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Breath-Analyzing Laser Technologies to Assess Health: the Optical Frequency Comb

Every New Year we look to the future and dream what is impossible. ReachMD radio is proud to present our special series Focus On Future Medicine and Genetics.

We are all familiar with the use of breathalyzers to determine blood alcohol contents, but according to new research breath testing could be a regular part of the primary care exam. Welcome to a special program focusing on the future of medicine, I am Dr. Larry Kaskel your host and joining us today are two scientists from JILA, a Joint Institute of the University of Colorado in the National Institute of Standards and Technology Dr. Jun Ye and Dr. Michael Thorpe whose research has shown that markers for disease such as asthma or cancer can actually be determined by analyzing trace molecules in the breath using LaserLight.

DR. LARRY KASKEL:

Doctors welcome to the show.

DR. JUN YE:

Thank you. It is great to be here.

DR. LARRY KASKEL:

So, Dr. Ye lets start with you. Can you tell me a little bit about how we can actually or explain how breath is analyzed by a LaserLight?

DR. JUN YE::

Yeah, this is true. Human breath contains many different types of molecules. In fact, a 1000 different kinds of molecules coming out of our breath and some of which the so called biomarkers and they are associated with certain disease, states, or environmental exposures like you have been to the bad place and you come back, your breath will contain some of that residual molecules and each type of molecules has a very different distinct signature patterns of absorptions the way that molecules interact with light. So, we can now use a very special kind of LaserLight that can allow us to force through all kinds of distinct molecular absorption patterns. In doing so, we can know from the breath what kind of molecules. How many of them are actually contained in there and from that once you can make a link between the existence of these trace molecules, so called biomarkers to the diseased state, you can now make a diagnostic

recognition of a particular human disease conditions or environmental exposures.

DR. LARRY KASKEL:

Dr. Thorpe can you tell me a little bit more about the information that is contained actually in the mixture of gases that we exhale, besides what I felt it was just carbon dioxide.

DR. MICHAEL THORPE

Yeah, so this is, I guess the answer to that is that in your breath you got the main constituents which are the nitrogen and oxygen, CO2 and methane and then there is about a hundred parts per million of gas left over that is <_____> said there is thousand different molecules. The information we know that contained in these molecules is very large, I feel it is still at its infancy, so we don't understand a lot of the molecules or the concentrations yet, but what we do know is already there are a handful of diseases may be 10 that have been linked to the presence or elevated concentration of these molecules and with tools like our new laser system that can look at very many molecules at once and correlate them to disease conditions, we hope that we will be able to extract much more information and <_____> able to a few more diagnoses and also monitoring of diseases or even monitoring of therapies using this technique.

DR. LARRY KASKEL:

So, how exactly does the laser works so that you are really just capturing exhaled breath, I mean do you breathe into a balloon, do you breathe into a bag and then attach it to some machine take me through that.

DR. <_____>:

Yeah, join again. Yes, indeed the breath, for example, can be first captured into a sample storage bag and then we can connect the bag into a little chamber that we made. In the chamber contains <_____> inlet for those human breaths to go into and it is actually containing a space where the LaserLight can zigzag between 2 mirrors and it is very <_____>, allow the LaserLight to go back-and-forth, back-and-forth to interact with these molecules to extract the information of how the light is interacting with different kinds of molecules and so basically we can control what kind of gas goes into our laser detection system and if just by analyzing a light afterwards we obtain the signatures of the trace molecules.

DR. LARRY KASKEL:

So how big is this machine? It sounds noninvasive, but you know is this some giant computer machine that you need to send it off to a lab or do you think Michael, one day it will be small enough to <_____> fit in a doctor's office.

DR. <_____>:

Yeah, will, so already we can built these things kind of the size of a large microwave oven and then <_____> you breath into a bag that is attached to this device and you get your results. In the near future it is not unreasonable to expect that these things get even smaller may be the size of the typical computer monitor or smaller, yet so, it is not a huge device.

DR. LARRY KASKEL:

So then how is the information translated for the doctor, because you know we are not PhDs, we are just slowly MDs and we kind need to be told how to interpret these things, does it print out a certain parts per million or does it say, oh this person has a cancer somewhere.

DR. <_____>:

That's actually an excellent question. This is essentially the missinglink that you are right on the spot. The machine can tell us, essentially we can print out a chart of a hundred typical molecules that might be linked with certain disease and we can tell you, you know parts per million or parts per trillion how many of these molecules are there in the breath in a different kind of molecules, but in terms of making the <_____> okay here is the presence of 3 different kinds of molecules and oh you are sick with asthma or you are sick with the lung cancer. In order to make that <_____>. In fact, the study needs to be done by the community to really; now we have the tools available. This would actually facilitate the special study where you can make a so called a biometrics, where you can list all these different kinds of trace molecules and then do clinical trials to have a <_____> and then <_____> to eventually have enough statistical samples to make a <_____> connections between certain physiological conditions of the patient and the breath to make sure that we can establish now. So, this will answer your question in a really short time and the machine itself gives you a realtime information that your breathing in a minute later would bring out a piece of paper, all kinds of molecules that is contained in your mouth and in terms of making the further steps forward to tell you what kind of disease he might want to be watch it for and that requires further study. I would just add that these studies have been done already for, like as before, a handful of diseases to really extend this to a very large number of diseases that would need to be the further clinical studies.

DR. LARRY KASKEL:

Sure. If you are just joining us, you are listening to the Commission Roundtable on ReachMD XM160, the Channel for Medical Professionals. You are listening to a special segment focusing on the future of medicine. I am your host Dr. Larry Kaskel and I am talking with two scientists from JILA, a Joint Institute of University of Colorado in the National Institute of Standards and Technology Dr. <_____> and Dr. Michael <_____> and we are talking about how we can potentially one day use LaserLight to analyze our patient's breath to determine if they have got some underlying disease such as asthma or cancer. So guys, have you identified clear markers that actually say okay this person has an occult malignancy somewhere in their body because we are seeing this particular marker Dr. <_____> and find that cancer.

DR. <_____>:

So this is Michael again, so far what we have done with our system is detect biomarkers that have been identified in previous studies and so far these have been biomarkers related to things like bacterial overgrowth or bacterial infections in the stomach that lead to ulcers.

DR. LARRY KASKEL:

H. pylori breath test.

DR. <_____>:

Yeah, exactly that kind of thing or elevated pneumonia indicating that you might have some renal failure or some liver problem. We are currently building a system that will be good for looking for some of the biomarkers we expect to be good for cancer such as that contain assay in these, <_____> volatile organic components and so yeah, we are definitely working down these avenues.

DR. LARRY KASKEL:

What would you expect to see if someone had asthma, what kind of biomarkers would be expressed in their exhaled air?

DR. <_____>:

The one that is typically used for that is the nitric oxide, and I think that one right now is somewhere 90 plus percent reliable in diagnosing asthma. Of course, there are some other molecules also, I think hydrogen peroxide is even one that may be carbonyl sulfide. There are few more, that if you can detect all 3 then you can get a very accurate diagnosis and our system is definitely looking to make those kind of measurements.

DR. LARRY KASKEL:

So, you know, you guys are crazy, wild scientists, so I imagine you have done this on each other's breath. What have you found in each other or others you know friends that you brought into the lab to analyze their breath.

DR. <_____>:

We have done a few breath tests and one thing we have seen is an indication of exposure, we looked at carbon monoxide on the breath of someone who smokes and then looked at that same molecule on the breath of someone who doesn't smoke. You can definitely see elevated concentrations of this and we have also looked at the ammonia concentration on the breath of healthy individuals. So far we have not had any renal failure, patient <_____>.

DR. LARRY KASKEL:

I would imagine to tell if someone's is a smoker, you could just say do you smoke instead of doing the laser test on them.

DR. <_____>:

That's absolutely right, but imagine if you had a high concentration of CO in the air in your home.

DR. LARRY KASKEL:

Sure, we would know, right.

DR. <_____>:

And you might not know it or you spent too much time on the interstate and that will become a health problem for you. Things like this.

DR. LARRY KASKEL:

What happens next, how do you take this out of the lab and start doing some clinical trials.

DR. <_____>:

We actually have been talking to a number of commercial companies. In fact, in our research lab is founded by a National Institute of Standards and Technology, US Department of Commerce and one of our mission is ready to help US industry, to really spread out you know, <_____> with the technology associated with fundamental research and spread out to the US industry to really gain competitiveness given next degeneration of our product development. I feel this is actually going to be catching on fairly fast. There are at least four commercial companies that have been talking to University of Colorado and <_____> of the technology <_____>. You know our lab is primarily a physics laboratory. We <_____> you know live on cutting-edge research of what's the next generation of technology and what kind of various problems and once this device catches on to do real medical applications, I think it will grow out of our lab. You would have to go on, you know, have a commercial product and go to <_____> medical doctors' office where you can really go through thousands locations and <_____> is that it will help advance society needs for advanced medical screening and painless diagnosis of diseases and so what we are doing right now is to make the system even more sensitive to a point where if you have only 10 molecules <_____>, you know 10 dangerous molecules coming out of your breath that we can tell and likely before in the previous example both me and Michael were talking about asthma. There are other molecules such as carbon monoxide, hydroperoxide, I think Michael already said, nitrite, nitrate, and so on. If you can detect all sorts of molecules, even though they are very minute amount, but you can tell them in quantitative terms and measure them all at once. The confidence level of diagnosing certain disease just goes a way high. You can almost reach a point where you have 100% confidence to tell a patient after analyzing his or her breath for 5 minutes stating that you would better go the hospital to see this particular doctor <_____> and that is really what we are going for, we have next stage on laser or the underdevelopment will give us this kind of sensitivity and we want to start to bring in medical profession into our laboratory bringing for example cultured cancer tissues, bringing relocation and then try to start to really analyze medically relevant problems and you know have a connection with the commercial companies to help them, assist them to commercialize this technology.

DR. LARRY KASKEL:

Well that leads to the next question, which will be you know you have to get it small enough, when you have to get it cheap enough to be cost effective and then you have to actually get insurance companies to reimburse the test, so how much do you think it is going to cost, I know you can say right now because it is still in the lab, but any ideas of what it would cost in the future to get this into a doctor's office.

DR. <_____>:

I think it will probably be cost effective especially, if it is able to screen a very large number of patients for a unit. Right now just for test setup that we would build in our lab. We spend on the order of 50,000 dollars and that is just for building one of these devices. It is always very much more expensive when you just buying one of every component. So, I imagine the cost can be cut down quite a bit in the future.

DR. LARRY KASKEL:

So you know, other things it might be useful for, I mean can you tell how much somebody drinks; can you tell if people are taking their medicine; can you tell if, you know, what someone had for lunch; you see those as applications in the future.

DR. <____>:

Yeah, absolutely that is actually exactly one of the <_____>, you know this is a diagnosed disease, but also for monitoring the environmental impact on human body. What you have been in contact with? Have you been making bombs at home?

DR. LARRY KASKEL:

You know things like that, it is not only for medical science or medical research, but it is, I imaging for <_____> security, even people who go deep sea diving were asking us can you test this bottle with the pure oxygen or are there some lethal amount of <_____> going deep sea could be in trouble <_____> before even food packaging, was contacting us. Can you sniff those wines, can you sniff whether our food packaging feels secure. We can imagine, once we can ceased sniff out of things here. <_____> kind of molecules contain the information. They can be used <_____> use in the society in many different places and that the key point is this device, it will be inexpensive and it can tell information quickly and that's what I think it was in the long run even if this device costs a 100 <_____> to make one, but the point is the patient can walk in and walk out in a few minutes and have some information <_____> and that is going to be incredible for the society in the long run.

DR. LARRY KASKEL:

Well, it is pretty exciting stuff and I would like to thank the two of you for coming on the show today.

DR. <____>:

Thank you for inviting us.

DR. LARRY KASKEL:

My guests were Dr. <_____> and Dr. Michael <_____> and they are two scientists from a Joint Institute of University of Colorado in the National Institute of Standards and Technology and they were here to talk about some exiting work they are doing on using lasers to analyze trace molecules in our breath using LaserLight.

I am Dr. Larry Kaskel and you have been listening to a special segment on the future of medicine on ReachMD XM160, The Channel for Medical Professions and please visit our website at (www.ReachMD.com) which features our entire library through on demand broadcasts and thanks for listening.

Thank you for listening to ReachMD radio on XM160 and this month special series focus on future medicine. Free CME on ReachMD is now easier; learn to ReachMD free custom application for your Iphone at ReachMD.com.

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