SOURCES, PATHWAYS, AND EFFECTS OF CONTAMINANTS AND TOXICANTS IN RELATION TO CLINICAL PRACTICE

22. Mold Contamination in Buildings: Putting the Causes, Pathways and Health Effects into Perspective

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DR. BALK: Good afternoon, everyone. This afternoon session is about sources, pathways, and effects of contaminants and toxicants in relation to clinical practice. We're going to be hearing about molds, heavy metals, and pesticides—all very important to clinical practice.

Our first speaker is Mr. Vince Torres. Mr. Torres is the associate director of the Texas Institute for the Indoor Environment, at UT-Austin.

MR. TORRES: I'd like to talk to you about a topic that obviously has been making the news a lot, at least here in Texas. Even though the focus for this afternoon is mold, I want you to think about it from the standpoint of mold contamination. As we try to solve the mold problem, we will be dealing with new building materials or treated materials that will resist mold, and then we will have to deal with chemical issues raised by these new materials. We're going to be dealing with ventilation issues, but if we aren't able to improve the outside air, then we're going to have to deal with how do we clean the air up before we bring into the buildings? So when we ventilate a building, we have to deal with the contaminants that we bring into the building in hopes of diluting the chemicals that we have in the building.

I'm going to talk to you about in the context of elementary schools, and the primary reason is because my primary field experience is in dealing with elementary schools. And it's also because I believe that teachers oftentimes get the short end of the stick. I certainly expect my son's teachers to do a good job, but we can't expect them to do a good job if we don't provide them with an environment that is conducive to learning in such a way that they can carry out that mission.

So I feel that if I'm going to be critical of my son or daughter's teachers, then I better be willing to make a commitment to provide them with a facility that will allow them to do their job. That's my commitment to teachers.

First of all, I want to clarify that although people oftentimes use the terms "mold" and "mold contamination" and "mold spores" interchangeably, that's one of the places where we go wrong. First of all, we have mold spores, which are the seeds that will germinate and grow at some later point in time. When people say that they have mold in their home, usually they're not thinking of mold spores, they're thinking of mold growth. Many people that don't understand the difference and don't realize that what we're really concerned with is mold contamination. Contamination, in the context that I want to use it today, deals with a substance in a quantity or a location that causes an undesirable effect. (Figure 22-1)

Mold that might be okay outdoors or on some cheese, if it's in the wrong spot, would be considered a contaminant. So I use the term "contaminant" and "mold contamination" when I'm talking about mold in a quantity and location that is causing undesirable effects either to the humans in the building or to the building or property therein. We're never going to get rid of all mold in all buildings, but we can certainly get rid of mold contamination that is causing health effects.

I also want to clarify the myth that mold problems just started. Actually molds have always been around. They're mentioned in the Bible. They're all around us. Hopefully by the end of this session, you will appreciate the fact that there are a number of different molds. Some of them are what we refer to as indoor molds. Some of them, we refer to as outdoor molds. Some are bi-molds, and can be in both environments. Those molds that tend to grow indoors, and that cause the greatest health concerns, are not necessarily the ones that we find outdoors.

A few characteristics of mold will help us better understand these issues. So many times I have had parents call me and ask "Do I need to have my house checked for mold?"

I answer "Is anybody experiencing any symptoms in your home?

"No."

"Is there a problem that's visible in your house?"

"No."

"Is there anyone in your home who's recently had surgery or is immunosuppressed?"

"No."

"Well, then why are you concerned about mold?"

“Well, everybody else is, so I figured I should be, too.”

We need to understand what molds are and why they can be a problem. First of all, molds are heterotrophs. That means they cannot synthesize carbohydrates, and they need a carbohydrate source for their primary nutrition. In most cases, this is a cellulose-containing material, but it can also be a protein or amino acid type material. For the most part, molds are looking for organic materials that have a carbohydrate source that they can use. To get this source they produce enzymes to digest or break down the carbohydrates in the nutrient source on which they are growing. To some people, these enzymes can be very allergenic. Not all molds produce enzymes that are harmful to all people. And incidentally, we've only characterized about 100,000 molds to date, and there are probably up to 2 million different mold species out there, so we really don't know all the different molds and all the different enzymes and chemicals that they produce. The most important thing to remember is that molds require water in order for this digestive process to take place. As the enzyme, which is very water-soluble, absorbs water it then becomes a catalyst to cause the digestive process to take place. This is a very important concept, and different species require different amounts of water.

The molds that we typically find indoors, the ones that cause problems, are the ones that can grow with very small amounts of water. These also tend to be those that can become aerosolized in the indoor environment versus those that become aerosolized outdoors.

Also different molds optimally grow at different temperatures. The ones that characteristically like to grow in the indoor environment are those that tend to grow best in temperatures of about 65 to 75 degrees Fahrenheit.

Most molds are saprobic, they live off of dead matter. However, some, those that can exist at body temperature, can be parasites. Some molds are symbiotic in that they live and work together with other microorganisms in a specific environment. But for the most part, most of the molds that we're familiar with live off dead matter, and that's why they're good, because they help decompose materials outdoors. But when they start decomposing the materials indoors, then that's obviously not desirable.

Molds also tend to be eukaryotes in that they are cell-forming. They are single cell and multicell organisms. The cells are composed of chitin, glucans, polysaccharides, and mucopolysaccharides. The thing to focus on is that the glucans are often endotoxin-like in nature when they come into contact with humans, and so they can be irritants.

Their sporulation and dispersion are highly dependent on the environment: Outdoors certain types of molds depend on the rain to sporulate. Other types of molds depend on a dog brushing against them or the wind to sporulate. Some of them require light in order to sporulate. So there are different characteristics that different molds require in terms of water, temperature, etc, in order to sporulate.

The outdoors, as you know, can go from one extreme to another. But indoors, we tend to try to keep our buildings at fairly controlled temperature and humidity. For the most part, the light inside of a building tend to follow a particular pattern, and so the growth and sporulation pattern indoors differs from that outdoors.

Molds that tend to grow indoors are not the same molds that tend to grow outdoors, in general. Why do we have molds that grow indoors? We've gone through considerable change in the design of buildings over the past 50 years or so. We went through a period after World War II when the G.I.s came home and wanted to have new homes, buildings. We respond to that by building houses quickly and not necessarily well.

I was raised not too far from this location, right here in San Antonio, and my mom would always talk about the prewar homes versus the homes that were built after the war, and how the quality of construction was different.

The materials may have been the same, but the quality of construction was different. Then we went through a period where people couldn't keep up with the building boom, and so they came up with new materials.

Then we went through an energy crisis, and we started building tight buildings, with insulation in the walls of the building. I grew up in a home that didn't have air conditioning, and so it was always open, and so the indoor air was exactly the same as the outdoor air. But putting insulation in the walls reduced the drying capability of the walls, so if those walls got wet they didn't have the ability to dry as readily as the ones that I grew up in.

In addition to that, the envelope is on. We no longer design buildings to shed water. We use different materials of construction, and these new materials of construction do not absorb water. (Figure 22-2) Believe it or not, brick absorbs quite a bit of water. A brick house is able to absorb a lot of that water and acts as a buffer when drying out. If you have a steel building, how much water does steel absorb? Zero. So if you get water in that steel wall, where is it going to go? If it can’t go outward into the brick, it's going to soak into that chalk and paper we use on the inside of walls—the so-called gypsum wallboard. So now there is a place for the water to accumulate and for mold to grow.

Then there's the use of HVAC (Heating Ventilation, Air Conditioning) systems in buildings. As we put HVAC systems in buildings, we create cold spots. If hot, humid air makes its way into the building, and if you don't have vapor barrier in the right spot, condensation will occur on those cold spots. Condensation, just like on a cold glass of water, is going to form water droplets, and that provides a source of water for mold to grow.

I got involved in a problem in my children's school. Teachers were being taken to the hospital at the rate of about one every other day.

We had a total of seven teachers that ultimately went to the hospital for respiratory problems, and when we finally got into the school building and we started taking things apart, on every interior wall about two feet up, we found Penicillium chrysogenum mold growing throughout the entire building. Now, this school was about 30 years old. It had been notorious for water leaks, and in a lot of these walls, there was also had mold growing from the top down. In addition to that, the school was undergoing a renovation or expansion—they were adding a library. They had employed very poor construction techniques and had actually brought a lot of dust into the building itself. And so you had dust, you had mold spores, and you had water that had been coming up from the floor in the building. The school had been built in such a way that rather than the water draining away from the building, it actually drained underneath it. So there was a vapor pressure difference that allowed water to travel through the concrete floor.

I got involved because I do this kind of work, and ultimately we vacated the school. I received a lot of criticism from my own colleagues in this regard. They said "You realize you've set a precedent here?"

But this was a case where all the factors combined to produce a disaster. We didn't have a place to put children within this school. The mold was growing literally on about 45 to 50 percent of every wall. The poor air conditioning system could not sustain the low humidity that was needed to control the environment. With water coming through the floor, and with the roof leaking, how can you justify keeping kids in a school like that?

And the teachers were getting sick and could no longer work in that building. We had two teachers whose medical doctors prohibited them from being in that building. They would leave the school and they would get better, and then when they'd come back, as soon as they came back to work, they'd get sick again.

As we all know, to have an exposure problem, you've got to have a source, a pathway, and then ultimately, the host that receives it. I'm going to talk a little bit about the environmental pathway. How does the mold get from where it's growing to the victim. Well, there are a number of different ways, and these are some of the major ones. (Figure 22-3) First of all, our buildings often operate under negative pressure, meaning they suck air instead of blowing it out. This means that outside air can be drawn through the walls, and if mold is growing in the wall it will get picked up by that air moving through the wall.

With HVAC systems, if you've got mold growing somewhere in a building, it can be picked up in certain areas and redistributed throughout the building. If the fresh air vents are closed, the HVAC system basically recirculates it to other areas. So the mold, or mold products, get into areas where the mold is not actually growing. The amount of outside air for ventilation is critical. If you don't have proper amounts of outside air, then the contaminants will continue to increase, and so you can get to levels that can be uncomfortable.

People may have direct contact with materials where mold grows, on the floor, on furnishings, or on pets. The aerosolization of mold spores is another method that the mold gets to the person. The smaller and lighter molds are very easily captured in the air flow and can be aerosolized quite easily.

With children we've got a breathing zone issue, particularly in elementary schools for children. In the kindergarten area, they all play on the floor. If the water is coming in through the floor then the floor and the lower part of the walls are going to be most involved with mold growth. So you're dealing with extreme amounts of exposure in terms of potential path of exposure because of where the mold tends to grow.

The amount of time spent indoors is another factor. Children will often spend a tremendous number of hours indoors. Who spends probably more time indoors than the children? The teachers. Okay.

Another variable is the molds themselves. Different molds and different strains of molds will generate different types of byproducts and different enzymes. Some are more allergenic than others. Some, but not all, molds produce mycotoxins. (Figure 22-4)

The substrate that the mold is growing on can be important. I read an article where there was a building material that had arsenic in it to prevent mold from growing, but the mold had actually started to grow, and it had digested the material and released arsine gas.

The host pathway is important—dermal contact, inhalation or ingestion. The amount of the ingestion and the duration of the exposure are important. We talked about the susceptibility of the individual. Children are going to be more susceptible. The elderly are also much more susceptible, because typically, they're in diminished health. Immune-compromised patients, people who are hypersensitive to different antigens, and asthmatics and others with respiratory problems are also going to be especially vulnerable.

There are other factors. Unfortunately, the research in this area is very limited and fragmented. We've typically responded to epidemics. We have limited epidemiological studies. We focus a lot on case studies. Controlled laboratory studies do not mimic well what's happening in the very complex field in terms of confounding chemicals, dynamic conditions, changes in the air conditioner setting on weekends, changes in relative humidity, and changes in temperature. We depend a lot on animal models, but many of the animal model studies have been done with direct intravenous injection or ingestion of the mold product. Some of the work deals with human ingestions, and the food industry has done a significant amount of work. But of course, how do you relate ingestion to inhalation?

Let me talk very briefly about health effects. (Figure 22-5) I'm going to talk about them roughly in the order to which we've clearly identified the causes of these different health effects.

First, the hypersensitivity diseases—allergic rhinitis, conjunctivitis, sinusitis, pneumonitis, and asthma. We also have irritation, and often people think that it's all allergies. Well, irritation is different. Mucous membrane irritation can be due to glucans or Volatile Organic Compounds (VOCs). Some of the mold VOCs are very similar to chemicals that we know cause problems—ketones, ethanols, acetone, benzene, xylenes, toluenes. We see trigeminal nerve stimulation. Some of these different chemicals cause a trigeminal nerve to respond, not necessarily an allergic reaction. And if the concentration of some of these chemicals gets to be high enough, we see headaches and dizziness.

Infections tend to be one of the least frequent effects, unless you're in a hospital setting. (Figure 22-6) Most of the infections tend to target people that are immune-compromised. So for the most part, infection is not generally found in the average home. On the other hand, if you have somebody coming home from the hospital who's had a liver or kidney transplant, then you need to be much more concerned than for the average individual. And if you have children with certain developmental problems where their immune system may be compromised, they also are in a special high-risk category.

In terms of toxicity, probably the three most generally agreed upon toxic effects of molds are 1) immunosuppressive activities inhibiting macrophage function in the lung, 2) direct toxic effects in the lung causing cell wall disruption, and 3) carcinogenic effects. The mold product, aflatoxin is recognized as one of the most potent natural carcinogens known.

I'd like to offer a recommendation, and bear in mind that I'm not a medical professional. So I'm not trying to practice medicine. (Figure 22-7) What I find in trying to solve people's problems as to what is their exposure, I find that their pediatrician or their allergist doesn't make a connection between what's going on in their school or their home environment and the symptoms that they are experiencing.

Water can contribute to mold contamination. As high humidity, water can contribute to dust mite problems. High humidity can also increase the amount of bacteria found in certain environments. So it's really important that some inquiry be made about the home or school conditions, especially if the pediatrician or allergist has not been able to diagnose any other more traditional causes for the symptoms.

DR. BALK: Thank you very much. That was very informative. We are trying to get our colleagues to take good environmental histories, as you're suggesting.