Episode 1 – UV light: friend or foe? Guest: Richard Weller, MD

Peter Kotanko
Welcome to the renal research institutes frontiers in kidney medicine and biology, where we share knowledge and advances in kidney research with the world. In this episode we talk with Dr. Richard Weller to discuss whether UV light is a friend or foe. Also take an in depth look to an earth whether incident solar UV radiation lowers blood pressure.-Welcome to the series Frontiers in Kidney Medicine and Biology and it's a great pleasure to welcome today Dr. Richard Weller.

Richard Weller
Thank you, Peter. It's lovely to be here.

Peter Kotanko
Dr. Weller, he is a Reader in dermatology at the University of Edinburgh, and honorary consultant. There he was trained at various places in the United Kingdom and spent some time abroad, as a research fellow at the Heinrich Heine University in Dusseldorf, Germany, and in his main research is, the action of UV light that hits the skin, and what it does to the cardiovascular system. I think it's kind of unusual, Richard, that the dermatologist would deal with the hemodynamics with the cardiovascular system with blood pressure. Can you tell us a little bit about your work? And what brought you actually to this field of research?

Richard Weller
Yeah, well, I've not ended up where I started, of course, because I'm a dermatologist. So I'm actually what I got interested in really is the cardiovascular effects of sunshine. Dermatologists obviously have been interested in ultraviolet, sunlight, UV radiation for, what 100 years, and we've really been thinking about it in terms of skin cancer, because of course, sunlight UV is the major environmental risk factor for skin cancer. But really, as a resident in training, I got interested in research and in nitric oxide, and this was back in the late 90s. When, you know, it was molecule of the year, the Nobel Prize medicine was awarded to the guys that discovered NO really exciting thing. And NO play department apoptosis. And we knew that an ad shown that UV could release no from the skin or that the skin released no anyway, and we're trying to work out what it did. And by knowing that nitric oxide effective apoptosis, I wondered if in some way it might affect skin cancer, because really all dermatologists think about, I'm afraid to say when they think of UV as skin cancer, and I hope you'll understand that is a short sighted view.

So I went off to the research in Germany, as you say, and I was in Pittsburgh for a couple of years. And I was interested in whether nitric oxide might affect your risks of developing skin cancer with UV because UV released much oxide and go to the fact that thesis and skin cancer and so on. And I did mouse work, usually experiments, tissue culture work, came back to an abrupt and started to actually move my animal model work into humans. And what I found was that, really, I couldn't replicate the quite clean mouse experiments in human studies. Now, nitric oxide, which was the focus of my mechanistic research, was initially described as being produced by nitric oxide synthase acting on arginine, and it cleaves NO, leave NO and citrulline.

So that work, got the big prize, the Nobel Prize for the three founders of the field. And I was doing my experiments by trying to turn off that pathway with nitric oxide synthase [antagonists] in the skin. And the problem was however, I delivered that nitric oxide synthase antagonists, I couldn't turn off NO release in the skin. And really, I was problem solving my experiments like you do when they don't work. And I spent a couple of years with the grant money going down and clock running up and publications not coming out. And I'm sure lots of us have been that it's anxious time. But what we found was that actually, there's an alternative means of nitric oxide production in the skin. And what we showed was that the skin contains large stores of NO3 nitrates, and NO2 nitrite and nitrate files. And initially, we couldn't really work out what they were doing there until my friend Martin Feelisch, who's now down in Southampton published a paper in which he showed that UV radiation in the presence of file SH groups can actually photo chemically reduce NO3 three nitrite, nitrate to nitrite. And they're not so there is a novel pathway independent of the nitric oxide synthase pathway by which sunlight can release NO from what had been thought to be a storage, an inactive form of NO nitrates. And then, you know, I was kind of, and it really was one of those eureka moments because I was at a meeting in brigantes in on Lake Constance with a bunch of my friends great NO meeting my experiments not working my friends experiments were working, sitting round over a pint looking at Lake Constance, and read one of these eureka moments because Martin, they've got this new pathway, I'd shown the skin contained all this nitrate. Well hang on, there's nitrate in the skin, the thiols in the skin, there's UV in the skin. So all the ingredients that can produce NO by this alternative pathway are there in the skin. And I then remembered before I was a dermatologist, I was a doctor. I kind of remembered from medical school days that of course, blood pressure is lower in some of them winter, heart diseases low and some in the winter, when I was a junior doctor doing internal medicine, we used to have these winter bed crises your hospital would fill up in winter with patients having myocardial infarctions, and so on. And in summary, it was much quieter. This has been replaced nowadays we have an all year round bed crisis. Now in the health services, we've reduced beds. But the point is we have this cyclical heart disease. So maybe sunlight via this pathway could release nitric oxide. And it would phase it out later and lower blood pressure. And basically adults we went on and we did the experiments. And we showed that sunlight does indeed release nitric oxide from stores in the skin. It does indeed move into the systemic circulation, where it leads and lowers blood pressure. So there is a beneficial effect of sunlight on cardiovascular disease. So it's an unusual place for a dermatologist to end up. But I think an important place. Yeah.

Peter Kotanko
No, I find this story of your investigation quite interesting, quite remarkable that you actually started with failed experiments in them found in a really innovative solution. Why this might have failed, and came up with this really, I think fundamental discovery about the skin is as a source of a NO. I mean, when I read the first time about, about your work, I was really wondering if the skin would produce enough NO to affect the systemic effect? What's this actually a surprise to you? Or was it kind of clear to you from the very start?

Richard Weller
The skin actually contains about 10 times as much of these nitric oxide stores, nitrate, and nitrite, as the circulation. So the skin is a huge store. And of course, you know, it's exposed to

UV all the time. I mean, there's lots more to be discovered here. We're still working away at it. And I might say, I was pleased that my friend and colleague, Christopher Schyvens, from my time working in Germany, really kind of working in parallel with me. I'm doing sort of complimentary experiments confirmed this. And of course, I then moved on with, I met some renal physicians in America, right. I don't know if you've any way of whom you will walk, which we could come and look at the epidemiology of this. And the really interesting thing is, initially, I'm showing a mechanism. I had done mechanistic experiments in human volunteers, which shine some artificial UV at them. We were doing forearm venous *blesseth tomography*. So we were calculating the brachial artery to measuring vasodilation the forearm, and we showed that UV does indeed directly vasodilate the systemic arterial vasculature. And that produces a transit for them blood pressure, but of course, they have an effect at population level, you need a sustained change. And that's when of course we did this work, which we published in the Journal of the American Heart Association last year, in which we looked at a third of a million dialysis patients. I hadn't really thought of this before, but the great thing about dialysis patients is that they have their blood pressure measured three times a week, year in, year out, and also of course, the that Fresenius has these two thousand dialysis centers all around America. And that means you can actually get in at an epidemiological level. And because UV varies by year, by time of year, and by location of both the wavelengths vary and the intensity of light varies, and also importantly, things like temperature, you can correct for, because in the past, dermatologists have grudgingly accepted the fact that oh well, yes, blood pressure is lower in summer. It's probably I mean, dreadful. It's probably the warm for vitamin D. Well, we know it's not vitamin D, because all this was all the correlation between high measured levels of vitamin D, and less heart disease, less strokes, lower blood pressure. But the interventional studies where you do clinical trials of vitamin D supplementation showed there is absolutely no effect of vitamin D on cardiovascular disease. And the Mendelian randomization studies which have been published show exactly the same thing. So if you're born with it with an inadequate or that pathway, you don't get increased heart disease. So we know it's not vitamin D. So the other explanation for these seasonal variations in in blood pressure and heart disease has been temperature. So the great thing about the study we did in this huge dialysis cohort was we could correct for temperature because, you know, if you're in Salt Lake City, it's sunny and hot. And if you're in Denver, it's sunny and cool, times two thousand centers, so you can actually take into account that temperature. And what we showed was that about half that seasonal variation in temperature, in blood pressure is temperature related, but half of it is still there when you correct for temperature. So that observational, epidemiological data of more UV lower blood pressure, independently of temperature, matches up to our mechanistic data, in which we show that shining UV at people releases energy to the circulation and causes arterial dilatation. So the whole kind of thing hangs together. And I've gone on to a clinical trial about using UV phototherapy to treat mild hypertension. And I'm just writing it up. And I'll be submitting it to publication very soon. And watch this space. But it's very exciting. And it all hangs together.

Peter Kotanko

Yeah, I'm very much looking forward to this. I mean, Richard, when you talk to your dermatologist, colleagues and friends, I mean, what, what's the reception there? I mean, we hear year in year out that, about the dangers of UV light, and then come stock the well and so it's not actually it's beneficial. How do you explain this trade off? To dermatologists to other colleagues,

but also more importantly, I think, how to explain this trade off to the general public, to the general population.

Richard Weller
I might say there's an Atlantic divide here. So colleagues in Europe, absolutely get it straight off it. So the skin cancer that matters is melanoma because that's the skin cancer that kills people. Okay? So melanoma is a disease is related to UV, it's common or in Australia than it is in Britain. But it's, it's intermittent sun exposure, , particularly sunburn when you're young. So this amazing stuff, you know, outdoor workers, have less melanin with an indoor workers. Now that might be self-selection, you know, maybe if you've got the kind of skin that doesn't burn, you become an app for work. I mean, that's, you know, his observational data, isn't it. But at the same time, it is consistent with the idea that it's intermittent sun exposure, which is the problem., There is no evidence anywhere that increased sunlight exposure correlates with reduced lifespan. In fact, quite the opposite. Fantastic epidemiology from my colleague *Pelle Lindqvist* in Sweden, where they've been looking at things prospective cohort studies in Sweden over the last 30 years. And they show that the more sunlight people have, when you correct for income, social class, smoking, general health, the more sun exposure, the longer lifespan. And when a dermatologist says to you sunlight is dreadful, ask them to name you one paper, one paper, they're showing that sun that more sunlight equates with reduced lifespan, there are none. And that's completely different from smoking, high blood pressure, diabetes, poverty, blah, blah, blah, blah.

You know, you say to a first year medical student, one of the papers showing that more smoking equates with a shorter lifespan. Well, you know, the Framingham study, the nurses' health Study, the sixth unit, you can go on and on and on. There are none for sunlight. And we use all-cause mortality, even though we know it's a risk factor for skin cancer. So, people buy that we know the fact that, you know, when you have a basal cell skin cancer diagnosis, these are the commonest. There are more basal cell skin cancers diagnosed in Britain than every other cancer put together. When you have a basal cell skin cancer diagnosed, your actuarial life expectancy goes up. So you leave your dermatologists consulting room with a longer life expectancy than when you go in when your BCSC been diagnosed. Now, I don't think that's bad news. But that probably makes me a bad dermatologist. I think it makes me a good doctor. Because you know all-cause mortality really trumps everything else. In America, there is this rigidly anti-sunlight life. And I feel a bit like a kind of an agent runner. I have had emails from several American dermatologists saying, Richard, we think this is great, we're really interested in it. I can't say this here in America. And literally, I feel I feel that I'm terrified the American Academy of Dermatology are gonna capture me and torture me and maybe reveal the information. I feel I'm kind of running these agents in hostile enemy territory, because they dare not say it in America. And I think the social reasons for this actually are quite interesting. Because they're in, look, what a lot of my research is showing is that sunlight, like everything else we do has advantages and disadvantages. As doctors risk benefit is the core of our being when I prescribe hydroxychloroquine is one of my patients with cutaneous lupus, I think of the benefits or hydroxychloroquine reducing the scarring lupus, and I think the disadvantages, you know, the side effects and so on. With every intervention we do, that is what we do, because we are doctors, and we deal with risk benefit. And dermatologists have completely lost this with sunlight. And I think I've been thinking about why this is. So the people who suffer from UV are

white skinned people. Okay, I work in Ethiopia a lot. I've been working in Ethiopia every year for the last 12 years. So Ethiopia is a two and a half 1000 meters. And it's on the equator. We do not see UV induced skin cancer there. I've just been having an email correspondence with a great friend of mine. Don't think Folgers there, we don't see UV and you skin cancer. The people that get skin cancer are white skinned people. But people that get sun aging are white skin people, UV induced damage is purely a problem with white skin people. Now, we're finding benefits here, you know, we're finding benefits of UV in terms of cardiovascular benefits. We know about vitamin D and rickets and bone health. And first of all, I think dermatologists don't see those systemic benefits. And secondly, the whole leadership of the dermatology world because it's been a European and American specialty. The whole leadership has been white skinned for the last 100 years. And I think it's been unconscious bias. They, people looking like me. I work in Africa, I look at people like me in Africa, or Texas, or Florida, and I see UV skin cancer. Um, and I don't see the systemic health benefits. I think we've had this unconscious bias rather than saying there's risks and benefits. And I think if we'd had a more diverse leadership of Dermatology. If one of my South Asian colleagues or one of my African colleagues have been there, they wouldn't have said skin cancer the real problem they would have said I never seen skin cancer. And I think it really reflects actually the lack of diversity of the derma.

Peter Kotanko
And that's a very interesting aspect you bring to the table here and in maybe this this series on kidney medicine and biology helps a little bit to address this also and gives you a forum to really speak up about this. Now, thinking of interventions, do you first see that UV lamps will actually become part of the of the armamentarium to treat high blood pressure?

Richard Weller
I go carefully here, because of course, the sun bed industry loves me, they're all over me. Would I like to go and give a talk here? Would I like to go and do that …? No, I just want no conflict. So please, I just want to keep away from this. So we know that artificial tanning lamps. UVA lamps are a significant risk factor for melanoma because it's really very intense UVA. And I am concerned about that, and I think you need proper trial evidence. So yes, we need to consider that. I've just done a clinical trial of using UVA lamps, results, which we'll publish soon, which I hope will give some hard data on the risk benefit ratio. And it needs to be assessed by the scientific and medical community, not by anybody else. We are good at data. We are good at saying you know how many views. Yes, I want cynics to be saying to me, I'm gonna approve this because that's how it works. That's good. We need the cynics. I am cautious about this, I have to go quite carefully because I don't want people rushing out and burning themselves. I think it is a possibility I think we need to know more about for the effective wavelengths. So for instance, in dermatology, we really revolutionize work coming out of New England, out of Boston years back, in which we defined the exact wavelengths which are most effective for treating skin disease. So we use 311 nanometre lamps to treat psoriasis and eczema, fantastically effective, incredibly safe. Because the energy is focused into the really effective wavelengths, you know that where the action spectrum curves have got the best, the best interface? least damage? most benefit? 311 nanometers is the sweet spot. It'd be great if we could find such a sweet spot for blood pressure. But I think that current lamps out there are too crude and we know they are a risk factor for melanoma and melanoma is the bad one. But

sunlight you know, the real stuff we've we evolved living outside in the sunlight we are evolved to If like me, you're a north, you know, you're a white skinned person in North Europe. That's what you're evolved to. If you're a South Asian person in India, that's what you're evolved to, you know, we have, evolution has given us all these different skin colors, depending on where we've ended up on adapted to different amounts of UV. So, yeah.

Peter Kotanko
Richard, just a question around the future. What kind of developments are you foreseeing? My understanding is you would want to identify specific wavelengths that may offer this the largest benefit of a risk ratio. And do you foresee larger randomized control trials? What's that? What are your thoughts around that?

Richard Weller
We did a randomized Sham crossover trial. And the big problem we had actually was technological, because the existing lamps we have the trials and people are, you know, fluorescent bulbs, and they weigh 50 kilos, huge, great lamps quite difficult to handle, particularly here in Edinburgh because you know, it's an old city. I live in a 200 year old apartment, which is kind of middle not particularly old here. Most people live in 100 year old apartments without lifts. And we said to the courier company delivering these lamps to people for whom food served from blood pressure, can you carry this 50 kilo lamp up three flights of stairs? And I won't for polite society give the reply, but it was no. So you know, the existing technology is difficult. But of course with LED lamps and new technologies coming in, this is changing rapidly, but it's going to make it much easier to develop practical solutions. Yes, we need to work out the wavelengths that matter. Skin color really matters. It is as we have moved, skin color is what mediates the interaction between sunlight and biology. You know, we have evolved different skin colors around the world to cope with different amounts of UV that's why we have different skin colors. That's what it does. And I think we need to be looking quite significantly at the effects of skin color on response because that really is what is going to determine it so we need to look at that, mechanism is, do you exhaust your nitric oxide stores are the mechanisms beyond nitric oxide? So Anthony Young down at the Institute of Dermatology in London that some nice trials looking at gene expression in people given photo therapy, and he showed that that UV up regulates and down regulates different cohorts of genes. And actually some of the genes which are regulated are blood pressure control genes. So I think there's mechanisms beyond my nitric oxide one. And I think we need to be looking at those other mechanisms. The problem is we have only focused on the adverse side of sunlight. And we just haven't thought about other effects, we've got this entirely one sided view of this big environmental, environmental input. So lots to do, and I cannot sometimes feel I'm all on my own, I want other people to get in on doing this. I'm dermatologist. Do you know, I'm a dermatologist and we, we feel we've owned UV. I, you know, we put a lot of, we put a lot of the groundwork in, I'm terrified that renal physicians might run along and steal all the interesting stuff from us. So you know, I wouldn't be good if other people got into it.

Peter Kotanko
Richard, it reminds me a little bit of this story about the gut microbiota. When I started med school, bacteria in the gut were kind of you noticed the bad side of the, of the biology and they

were in the we will train how to use antibiotics to destroy them and clean them, and so on, so forth. And now, now it's more than obvious how vitally important this this compartment is. And I, I think that maybe the same will happen with the perception of, of UV light. Now, you actually gave a terrific TED talk on this. And I'd really like to know, how was this received? What kind of reactions did you get from the various quarters be it be it the interested public be it? Be it colleagues? Or what was the reaction there? Well, that

Richard Weller
It was a great experience. And I have to know what a TED talk was when I was asked to give it. And I, you know, I threw some slides together. And I paced up now for about 20 minutes saying to my wife, what I thought I'd say, and it's had 1.3 million hits. My mother accounts for a million of those. But I mean, there are 300,000 individual hits as well. Yeah, I mean, it's been really well received. And it's a great, it was a great means of, I suppose getting the idea out to the public, because you need to sit down and spend 12 minutes on it. It is getting out to the dermatology world. There's a big, there's a kind of problem, but it's a real crossover project. So you know, so here, am I, a dermatologist, looking at renal patients, dialysis patients with an environmental input, UV, with a cardiovascular output, blood pressure, in it? What is it? Is it dermatology? Is it renal? Is it cardiovascular? Is it environmental sciences, so an absolute? So I'm kind of outside my tribe, and, you know, dermatology meetings will have a section on UV, they will have three sections on UV, they'll have skin cancer, obviously, they'll have photo dermatosis. That's the other rashes caused by sunlight, and have a public health section, which is basically how do you stop people getting into sunlight? And so I can produce work, which is very highly cited, goes in excellent journals. It's really interesting, but there is nowhere for it to fit into a dermatology meeting, because there is there isn't a badge session that fits it. And, you know, who am I to tell cardiologists how to do cardiology, or renal physicians how to do renal medicine, you know, it's a kind of, it's a sort of crossover thing, which is why it's exciting, and it's why I enjoy it. But it is a I just wish I got a home. You know, I wish I could say that's the meeting where are the other people doing UV systemic health stuff, and it's such a place doesn't really exist yet.

Peter Kotanko
I totally understand the enthusiasm for these areas where intersections happen between various fields because it's my firm belief that’s exactly they are where progress happens. Progress happens when, when science becomes diverse. When we, when we see , these areas of intersection between various disciplines and that's why at least from for me personally, it was such a such an eye opener to see you talk at the American Society of Nephrology to give an invited lecture there and to see you target the Renal Research Institute conference a few years ago. So I, I really feel that this is the way to advance the field. So, just to wrap this up, I mean, what would you give as an, in two or three or four sentences, as an advice to, to the general public, to the interested general public? In what, what in a few words, is really the, the essence of her research over the many, many years? I know, it's a difficult ask. But yeah, let's give it a shot.

Richard Weller
Yeah, so I start with my dermatologist hat by saying don't get sunburned. You know, getting a sunburn is bad for you don't get sunburned. I think beyond that, honestly, I would just relax a

little bit more about it, I wouldn't get over anxious about it. You know, don't smoke, take exercise, eat sensibly, don't get sunburned. There's more to sunlight than just the damage it does. And I think we need to be thinking about that risk benefit ratio. But to calculate a risk benefit ratio, we need to know the benefits, not just the risks, and that really applies to sunlight.

Peter Kotanko
Richard, in these days, there is hardly a conversation without COVID. And I don't know, is there actually a COVID aspect to your work?

Richard Weller
Yeah, so who hasn't thought about COVID and how they can save the world by recalibrating their search. Sure, so there is we had a paper published last week, or you know that the manuscript is accepted by the journal is being typeset at the moment. So when COVID cropped up, got it a year and a bit ago, it's been a long year, hasn't it? You know, initially we were thinking respiratory disease, it's gonna be behave like flu. And I had kind of early thoughts that well, it's another respiratory physician. But then the data started coming out that actually cardiovascular risk factors, you know, heart disease, high blood pressure, diabetes, significantly increase your risk of dying from COVID. And I thought, well hang on in some of the work I've been doing is showing that sunlight, reduces blood pressure reduces risk factors for cardiovascular disease, even diabetes, so maybe we're going to have an effect of could there be an effect of UV on COVID deaths. Now, traditionally, you've kind of waited for seasons, you know, you've watched things cycle, you know, we have winter flu, epidemics, and all these sort of things. And three months into the COVID pandemic, well, that's one season down, you've got to wait another three seasons before you can do anything except Johns Hopkins started that amazing. I'm collating all this data, around COVID deaths initially in America. Now, of course, America is so big, you've got different amounts of UV falling all over it exactly the stuff we were doing Peter with blood pressure. I got together with one of my colleagues here in Edinburgh, who is a geographer who looks at remote sensing data. And we were able to look at COVID deaths at county level in the United States, between January and April of last year 2020. But we could then look at the UV falling there. But we could then do some really quite complex modeling. Because if you're going to die of COVID, a few things have to happen. You have to meet somebody with COVID, you've got to get affected by it, you've got to get sick, you've got to not respond to treatments. And then sadly, some people will die. Now there's are all different events between being healthy and dying, of COVID. And they've all got different things influencing them. So the first thing we had to correct for was your chances of catching COVID. So the first bit of the model, we corrected for population density, and the proportion of the population with infection. Clearly, if you lived in Manhattan, in whenever it was, March 2020, you know, you were bumping into masses of people on the subway with COVID. If you lived in Montana, you know, you see a person a week they're in their truck, you're indoors, so you know, entirely different risk factors. So we first of all correct for population density, and things like that. We then put in a second array of corrections for things that we know affected your risk of dying from COVID, so age, ethnicity, social deprivation, air pollution, lots of factors like that. And we then do all sorts of complex modeling at a higher order effects or the state level affects different health systems in different states, different cultural things, whatever, put it all together. And we could then cross reference basically UV and COVID deaths. And the other thing we did was we then excluded the counties

in America, where vitamin D forming UV was forming. So not all sunlight makes vitamin D, only short wavelength UV mimics it. So we basically excluded the 20% of counties, which between where between January and April there will be vitamin D foam. So we looked at the, what we call counties, and now we call it the vitamin D winter, the 80% of American counties, two and a half thousand counties, where vitamin D wouldn't be food. And we found a straight line dose response curve, more UV, less COVID deaths. But we then went, and we repeated the study in Italy, and in England. And these were effectively separate studies, because the way you collate all of this data in a structure is ethnicity, social deprivation, in Italy and England have different ways of measuring this, all of us measure it, but we measure it in different ways. So effectively, it was three different studies. Each study showed the same thing, more UV less COVID deaths. Very exciting. It was published, las, well, it was it became You know, it was accepted went online last week. And yeah, so really exciting stuff.

Peter Kotanko
So fascinating, really fascinating work. And I, I hope it helps also to bring, in addition to vaccination, in the causalities caused by COVID, down in the, in the summer in the Northern Hemisphere.

Richard Weller
And Peter, you're absolutely right vaccination. So when we become at the site, and we thought it'd be a fair bit of precedent trust in it. And before it came out, we had a little kind of chin wag, between us working out what should be the key, you know that the one line a message, and initially we said, vitamin D independent effect, you know, more sunlight, not me, that was opposite. However, what was really interesting, unfortunately, the people that picked it up on the Twitter in the Twittersphere, are the kind of vaccine denying thing where the mask, don't take the vaccine, that whole kind of alternative subculture picked it up. quite frightening. They'll say, oh, look on the site you didn't even ask. So we have switched our message. So whenever I'm talking to someone, I say, get the vaccine. follow your government's advice on masks, social distancing or whatever. Sunlight probably helps a bit too. Yeah.

Peter Kotanko
I think that's really important message me and but it's so interesting to see that actually being outdoor with social distancing. With all those and non-pharmacological intervention in play. Maybe. But maybe really adds to fighting this pandemic and keeping the death rate low. Okay. Thank you so much. I really want to thank you, Dr. Weller, for this wonderful conversation. I personally have learned a lot through us working together over the past years and have learned a lot through this conversation here. Really, thank you. And I wish you all the best for your future research, and stay safe. I hope that your work really helps to bring fields together, because it's the only this is where true innovation, true progress. happens. So really, thank you.

Richard Weller
So Peter, thanks. I've loved the conversation. And I've loved that work together. So many thanks for this invitation I've really enjoyed it.

Peter Kotanko
Thank you for joining the renal Research Institute for this episode of Frontiers in Kidney Medicine and Biology. We invite you to engage with us on our social media channels. And look forward to seeing you again soon for the next episode of Frontiers in Kidney Medicine and Biology.