi anemia, syndrome, and ataxia telangiectasia. These are the pre-disposing factors that

we know of and then there are some viruses, actually, that can put people at the risk of ALL like Epstein-Barr virus, EBV, and HIV. Because what happened with EVB, it attacks your B-cells and the B-cells get to be dysfunctional so that's why you can end up having ALL. And HIV decreases your immunity so that, basically, your immunity doesn't see when cells misbehave so they can actually go on and proliferate and they become cancerous cells.

Lizette: And do you see a lot of patients that are diagnosed later. It's typically not the first thing you look for, ALL, when a patient, has certain symptoms which, I mean, how do they present?

Dr. Abdul-Hay: So, I can give you an example. Yesterday, I saw a new ALL patient, he is a 27-year-old. He actually was doing well; no medical problems whatsoever. He started feeling tired and fatigued and he started having headaches and photophobia and, basically, he went to his primary doctor. So, his primary doctor did a CBC for him, just because he was not sure what was going on; and then his CBC showed that he has a very low hemoglobin, so he was very anemic, and he has a high white blood cell count. So, what happened is, his hematologist called me, and his primary physician called me, and is like, "I have this patient and, can you please see him?" So, I saw him the same day. I did a bone marrow biopsy and, there, he ended up having ALL. So this is someone that was working until the last moment and this is, I mean, it just happened. He started having some symptoms. Usually people with ALL, they get to be diagnosed on a CBC because they have some symptoms like, most of the symptoms are either B symptoms, what you call B symptoms, meaning fever, weight loss, or night sweats, or they ended up being tired and fatigued and someone checked their CBC and found they are severely anemic and did not have an explanation for anemia or cytopenia, hemoglobin or platelets. This is usually the presentation that we see.

Alicia: Right. That's interesting. I was also reading, a patient's story and she was saying, that she had a burn that took a while to heal and she also had shortness of breath, which is what you just mentioned, and she, like you said, she was working. there was nothing, that was that out of the ordinary other than those two things; and when she went in, she was later diagnosed with ALL. So, like you mentioned before, the symptoms of ALL are very much associated with a number of other less serious diseases that you don't necessarily think ALL first, like Lizette was mentioning, do you find it is difficult to diagnose?

Dr. Abdul-Hay: So, it is not difficult to diagnose once you have some abnormal labs, but it's difficult to present. So, like I had this lady that was in her sixties, she started every day feeling more and more tired and she's like, "okay, maybe I'm getting old."

Alicia: Hmm; hmm.

Dr. Abdul-Hay: And then, she did not seek medical care for a while and she started delaying things, and things, and things and, eventually, she went to her primary doctor who did a CBC. There were some abnormalities; not like severe abnormalities. Her hemoglobin was somewhere around the 7.5 and he told her, “you know what, you should go and see a hematologist”.

Dr. Abdul-Hay: And then, she also wanted to delay things because, she’s like, “okay, maybe, ah”. People, sometimes, they just don’t want to deal with the fact that there is something maybe serious; and she’s like, “no, no, no; I’m going to be okay.” She started delaying things, and things, and things and by the time she came to me, she was really very, very sick actually and, unfortunately, one of the things that ALL has a tendency, it can go to screen, it can go to CNS. So, she ended up having involvement in her cranial nerves, actually, and she had the CNS disease. So, that we do not want and she, basically, started like, “oh, I should have sought medical care and when they told me, I just delayed my care. I did this to myself”. But you know, because it can be very slow, presenting symptoms, not every patient presents rapidly like the one I saw yesterday. They can be slowly, especially in the elderly, and then they can attribute them to something else.

Lizette: And I think that’s important to know what you said about, you know, presenting just because, you know, you can try to justify it. I do it all the time. You try to justify, you know, why you are tired or, even doctors, you know, you have a high blood count, “well, let’s see if you have an infection” or, you know, really have to start the ruling out process, but I think just the initial to get that CBC, that complete blood count from a physician to see if, you know, something isn’t right, I think is really important for people to do. Not everybody is going to be diagnosed with ALL, of course, but it’s really good to get that complete blood count as that starting point.

Dr. Abdul-Hay: That’s true; and a lot of times, like, if you present with, say, joint pain and your primary doctor is going to say, “oh, maybe it’s arthritis” or something like that and you are not going to get the complete blood count done. So that’s why this is a blood disorder. It is not visible. You don’t, like in other cancers, you may start feeling like a lump or like some changes in the skin or something like that. This is invisible. This is inside your blood. You are not going to see, a lot of time, any physical presentations unless you’re severely anemic and you have pain, or something like that; you probably will not and that is why it can be, for a while, misdiagnosed or delayed to get diagnosed.

Alicia: Right; and you mentioned that the patients, get a CBC, the complete blood count. When they are then referred to a hematologist, what are other diagnostic testing that the hematologist then performs to further, investigate the ALL or further define the ALL?

Dr. Abdul-Hay: So, you know, it depends on age. So, when I have a young patient, so ALL has like, a bimodal presentation. It's either of the young, like pediatric, I don't see pediatric, I see other, but when someone in adults, young adults is between the age of 18 to 39, or the elderly, actually, above the age of 50. So, when I see someone between the 18 and 39 and they present for me with not just one cell line that is low, like anemia, say your white blood cell is low or high, or your platelets, then I get really worried. So, the first thing I do is I try to do a differential on the CBC. I try to take a look at the proliferative smear to see if I see any of these abnormal cancer cells, called the blasts. So, if I do see monoblasts, which are early precursors of white blood cells; they haven't got the time to mature, then I am very worried. At that moment, these patients will get a bone marrow biopsy and an aspirate and this is really the gold standard test. From the bone marrow aspirate, we do some testing, including flow cytometry and we can diagnose ALL. So, I am always cautious, you know, I am a hematologist so when the patient comes to me, they never come to me for anemia. I am a leukemia and transplant physician. Most of the time, they come to me and the first thing I am thinking in my mind, "okay, leukemia unless proven otherwise." So, yes, the gold standard to get diagnosed is a bone marrow aspirate and biopsy. However, a lot of time, actually, they present with a very high white blood cell count, like in the hundred-thousands, normally it should be around ten thousand and then because they have a very high white blood cell count, you can see that the leukemic cells are very visible on proliferative smear. They are very visible even on the CBC and you get your diagnosis very easily just by peripheral blood.

Lizette: Now you said, bone marrow aspirate as well as bone marrow biopsy. Is the bone marrow aspirate sufficient or does the patient get the biopsy?

Dr. Abdul-Hay: That's a great question, actually. And I always say if you can get the diagnosis from aspirate rather than doing a biopsy. So, the aspirate is the easiest test to get, you can run a flow cytometry and get results within hours. The biopsy, you need to stain it and, actually immunohistochemical staining and it takes a few days to get the results. The aspirate, you get the results quickly. Why aspirate is needed because, you know, you can run the flow cytometry and have the result in 2-3 hours. And the second importance of the aspirate is you send genetic testing from there. So, as I mentioned earlier, that ALL, a lot of time, is to see if there is genetic cultivation, chromosomal abnormalities. So, the best test to do that is by running a karyotyping and by running a FISH, which is Fluorescence In Situ Hybridization, to look for translocations; and this you need a fluid to it. So, this is why you need the aspirate blood to do it. And the marrow is the best source because this is where cells are starting to be produced and divide so there is a lot of dividing cells so you can get a better quality than doing it on peripheral blood. The biopsy, really, is more of a luxury. So, the reason of the biopsy is, say you have someone that has a dry tap, meaning that they have a lot of disease of the marrow is packed; you cannot get an aspirate, you need a biopsy because this is how we are going to get your diagnosis.

The second issue that helps me with the biopsy is I want to see how advanced is this ALL? Meaning, if there is some burnout of the necrosis, or burnout in the biopsy or no, there is some similarity of other precursors in the biopsy. But really, the aspirate is what you need and you can get by with an aspirate to get the diagnosis or you improve prognostic things that you need from the FISH or the chromosomes abnormalities. You can get all of this from the aspirate.

Lizette: I think from the patient's point of view, they always think, okay, the bone marrow biopsy, they've heard that it's very painful so they're thinking, you know, do I really need to get something that is so painful, but on the other hand, you know, you want your doctor to be as accurate and have the most information as possible. But we do hear a lot of people, that don't have good experiences with bone marrow biopsies.

Dr. Abdul-Hay: Unfortunately, that's true. So, I won't fight you; there is some pain with it, but when someone does it very, very frequently, I mean they become very efficient and quick to do it and the pain is very, very minimal. So, I rarely had a patient saying, "Oh, I don't want bone marrow biopsy, I don't want to do it again." Unfortunately, they get a lot of bone marrow biopsies, not just on diagnosis for like after you induce them or give them chemotherapy consultation, you need to check to see if they are in remission and this is your only need to do it; so, bone marrow biopsy or else it—the results. Aspirate is fine. A lot of time, I don't do a biopsy. I just do an aspirate, but I never had really patients saying, "oh, it was traumatic, I don't want to repeat it." But yes, they do experience some pain. That's like when you go to a dentist. They are going to numb you, you are going to feel that numbing and when it goes through the bone, you really can't numb inside the bone that much so you are going to feel a little bit of the pressure more really than the pain.

Lizette: But, you know, I have to agree with you because a lot of patients have told us that they've been to different places for the bone marrow biopsy and they found that it is less painful when they've gone to a place where they do them consistently and they do a lot of them. So, you know, we have heard that from patients all the time that, , they've gone through, you know, several bone marrow biopsies and some were not as painful and they really did say that it was, they think, because, the Center, they do it so many times, that it did make a difference.

Dr. Abdul-Hay: I agree with you completely.

Alicia: On our podcasts, we have listeners who may have just been diagnosed, who are caregivers, who know someone who may have, the disease we are speaking about and we always encourage people to have open communication with their health care team. We stress the importance of shared decision making so the person doesn't feel like they are just being told what to do and they have no say or input because it is their life that's changing. So, what are some questions, from a doctor's perspective? What questions can they ask their doctors?

Dr. Abdul-Hay: So, I always tell my patients they should ask me whatever they have on their mind, because, really, this is so important to have an open communication. There is a trust relationship here. Someone is giving you their life, really, and they have to trust you. So, and sometimes because they are so overwhelmed when they present, you just told them, "oh, you know", they came for an abnormal white cell count and now you're telling them you have acute leukemia. So, they are overwhelmed and sometimes they just don't want to ask any questions. They just sit there and listen. And this is when I actually intervene and tell them these are the things you should be asking me and these are the things you should be considering. One is can I cure you? What's the success of cure? What's the success of remission? And prognostic. What type of ALL do I have or you have? And what are the indications for a transplant? Do I need a transplant with this, with these findings that I find based on the cytogenetics or white blood cell count, the age? So, I do tell them the prognostic index—the prognostic—it's very important that they know how serious this disease is, how aggressive it is and what to expect. And, this is basically, I try to do it the first time. I don't want to overwhelm them by telling them, "okay, this is your treatment. You can get this chemotherapy and, then, this is the side effect of the chemo and all of this". The first time, I am trying to get them to understand their diagnosis and to understand also the prognostic finding, like where do they fit? Do they fit in standard risk, high risk, intermediate risk and what are we going to do? Is it going to be only chemotherapy? Is there going to be, possibly after chemotherapy, they are they going to need a transplant or not? That's the first time. And then, I give them time, you know, to absorb all that.

And then, the second interaction, it could be the same day in the hospital; I come afterwards to interact with them; even in the clinic or they can come this next day, depends how urgent I need to treat them--is about chemotherapy and the treatment they are going to get, the side effect of the treatment. They need to, you know, know all of this information.

Lizette: And you mentioned, the risk and you mentioned the risk factors. When somebody has a higher risk, do they get treated usually more aggressively or can you talk more about the risk factors?

Dr. Abdul-Hay: So, really age, and the white blood cell count on presentation, and the genetics are the key for risk certification. Anyone presenting as an adult is considered high risk above the age of 18. Now, someone is about the age of 39, meaning they are not anymore young adolescents, above the age of 40, they have worse prognosis, okay? So, age is the key. So, about 40, meaning they are higher risk automatically and, that said, there's some data even for people that are between 18 to 38 that have some high risk; then pediatric less than 18. Now, that's one. The second is white blood cells presentation. There are two types of ALL. There's the B-ALL and there's a T-ALL. So, the B-ALL, you need on presentation to have a white blood cell blast count of above 30,000. The T-ALL, from studies, it has shown to be—

you needed to be above 100,000. So, if you about 30 or 100,000, B-ALL is above 30; 100,000 for T-ALL, you might automatically get one for higher risk.

And then, genetics. The genetics that we care about in ALL, so hypodiploidy, meaning lower chromosomes is a bad indication in ALL. That puts you at a high risk. And there's the translocation (9;21), which is another name, Philadelphia chromosome that puts you at a higher risk. And now we know from using data, there are others which are called Philadelphia-like, meaning they behave like Philadelphia, but they do not have the translocation (9;22). And usually they are into two categories; one is called CRLF2 and one is called CDKN2A. If you do have any of these Philadelphia-like or Philadelphia, then you are higher risk. And the last, actually, in higher risk is a mutation in, chromosome 11q23. You have a deletion there in 11q23. It used to be called MLL, then we changed the name to make it harder for people. KMT2A...

Dr. Abdul-Hay: If you do have any of these genetics, abnormalities, or high white blood cells, or age, then you are higher risk. That means, most probably, you are going to require a bone marrow transplant.

Alicia: We want to make sure that the people who are listening are able to have this information so that they can have these conversations with their doctors and not feel like they're just thrown into a world of the complete unknown. It is a completely different world, we can't argue that, but want to at least provide them with the tools, the information that they can then enter the conversation and feel as if one, they know what the doctor is saying to them and then; 2, they know the questions they can ask and feel comfortable asking.

Dr. Abdul-Hay: And you know what, they should not feel that they can't ask this question. They should ask this question: What is the chance of cure? What's the chance of me being in remission? What are, these are hard questions, but they need to know about them and they should not shy away from asking them. And they should also ask, like, what is the risk of me, God forbid, relapsing after all of this treatment? They have the right to know and they need to know that; and I always find it that these are the hardest questions for patients to ask. They always try not to; probably some of them, they don't want to know the answer, but if I was saying myself, if I was a patient, I would really like to know. I want to know. I want to believe that there is a chance for me to cure and I want to hinge on that and focus on that and I want to do all that I can to get over this. I keep telling patients it's a relationship together. We are going to work on this. You are going to do all the heavy lifting. I am just there to guide you and, hopefully, together we will arrive in a state where we look at this and say, "oh, do you remember one year when you were being treated for your leukemia and now you are in remission"? And, it's, there is no more reward in the whole world than when you have a patient come in to you for a follow-up, just to tell, like, it's been a year since his transplant or her transplant; and they are just coming for a follow-up, a regular follow-up. It's like a social visit. How are you doing? It's like a house of kids.

Dr. Abdul-Hay: It's amazing! Wow! You made it so much back into life and now there's just like, they share their stories with you. They share pictures of their children. It's amazing! It's just very rewarding, but they have to ask all these questions because a lot of physicians will not tell you these unless you ask for them.

Lizette: That is what I was going to ask you. Do you actually wait for a patient to ask you? Or do you see that when a patient is not asking those kinds of questions, do you actually bring up the topic?

Dr. Abdul-Hay: I try to bring up the topic, but I don't like being straight forward, to be honest with you. I tell them that do you want to know, from studies, the chance of remission after induction? I don't do that very frequently. I leave it up to them if they want to ask me these questions. I always ask them, you know, whatever you need to know you should ask me because this is your life and you need, you have the right to know every detail about it.

Alicia: I know it's scary to ask the question, but if someone is diagnosed, the diagnosis is now consuming their mind and their thoughts; but if you are able to have that conversation and say, what's the possibility of cure and have that bigger conversation, then that can become what their focus is as opposed to, "I was diagnosed and now what do I do?" The feeling is completely helpless.

Dr. Abdul-Hay: Correct. there's a lot of misnomers because a lot of people think, "oh, you know, I have acute leukemia. I am sixty-five. That's it. I am going to die." No, no; this is not true. But they become so depressed and they don't want to even open up and it becomes a challenge to convince them that, no, there's a, you know, there is a very high chance we can put you into remission. We don't, in this era, you know, I transplanted a patient, a 79-year-old, an allogeneic stem cell transplant, and he did great.

Alicia: Wow!

Dr. Abdul-Hay: So, I try telling them that there is no cut-off for transplant age anymore. It's about how good you are; how much social support you have, other comorbidities. It is not the end of the world. You know, we can work together. We will get you there. You just have to believe. And that's why I said it is very important it's a trust relationship. When there's this trust between the physician and the patient. The patient opens up to the physician and then, really, it becomes easier for the physician and, it becomes more, they can live with it easier for the patient. It is not easy to live with acute leukemia. I won't lie to you if your life won't change at that moment. It will. You are going to get chemotherapy, induction, you can end up having, everyone ends up having low white blood cells. You may end up having fever, neutropenic fever, admitted to the hospital, being on antibiotics. You are going to get poked a lot. You're going to get, you are probably going to end up having--is it a PICC

line or a Mediport to access your, to access to draw blood and give you chemotherapy. You are going to lose your hair. All of this. So, your life is changing remarkably overnight so there's no way it's not going to affect you spiritually or socially. All of this is going to affect you and, unfortunately, as a physician, I am treating the disease. I am not treating the other aspects and that's why they need to open up. My team consists also of a social worker. We always try to involve her to see if they need some support at home or if they need even psychiatric support, or all of this. It's a multiteam and it's not just, you know, treatment, "okay, this is what you are going to get. This is the medication you are going to get and that's it." No; it's more complicated than that and patients do understand that. But at the moment, the shock is usually the hardest part and then, with time, when they start seeing their counts doing better, they are feeling better, they really start looking forward.

Alicia: That's such a great point. And your approach is so, it's so wonderful to hear because, again, I mean, like you said, I mean, when people have their idea of a doctor, they think they can only say so much and that, you know, we are only here to read charts or only here to look at scans, but to hear you speak in such an empathetic way, listeners know that these doctors exist and, you know, there's the benefit in doing your research and finding that doctor that they feel comfortable with so that they can know that they are being seen completely and that their treatment is being mapped out by someone who is taking everything into effect.

Dr. Abdul-Hay: That's true. I mean, unfortunately, in this era where there's so much, the medical charts, we need everything to the date; we need to write things; like, I see a patient for 15 minutes with my chart to put my note with my chemo orders. All of this takes, like, 30 minutes in follow-up. So, but one thing that I actually have been doing and will always continue to do, and I encourage every other physician to do, when I am in a patient's room, I do not write anything on the chart. I am just there to just listen to the patient, and ask the patient, and then reply to the patient. I have the chart just to look at labs. I write a note at the end of the day. I put my chemo order at the end of the day or the day before. And that's because I need to give that time for the patient; first of all, so they can, this trust relationship; and then second of all, more importantly, because, you know, they need full attention. They need to understand you are there for them and, at the same time, they have the time to ask any questions they want. And because, as I said, half of the treatment is medication. The other half is really the support, that the support you provide as a physician, the support the team provides for the patients. Like, we work with a lot of nurse practitioners. The nurse practitioner gets to know them very well. At Christmastime, for example, they share cards. I had a patient that I was treating and he was expecting, their first child. So, it was so hard. He was diagnosed with ALL and I was treating him; and his wife was going to deliver about three months, afterwards and he was very close to having a transplant because he had the high-risk features. So, you know, when his wife delivered, he we wanted to make sure that he be there

so we delayed his transplant to be there and then when his wife delivered, he came to the clinic and we actually decided to get him a gift for his newborn baby so.

Alicia & Lizette: Ahh; ahh.

Dr. Abdul-Hay: You know, he felt like, he felt like part of a family. And we know the name of the baby. We asked for the from, from friends, you know, what is the name of baby and we did this for him. And when he went to transplant, went into the hospital because, you know, they stay in the hospital for 3-4 weeks so he, it was 3-4 weeks where a newborn baby—he is not seeing his newborn baby.

Alicia & Lizette: Awe! Awe!

Dr. Abdul-Hay: He's doing FaceTime and it is heart breaking. So, we wanted to make sure that he gets to at least spend some time before he goes for transplant so we tried to give him some maintenance treatment and all of this. So, half of the treatment is medication, but the other half, there are other factors there.

Alicia: That's so true and that's so kind of you and your team.

Lizette: Yeah.

Dr. Abdul-Hay: We truly believe that patients are part of a family more than, really, they're not numbers. They're not just clients.

Alicia: Yeah. Doctor, we have to warn you. You may see an influx of people reaching out to you just because of how personable you are.

Dr. Abdul-Hay: Thank you.

Alicia: Thank you so much for joining us on this episode Dr. Abdul-Hay and for sharing your expertise with us on the topic of acute lymphoblastic leukemia. Thanks for all you do to not only advance science, but for your patients. It has been so great chatting with you today.

Dr. Abdul-Hay: Thank you very much for having me. It was fun and, it was great. Thank you.