Montana
Asthma Control Program
Chronic Disease Prevention & Health Promotion Bureau

Webinar transcript: Spirometry, a key measurement in diagnosing and treating asthma

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Bill Pruitt: So, today we're going to talk about spirometry as a key measurement in diagnosing and treating asthma. I am a certified asthma educator and I was really glad to hear from Anna and her introductory talk that you guys have that opportunity, to get some support and take that exam. It's been valuable for me. I thought I knew about asthma until I really started getting ready to take this AE-C exam. So, if you get a chance, I would encourage you to do that. My contact information is on this front screen and if you need to get in touch with me you might want to take a look at that, and I'll certainly take emails or phone calls after we're done and in the future, if you have anything that I maybe can help you with, I'm willing to do that. So, let's get in touch.

Being from the south I use the term y'all a fair amount, so hopefully you'll get along with that, I could say you guys but it's just not part of my nature.

My conflict of interest, I am on the Speaker's Bureau for Hill Rom and I do some training with them, but there's no conflict or any problem with this presentation, so that kind of clears that off the deck. Our objectives today, I want to take a look at how spirometry is interpreted, how we do it, performing it, and talk about the pre- and post-tests for taking a short-acting bronchodilator, what to expect with those kind of things, the equipment and supplies, we'll discuss that a little bit, look at the testing procedures, and take a look at defining positive tests. We'll do a few cases at the end to help kind of fit this all together and make sense of it for you, I hope.

One thing to be aware of, the asthma guidelines, how do you take care of people with asthma, we operate a lot of times here under the what we call the EPR-3 guidelines or the NAEPP guidelines. You may hear them referred to either way. You can see from this slide where those originate from, through the National Institutes of Health under the National Heart Lung and Blood Institute. They established the National Asthma Education and Prevention Program, the NAEPP, and they have now published a third set of guidelines for how to handle asthma. These guidelines are the basis of the exam, for taking the AE-C exam, so I wanted to be aware of that.

There's also another set of guidelines that are very similar, which are published under the World Health Organization in conjunction with the National Institute of Health and that would be what we call the GINA guidelines, or the Global Initiative for Asthma. So, that's a little background and resources for you to go and take a look at the guidelines and understand where all this comes from.

Okay, why perform spirometry? We see a lot of patients here that have kind of a questionable issue, but I don't know what kind of disease process do they have, so this gives us a little bit extra clue and insight as to what's going on for the lung function and maybe helping the diagnosis of a disease or maybe rule out a pulmonary cause, and that points the finger then at a cardiac problem, a lot of times if you have someone who's short of breath, etc. We may do it to check the response to a new medication. We also use it to monitor the progression of disease and how effective are we in treating it. There are times when it's good for a preoperative look at patients before surgery. It's also utilized in gathering data for workers compensations claims, and then the final reason would be for research. So, that's why we do this.

This next slide says it's a valuable tool, but it doesn't stand alone. We really use it to help support or exclude diagnoses, but we need to add to the information we get from history, the physical exam, the history, maybe lab data and imaging as far as radiology results, all this package helps us to establish a diagnosis, such as COPD or asthma, or chronic bronchitis, emphysema, bronchiectasis, cystic fibrosis, it goes on and on, but this is a very important measurement that's very objective.

The problem we have sometimes with patients is that they're kind of poor perceivers, as they say. You ask them how they're doing and they're, oh, I'm fine, you know, that's the response you get when they sound awful or they look like they're having a real hard time, struggling. So, by getting an objective measurement we can kind of take that subjective part out of this and actually do a good baseline measurement and follow up as we go forward, so that's an important part of this. It's unfortunate there are a lot of offices and practices out there that are dealing with pulmonary patients that don't do spirometry that are kind of flying in the dark and they don't know just where are they as far as severity or progression of the disease or whatever.

For undiagnosed patients there's also, we have a suspicion of lung disease, well they may be presenting with what I call the four classic symptoms. They may be wheezing or complaining of chest tightness, usually shortness of breath or dyspnea on exertion, and then cough, with asthma a lot of times we see maybe all four of these, COPD tends to, people don't talk about chest tightness, but they will do that, you'll hear about wheezing, shortness of breath, and coughing with them a lot. So, as far as what kind of clues, what kind of signs and symptoms, that's kind of where we start.

When we do spirometry, we are looking at measuring volumes and measuring capacities. We have four volumes and four capacities, and you can see on this screen we're actually trying to measure what we call the vital capacity, which is right here and that's why it's circled in red, that's where spirometry lands. If we have somebody that we're trying to do more exploration, we need to get lung volumes, and the lung volumes that we cannot measure with spirometry would include residual volume here, and that's part of what we see for functional residual capacity here, and total lung capacity here, so these are not measured with spirometry, so if we have to do a further investigation and go deeper into a case we would have to get lung volume measurements, and that's what we are trying to gather, and then the

third major test we would do to do a complete pulmonary function test would be to do a diffusion test with carbon monoxide.

So again, this slide shows us the four volumes or four capacities and this kind of separates it out. We're doing tidal volume breathing here, if we take a big deep breath in here we're actually moving through tidal volume and inspiratory reserve volume, that's what we call inspiratory capacity, and then when we blast the air out we move down here through the vital capacity and then we've come back up to normal breathing. So, we get, the volumes and capacities are listed except for these three, the residual volume, functional residual capacity, and total lung capacity, and those cannot be measured by spirometry, we have to do that with other devices.

So, how often should we do spirometry? This is based on the expert panel review-3 guidelines or the NAEPP guidelines, that was the 2007 publication from the NHLBI we showed you. Lung function measurements with an initial assessment of a patient, after we've had them started on treatment and they've stabilized and symptoms are looking pretty good, so we're looking for kind of a check and see are we getting them close to normal function and being able to do what they want to do and having asthma and good control. Then the third item here, anytime we see a patient changing condition, you're going maybe downward or there's a loss of control, we need to check the spirometry. And then the final point would be once we have somebody who's kind of moving along well and their asthma has some pretty good control, we should at least every one or two years apart do a repeat on the spirometry to see how we are doing as we move through time.

This next slide talks about what we may have, an overview here, where males tend to have higher values than females because we're bigger, height will increase our volume and also our flow. Our lung function tends to plateau at about 25 years old and then we start on a decline from that point forward really, so we kind of have naturally occurring emphysema going on as we get older after about age 25, so for those folks out there under 25, good luck! Over 25 we're heading down. You can see lot of capacity decreases, but as that happens the residual volume increases and the trade-off leaves total lung capacity about the same. Again, we have measurements of all our volumes and capacities except these three.

Spirometry is pretty easy to perform with patients at about six, seven, eight years old. I've heard patients, you know, we've had people with some success with five-year-olds, it starts to really get questionable under, you know, about four or five is about it, really, the earliest you could do this. As we're doing spirometry we need to keep in mind, for good test validity, we need to have really good patient cooperation, patient technique, and it needs to be reproducible, and these all rely on good coaching. So, you have to know what you're doing and how to do it, so if you're doing this test yourself, practice makes perfect in a way, but you need to be real aware of the standards. If you're having someone else do your patients and record this information, you might want to look over their shoulder a little bit and do some quality control and make sure that they're doing things the right way, because this

is the, coaching can be a variability in here that you just, you may not get good quality tests if the patient, if the person in coaching is not doing a good job walking the patient through the steps.

This is when I bring a patient in and I'm doing spirometry I have to tell them upfront, this is work! If you've never done this on yourself take an opportunity to measure this on your own and you'll find out what I mean. You don't normally do this vital capacity, forced vital capacity maneuver, it's just a foreign maneuver for us to do naturally, and so you'll find out it is work. This slide now, we're going to start looking at some of the details and what are we talking about, hopefully you've seen this. If not, we do spirometry and capture two different graphic representations that we have, volume time curves, and you can see on the y-axis is a measurement of volume on that, on the x-axis is our measurement of time and the normal flow point or volume-time curve here. This is a normal patient blasting their air out and getting to the end of exhalation.

So, the things we're measuring with this, the key issues here, one would be what we call FEV1, which is at one second in time, and that would be the forced expiratory volume at one second, so it would be right here, measured at about this point on this curve over here on the volume side. So, that would be the FEV1 around in this area, and then the forced vital capacity, so as they continue exhaling, forced vital capacity, to be out at the very end point here, coming back to the volume line. And so, we would have an FEV1 measurement, an FVC measurement, and then we would look at the ratio of FEV1 to FVC.

If you have someone with restrictive lung disease, the curve looks pretty familiar or similar, it's just a lot shorter. So, restriction tends to fall in down here. They have a reduced force vital capacity, but they may have a normal FEV1 and they may have a normal FEV1 percent, or even increased. With obstruction, there's a problem getting air out, so we're now, we're starting to see that FEV1 drop, so their expiratory flow is a lot lower, and as they're breathing, trying to blow out, and blow out, blow out, they're going to tail off here, and actually a lot of machines will only record out to a certain point, you don't have paper that keeps on going and going, so you have to cut this off and maybe restart it and keep this line going on across. So, you may have somebody with obstruction who carries out across this page two or maybe even sometimes three times across the page for a really prolonged exhalation, so that's something to be aware of on the volume time curves.

These are showing some of the quality issues we may run into. Here's a good effort where somebody is really blasting out nicely. Here's where somebody didn't blast out so hard, so they may be holding back and that's part of that coaching and understanding as you do this and listening to the patient, kind of capturing their effort in your mind's eye, so to speak, but that would be a poor effort. Here's where somebody didn't take a complete big deep breath in, and so when they blew out they didn't get their good forced vital capacity exhale because they weren't at total lung capacity when they started.

Here's where someone started to blow out pretty good and they got going and then they may have stuck their tongue in the mouthpiece, or you might have had premature termination of this flow, or this exhalation, some bite down on the mouthpiece, or they close their glottis, which you, as you're blowing

out, need to kind of shut your air flow off by moving your voice box around a little bit, getting your glottis to close, and that may be kind of hard to see unless you see this completely flatten off and no flow. Here's where we have a poor start, somebody hesitating in here, and then here's what a cough may look like. If the cough occurs within the first second, we have to say, we're not going to record that one or keep that one. What we needed, you can cough later on, but you, if it's within the first second, it's not acceptable.

The other graphic representation besides the volume-time curve we get is what's called a flow volume loop. This would be exhalation as we blast air out. When we reach that peak flow here, then we continue to exhale as flow is tapering off. When we get down to the bottom line here, that's the forced vital capacity along this x-axis, and then a lot of times we may have a patient then suck the air back in again to fill back up, so we have peak expiratory flow, we have peak inspiratory flow, so that's what this looks like. So, if you're watching a patient or listening and watch them create this, they take a deep breath in and go blow, blow, blow, blow, keep blowing, keep blowing, now back in again, so that's what a flow volume loop looks like. Keep in mind the normal exhalation, what we're seeing here, the FEV1 divided by the FVC.

What this says is, of all the air you can blow out, of your forced vital capacity, how much can you get out in the first second? The general rule of thumb is we get about 75% out in the first second, so this is what I'm looking at. What this tracing is, as we're doing that blowing out, this is what happens in the first second, and all the rest of this exhalation would be what happens as we tail off and finish that expiratory effort. So, this may be a total of eight or nine seconds, but the first second would be where you see the red on this screen, so keep that in mind as you're looking at and thinking about the flow volume loop.

So, we have the FEV1, that's not showing here, the FEV1 would be measured on the volume-time curve, the forced vital capacity again is going to be measured from the start of exhalation out to the end of exhalation, and then we have a peak expiratory flow at the top, peak inspiratory flow at the bottom. So, those are things to watch as we do a flow volume loop. Here's what disease looks like if we have obstruction. This is the normal flow volume loop, let's say as an example, and you can see here, with mild to moderate obstruction what happens is the patient may hit a good peak flow, but as they're exhaling this expiratory limb starts to scoop out. This is a telltale sign for obstructive lung disease like asthma, like COPD, so as that scoops out we're seeing mild to moderate obstruction, and as this gets worse we may see things like this occur where they may have actually started to not get a good peak flow, so, they can't exhale as hard, as fast, as they used to, and now we really start to get a severe scooping here, so that would be moving more into severe obstruction.

Again, these patterns may be showing up for asthma or COPD, but you have to remember with asthma a lot of times we should be able to reverse that airflow obstruction, so we would see a real clear change from pre- to post-short-acting beta agonist, what we call a SABA, that would be your albuterol product for most all your patients when we do a pre- and post-bronchodilator.

These are some examples of good flow volume loops here, and as we see problems, a patient that has submaximal effort, you can see the peak flow is a good measurement of your effort, so if you blast out hard, you get a good spike up here, it is kind of like a dunce cap or a sailboat sail, as you start having somebody back off, this tends to round over, and if they're just giving you a deep breath and then they do like a sigh then this would just kind of look like a mound in, like this, so this is, you're way up here compared to okay, both of these you can get a good deep breath and blow all your forced vital capacity out, but the effort is going to be showing up here, and then on the inspiratory portion down here for inspiratory effort. Someone who's not at total lung capacity will start to see this kind of a, you've got a fairly normal shape, but you can just see our volumes are reduced.

Here's where a cough occurs, and that's a little dip in there where you see a cough, someone who doesn't start rapidly, they kind of ramp up to this peak flow, so instead of getting a good and kicking it they go ah, kind of ramp up here, and then come off, so that's not a good start, we might have to try again with that. Again, someone who may close their glottis prematurely or stick their tongue in the mouthpiece, it would have a premature stop at the very tail end of their exhalation. This is a submaximal inspiration and, a lot of times, we may not be real keyed in on the inspiratory portion of this because of where really measuring everything and looking at the expiratory part. So, this is okay sometimes, don't worry too much about that unless we think there may be some issues and we'll talk about that in a future slide.

Here's what would happen if you stuck your tongue in the mouthpiece, or you may have something going on, later we'll talk about this in the future slide, too, but there may be something happening in the chest to be aware of if you see this blunting coming across this flow volume loop like that.

Let's go to the next slide, here we go, the ATS, the American Thoracic Society, sets the standards for all our equipment and they have a really good website here, a location on the web to find the standards for pulmonary function testing. So, their statements, they cover all the different states, all the different tests, spirometry, lung diffusion, lung volumes, and also interpretive strategies, and just a lot of good information, if you want to look there, and this also will help be a place to go for a resource when you're studying for the AE-C exam if you want to have more understanding of pulmonary function tests. But these, you can read through this slide what the ATS is setting up for us.

For calibration, we should be checking it daily, using a three-liter syringe, plus or minus three percent for accuracy, using different flow rates, so these are, these are some things to think about as you're looking and doing spirometry for quality issues.

Predicted values, how do we predict what somebody should be able to do on tests? I'll tell patients, we're going to compare your measured values to predicted values, what it be as if you had never smoked, never had any lung problems, everything was normal. Well, these predicted values, if we're looking at what do we consider to be abnormal, my rule of thumb, and it's easy kind of to grab this 80% of predicted, so if you're between eighty and a hundred percent predicted we usually say that's pretty

normal. We're now beginning to start using the lower limits of normal with, it's called LLN, to evaluate and define an abnormality, so either one of these are kind of workable, they're starting to shift more to those lower limits of normal but, I use 80% because this is kind of, I'm accustomed to it, and it works out most of time pretty well. So, be aware of that.

Adults, the American Thoracic Society recommends that you use what's called the NHANES III, with predicted values for patients who are between 8 and 80, that's the national health and nutrition evaluation survey I think is what that stands for. For pediatrics, they recommend using the Wang resource which is down here for the predicted values on the subjects less than 8 years old, so this is something was published in 1993 for predicted lung function between 6 and 18, but they say once you get above 8 years old you'll pick up some good predictive values from the NHANES III.

The key determinants here for getting predictive values are really in three spots. We see how old are you, how tall are you, and are you male or female? That drives our predicted values. It's good to measure how tall somebody is. You may ask them and they say well I'm five nine and you measure nearly five seven and that can change your predicted value, because the shorter you are the less volume you've got, so that's important. Race and ethnicity can also influence predictive values, we also sometimes call these reference values, but either way Caucasian versus African American versus Asian versus other races, other ethnicities, may affect the predicted value. Then we also have results influenced by things like weight, ideal body weight versus actual weight. If you have somebody who weighs 500 pounds and you do spirometry, you're going to expect to see maybe a restrictive pattern. The environment can also affect it, and also do they smoke or not, and then reports-- we get measured predicted, and % predicted when we look at a report.

So, here's an example of the forced vital capacity. We have a predicted forced vital capacity for this patient of 5.28 liters, that would be based on their age, their height, and their gender, sex, so that's predicted. When we measured them with spirometry we got 4.71, the percentage here works out to be 89%. The FEV1, you can see the numbers and they work out here to be 81% predicted and then the FEV1 divided by the FVC, we call this the FEV1 ratio sometimes. This is looking at, of all the air we blow out, how much did you get out in the first second? We're seeing a measured value here at 65%. We don't worry about predicted too much or the percent predicted, this is the real deal right here. Our GOLD guidelines say that if the FEV1 ratio here is less than 70%, you've got COPD. If we see a reduction here that is starting to aim us towards some kind of obstruction, and generally if we have a low FEV1 ratio like this is showing me, we will generally have a very low or a low FEV1, we may have normal, based on that idea of 80% cut off, these are both normal, but you can see this is close to 90, this is close to the very bottom edge of normal.

So, between those two, I've got a low FEV1 ratio, and on any patient, this would be considered an abnormally low ratio and we would want to go on and evaluate them with this. The ideal situation would be to do a pre- and post-bronchodilator measurement to see how does this respond to albuterol.

So again, the ATS is now using lower limits of normal, I didn't put that on this slide, I've been using percent predicted for so long I just kind of stay there, but I should move on up.

When you're doing spirometry, it's ideal, if you can, to withhold these drugs, the short-acting beta agonists like albuterol, at least four hours, long-acting beta agonist like Serevent or even an Advair product, a combination or Dulera, those kind of drugs, if you can hold off and not do spirometry, have them be 12 hours out from those. If it's one that lasts for 24 hours like spiriva or tiotropium it should be 24 hours, if you can, before you get spirometry measurements, and ipratropium bromide or atrovent would be about 6 hours, these are short acting muscarinic antagonists, long-acting muscarinic antagonists. So, another thing we can hope for is that we don't have a patient who's had caffeine or cigarettes before doing spirometry. Caffeine has methylxanthines and it's a naturally occurring bronchodilator and it can affect your results a little bit. Cigarette smoking can cause some irritation and bronchoconstriction.

So, for quality control we really look at six particular things, this slide goes through that. The calibration should happen every day, and as we're doing tests we do at least three tests, and these are done every time, we should have, each time you blast through the machine you should have an acceptable start, so there's no hesitation. They should blow out for at least six seconds if it's an adult, this drops to, I think it's a minimum of three seconds if you're less than ten years old. And then you should reach a plateau or reach an end of the exhalation so that you're really having very little air coming out before that effort is ended, and that, it's like a little trickle, it's less than 25 milliliters change over one second, so every time we blow out we want those things to happen. Then we all want to take a look at the comparison for number four, five, and six. We compare the best forced vital capacities. They should be within 150 milliliters, FEV1 should be within 150 milliliters, and the peak flow should be within about ten percent, as the two best, most acceptable tests. So, that's kind of a quality-control quick run-through.

Another issue we may find out as we're doing testing is, these kind of things pop up pretty commonly, they don't take a good full inspiration, they don't give you good full maximum expiratory effort, they may be delaying and getting that start of the forced exhalation, so they take a deep breath in and kind of hold off a little bit before they really kick off blowing out, they may not blow out long enough, too short a time, or they may actually be leaking air around the mouthpiece. You know, they recommend using a nose clip, so that would be something to look at. So, when we're doing this we want to observe the patient throughout the test and give them good coaching and encourage them to go, keep going.

Possible side effects are listed here. You should avoid it if you've had a recent heart attack or stroke. The vital capacity, this is a description of this, you inhale fully then blast out, blow out forcefully, as long as possible, to reach the end of exhalation, at least six seconds of exhalation, they may go fifteen seconds or more and the directions here kind of sound like this as you're coaching somebody. You should encourage them to keep going until they've blown all the way out. We do at least three of these maneuvers and usually if they can't get it after eight shots, eight attempts, you just say okay, we've tried. Some people don't understand how to do a deep breath and blast out, or they may have

something interfering with the test. We save all the tests that are recorded, but we pick the top three, the best three, for any kind of report.

We can allow a patient to rest in between if needed because this, like I say, is work for them, and you're looking for no coughing, no leaks, they want to give maximum effort, no sigh, so those are the things we look for, and as we do the forced vital capacity again, we're measuring three key issues, the forced vital capacity itself, how much can they blow out with one breath, how much are they blowing out in the very first second, the FEV1, and then that ratio, the FEV1 to the FVC, so, we may call that the FEV1 ratio, the FEV1 percent, or the FEV1 divided by the FVC. Just a little note here, if you have somebody who's blowing out for 20 seconds on exhalation, you can substitute the FEV6 measurement for the FVC and then do all your comparisons based on that.

There are other measurements that come out from the forced vital capacity that are on this slide, I don't want to confuse the issue, these are some of the details that we look at and really, they don't contribute towards diagnosing a whole lot. We may see some major changes with these too with a bronchodilator, so it's kind of something to be aware of, but of these on here the peak flow is pretty, pretty important to look at, patient effort, and then being aware of that forced expiratory time, the FET 100% is pretty important. We have the forced vital capacity recorded in a volume time curve or flow volume loop. We measure at ambient temperature pressure and saturation.

There's a cold calibration when the machine is cold, we blast our air through it, we're blowing out hot, wet air, so it's body temperature pressure saturated so the machine will actually convert these ATBS measurements to BTPS reporting.

So, when we're looking at patients and looking at obstruction versus restriction, this is the important slide for obstructive disorders. They have a limitation of expiratory airflow, so you can't empty out as rapidly as normal, so they have a long exhalation. The examples of obstructive disease would be asthma, COPD, which includes emphysema and chronic bronchitis, and cystic fibrosis. For restrictive diseases, they have reduced lung volumes and often reduced lung compliance, so things like asbestosis for example, or any kind of fibrotic change would be restrictive, or morbid obesity, even pregnancy. Lung resection, scoliosis, these are all restrictive. They have a shorter exhalation time. Here's some examples, interstitial fibrosis, scoliosis, you can see those, so those, that's a comparison on how we're looking at spirometry information, and then sometimes they'll bleed into each other. You'll have someone who smoked for 30 years has asthma and they work around a lot of asbestos, so, but because of all those exposures they could have a lot of the same problems overlaid.

So, obstruction, you can see decreased force vital capacity sometimes, or it could be normal. They usually definitely have a decreased FEV1, their FEF 2575 may come in low, and then that FEV1 ratio will be decreased in obstruction. Total lung capacity for them, if you're looking at the full lung volumes, may be normal or increase, that would be for, like, air trapping or hyperinflation.

On restricted disorders, we have a decrease in our, all our volumes and all our capacities tend to be reduced. So, forced vital capacities down, the FEV1 may be down, the FEV1 ratio could be normal, maybe even increased, and then the 2575 may be decreased. Here our TLC like our forced vital capacity will be decreased with restriction. COPD GOLD guidelines tell us that we start looking at COPD when the FEV1 ratio gets to 70%. You can see that where we are now. Spirometry, when we're measuring just spirometry and nothing else, then we're left with the idea of restriction is a possibility, we can't really confirm it unless we're getting the lung volume measurement and we're looking at things like plethysmography or a nitrogen washout.

Before and after bronchodilator therapy, or a pre- and post-bronchodilator, is very important to evaluate asthmatics because they usually all will have a significant response to the bronchodilator. How we define that significant response, this is based on the American Thoracic Society interpretation guidelines, but you look at a 12% change and a 200 milliliter, 200cc increase, in the FEV1. This is kind of like the favored son, the favored change. Or, you may see that same happen in the FVC, either one of those will give us this idea of being a significant response, and when we see that, that's what we talked about, reversible airflow obstruction. We can reverse it or change it or have a significant impact on it with something like albuterol.

So, the way this is calculated, you take the post-measurements, the post-treatment, subtract the pre-treatment from that and divide it by the pre-treatment. So, we'll see that calculation done to get what we call percent change. Again, asthma patients usually show a significant response, and COPD patients may show a positive response but it's not into that category of being significant unless they have overlap syndrome. That would be someone who has both COPD and asthma.

So how to, when do we do this, if we want to do a pre and post? The indication generally is you have an FEV1 ratio that's less than what it should be. Again, we want to make sure that we don't have a pre- and post-test done when you know they come in and they had two puffs on their albuterol inhaler in the parking lot, then they walked into the office or the lab and no one, we're doing spirometry on somebody who's, you know already kind of bronchodilated so to speak, so we want to make sure that they are trying to get them kind of clean from medication. When we do this, we'll give them a treatment and wait for 15 minutes before retesting so it gives it time for the albuterol to work. So, you can see these are some of the ideas we think about. Giving this medication could be through a metered dose inhaler, this is using a valved spacer device with a kid, pediatric patient, or maybe using the nebulizer here with an air compressor.

And then this is what pre- and post-test information will look like, and this actually shows here's what my predicted volume time or flow volume loop, this is the expiratory portion only, but this would be blasting out to this peak flow and coming off like that, that would be my normal predicted tracing, and this is what the patient did pre-bronchodilator. They blasted out to this point and exhaled, here's that telltale scooped out appearance, and then they inspired back this way again. After the bronchodilator, you can see a real nice jump, and increased peak flow, there's a nice increase all the way down through

this exhalation, they've got a bigger forced vital capacity and then the big inspiratory side here on the volume-time curve, you can see how flat these are coming out, the FEV1 measurement right here.

The forced vital capacity didn't tail off at this end and it actually continued, that was what I was talking about earlier where the FVC kind of continues here because our sheet of paper runs out, so that printer just keeps on printing, but it kicks over here to restart. So, we've had an increase in forced vital capacity and we've had an increase in the FEV1. When we look at the numbers, here's where we see that idea, at least 12%, 12% and 200 milliliters, so we've got a 12, a 25% increase in the forced vital capacity and the actual measured change from 3.14 to 2.52, that was 620 milliliters, so this qualifies for a significant response, where really this is, like I say, this is the favorite son or the one they usually look at first off, as the FEV1 has a 35% change and they increase the difference between the measured value here, 1.59 and 2.14 works out to be about 550 milliliters, so this is a significant change to the bronchodilator.

Notice our FEV1 ratio here pre-bronchodilator, this is the measured value, only 63% post-bronchodilator. It moves up to 68%, but there's still that scooped out kind of look, there's still some airflow obstruction going on, so this, like I say, this is a typical asthma response. There may be something underlying with this too, maybe mixed in with some COPD, or we didn't get a complete reversal, this is not coming down to a complete straight line down on exhalation, but this is a good positive response, a good significant response, to a bronchodilator.

In this test, we've got the inspiratory portion down here, we also have what's called the MVV recorded, that's maximum voluntary ventilation, that's another test all together, but you can see the patient blew out for about another second, they've had a seven second exhalation, went to an eight seconds exhalation, that's a little bit bigger here, but you know, some big positive changes all the way up and down. But, the main 3 are going to be right here at the top. FVC, FEV1, and FEV1 ratio.

The next slide here talks about the COPD overlap syndrome. With these people, if they have both diseases they tend to have more frequent exacerbations, more rapid decline in lung function. You can see here, and there's about 15 to 20% of patients that have a concurrent diagnosis of asthma and COPD, and there is, in the GOLD guidelines, a good description of this overlap syndrome. They give us this information, if you have somebody you think may have both diseases, you want to kind of look at them and think about this asthma COPD overlap syndrome.

So, the post-bronchodilator information here, asthma usually hits, COPD we don't generally see that unless there is the overlap, post-bronchodilator increases of 400 milliliters, we see that a lot of times with asthma, like we just saw that previous case, that big of a jump is unusual in COPD, so if you're seeing it then you may have overlap. There's problems with central and upper airway obstructions as far as fixed obstruction, from maybe a tumor or scarring in the upper airways. You can have variable extra-thoracic problems. You can see this list here, you may have variable intra-thoracic problems going on, and these kinds of things can show up when we look at the flow volume loops. So, for a fixed obstruction you can see this is flattening off, my exhalation, and flattening off the inspiration for the

flow volume loop, and that would be the foreign bodies or scarring. Variable extra-thoracic, like a tumor or weak pharyngeal muscles, tracheomalacia, paralyzed vocal cords, will tend to flatten off the inspiratory piece, so if you're thinking there's a problem in these areas you might want to take a hard look at the inspiratory portion. Then exhalation is limited here if we have like an intra-thoracic kind of issue with a tumor or a mediastinal adenopathy, so there's some guidelines to think about for some of those outliers who have odd-looking shapes on their flow volume loop.

When you're doing interpretation, here's, you know, when the rubber meets the road, so to speak. You want to review your demographics, take a look at your patient's kind of general situations here, check their symptoms, and ask about these. With asthma, it tends to maybe be seasonal or occupational, there's some patterns to it, maybe. You want to ask them once the last time they had a medication that may affect their spirometry, this is important that we take a look at this and see where are they. Look over their history, their chief complaint, include things like are they vaping, are they using hookah or water pipes or whatever, don't just think cigarettes and cigars.

Are there comorbidities? Now, here's the comorbidity list of patients between COPD and asthma. We may also see these other issues popping up, so there's a long list here, and all of these can have some effect on their symptoms, on their shortness of breath, on what they're coughing up, on their spirometry information, so be aware of these different things, the comorbid conditions. When interpreting spirometry, we want to make sure you look at the comments of whoever is doing the tests, they should give you some comments, usually that's typed in on the results somewhere. If they're complaining of chest pain or they're having a problem with frequent cough, they may be unable to perform the test, so that will affect what you're looking at if you're interpreting this kind of away from where that patient is, you may not see the patient, you're just looking at the spirometry information.

Another thing is just look at your graphs and see what the appearance looks like. We've seen that telltale scoop down flow volume loop for COPD and asthma. And then look at the numbers that we have, checking the measured versus predicted values again, looking at 80% as a cut-off as normal or the lower limits of normal, we usually see things moving that direction. Differential diagnosis would include these things. They may have asthma, or you can read through the list. A lot of times, they'll also have sometimes overlap with GERD or the vocal cord dysfunctions. Some of these other issues here, Churg-Strauss syndrome, allergic bronchopulmonary aspergillosis, etc.

So, let's do a case and talk about a couple of these and then hopefully if there's questions at the end we'll move to that. I'm going to walk through a couple of cases and hopefully this has given you a look at how you approach these folks. So, here's a patient, they're not in any kind of order, I grabbed teaching case number 8 out of my file. The 46-year-old female, you can see five feet tall, 116 pounds. She's got early hypertension, says she has been told she has asthma. She has a productive cough almost every day, she has daily wheezing, chest tightness, it occurs more at night, sleeping is interfered with, complaining of cough, wheezing at night and pretty much every day. She's short of breath, has faint

bilateral inspiratory and expiratory wheezes, she complains of reflux. She's got a 30-pack year history of smoking, she quit two months ago. Recently was admitted for pneumonia.

You can see her allergies here, she's got a nice list of pretty common things, pollen, dust, dog dander, that kind of thing, cleaning products. She works as a housekeeper, so being near cleaning products, and she's a housekeeper at a hotel. Family history, we've got some positive hits for here, for maybe a genetic tie-in. She's using albuterol, two puffs inhaled as needed, plus a nebulizer. She's using these guys several times a day. She's taking Zyrtec during the pollen season and she last had her albuterol nine hours prior to us testing her.

This is what her information looks like and you can see this is the flow volume loop, just the expiratory portion. We didn't record the inspiratory portion, which would normally be down like this, and here is our volume-time curve. This is a predicted peak flow and a predicted forced vital capacity. So, if I were to draw out what the predicted values look like, she should be up in here, she shouldn't be hitting an FEV1 at this point with an FVC coming up to here, so she approached a normal forced vital capacity, but she's got really reduced air flow going on, and like I said, when we're doing these clinic recording, our recordings at our clinic, we generally only look at the expiratory, we don't get this unless we have some suspicions of other issues going on with these patients.

So, this is the pre-bronchodilator information. 46 years old, her FEV1 here you can see is really reduced, is at 32% predicted, and her FVC is pretty normal, 91%, that looks good. The ratio here is only 0.29 or 29%. Normally she should be at around 82%. And, a very reduced FEF2575. It's taken her 12, 14 seconds to blow her air out, so you can see we use the NHANES III as our reference values here, and BTPS, we talked about that briefly. So, this is showing that the spirometer we used gave me severe obstruction, and I would agree, on the pre-bronchodilator. Now, for COPD, we want to look at post-bronchodilator information, for asthma we would look at the pre-bronchodilator but we would do a pre- and post-test with an asthma patient to see that they have significant response.

Now, here's the pre and post information, you can see these land right on top of each other, there's very little improvement. In fact, if we look at the numbers, going here to look at all our numbers, she actually dropped off on her forced vital capacity by 5% measured value here, the best measured value was 2.29, predicted being 2.52. After the bronchodilator, she dropped to 2.17. Her FEV1 went from 0.66 up to 0.69, which was only a three percent change, so you can see this didn't show much improvement. So, this may be an issue where she's claiming asthma, she's got a history of smoking, it could be a crossover situation where we've got both asthma and COPD, or she could have had asthma for a long enough time without being treated with an inhaled steroid that she may have had what we call airway remodeling, and that goes into a fixed airflow obstruction picture, so you have an asthma patient who ends up getting the remodeling, which causes our airways not to be responsive to albuterol as much, so that starts to look like COPD.

As far as treating her, taking her down the plan of care for asthma, and I said here this is severe persistent asthma, probably also an overlap syndrome, but because of her complaints of what's going on she lands in severe persistent asthma, and she's in about a step five or step six on the, here's the National Asthma Education Prevention Program, NAEPP guidelines, so she should be worked up with a high dose inhaled steroid and a long-acting beta agonist, there are some things to consider, or if she goes to the step six, the high dose LABA plus an oral steroid, we want to make sure that we do all these issues here, step up if needed, but checking her adherence to using our medications, her environmental control, comorbid conditions. If she gets in good control or things are looking better, then stepping down after three months.

All these patients should have a short-acting beta agonist available, so that starts these steps, but that carries through step one, two, three, all across this. Any person with asthma should have that as a relief medication, and then these would be our controller medications.

So, this is the stepwise approach, one of the three major graphics or charts that we would use when you're looking at the EPR-3 guidelines. So, her plan of care would be laid out here. We want to control her GERD, get her on the right inhaled medications, put her on a leukotriene receptor antagonist, like Montelukast. She may need some help getting medications, these are expensive drugs, so a drug assistance program would help. Making sure her technique is good, having her avoid triggers as if at all possible, get her to continue her quit attempt with smoking, she needs a flu vaccination every fall, a pneumococcal vaccination is indicated for her, give her an asthma action plan, make sure you discuss exacerbations. Diet and exercise is sometimes with patients a weight loss issue, if they've got obesity that contributes to the inflammation. Two weeks would be appropriate for follow-up.

The teaching case number two here, we have a patient who's a 47-year-old female. You can see her demographic information. Told she has asthma, daily coughing, not complaining about wheezing, but nighttime issues, more coughing and chest tightness, shortness of breath. Currently she's not complaining of wheezing, but if you listen, she is wheezing. She's never smoked. You got a good list of some triggers here, she works in a grocery store, she's complaining that the propane powered, when they crank up the floor cleaner, it gives her a lot of trouble. She's using her albuterol and nebulizer several times a week. She tried Advair for about two weeks and quit, she says it made her face swell. So, seven hours prior to testing she had her albuterol.

Here's her pre-bronchodilator information and you can see she's very scooped out, missing her peak flow, missing her forced vital capacity, missing her FEV1. She's pretty far off, but the results here showing 108% on her FVC, but only 55% on her FEV1, and her FEV1 ratio of 41% where it should be for her age, and the information here, around 82, so she's having moderate obstruction based on the computer interpretation. Again, with asthma, we want to see what her pre- and post-tests look like, and so here's what happens with her post-bronchodilator.

Nice increases here and with her numbers. She has a 26% increase in her FEV1, her FVC decreased a little bit, sometimes these folks get a little worn out as we work with them, and we had a nice increased peak flow, jumped up 38%, huge increase in the FEF2575, but that's not diagnostic, that just helps to reinforce what we're seeing here already, and you can see her forced expiratory time she actually chopped back, she was at 24 seconds blowing out, this dropped back down to 17 seconds, and only missed about 210 milliliters of that forced vital capacity, so that's a 7% drop here, in the face of a lot less time blowing out.

Looking at teaching case number one here, I'm going backwards in our numbering, 38-year-old female, 5 feet and 2 inches tall, 119 pounds. You can see her complaints here, smoked a little bit then quit. She says she's got no drug allergies but she is complaining of sinus issues, dogs and dust are triggers for her. History of asthma, and she's using albuterol PRN. Here's her pre- and post-bronchodilator information, and so we can see here the graphic representation shows a pretty nice change. This looks pretty good. When we look at the numbers, we're seeing 22% increase in her FVC, this moved from 2.78 up to 3.38, so that's, what, about 600 milliliters. Her FEV1 went from 1.32, best trial here, up to 1.73, okay, so this is a 31% change. So, it is a significant, she had a significant response to the bronchodilator here, so we're looking at with this patient with the, you know, as we start grading them out, this would be someone with severe asthma, but we've put her on step five or six on the EPR-3 guideline steps, and then come back later and assess control.

So, we're going to have a little time for questions here at the end. I'm going to come to a kind of conclusion here. You can see it's an objective measurement for lung function, it helps if you have a trained person doing this to properly record and look for issues in quality. It takes very little capital to invest in the spirometer, but it can give you excellent information for tracking potential issues, and this is a billable procedure. So, you want to be able to do this pre and post, billable also.

Also, for guidelines you can find more information in the AARC for the clinical practice guidelines, COPD go to the GOLD guidelines, for asthma we talked about the National Heart Lung and Blood Institute has guidelines for asthma which would be your EPR-3 guidelines, or the NAEPP, the National Asthma Education Prevention Program, and then if you want to become a certified asthma educator there's the NAECB website for taking that board exam to get your AE-C credential. So, there is a companion presentation to this one I wanted to mention, which is on the Montana.gov website for a webinar we did back in 2015. It's a lot more case-based presentations and you can take a look at that, and I appreciate Anna having that be available for everybody. So, thank you guys for listening, I hope I've kept you awake through this presentation, and if you have questions now's the time.

MACP: I'm going to take the screen back from you, and if anybody does have questions please feel free to use the chat box or unmute yourself. I'm going to go ahead and put the slide back up about the continuing education information, so I am going to be emailing you tomorrow with an evaluation that you'll need to fill out and the only people receiving that email will be the people who logged in, and so again if you're looking at this in a group be sure to contact me individually. But, yeah, Bill that was

incredible, thank you so much for going through that for us a second time. This is good as the first time around. If anybody has any questions I encourage you to come forward now, I know it might be getting to the end of people's lunch hour.

Oh, here we go, I've got a question for you, Bill. Do you have a comment on how do you address transgender issues, since the predictive values differ based on gender?

Mr. Pruitt: That's a good question. I've thought a little bit about it. I kind of think, as far as it's hard to change some of the structural things are going on in your lungs and in your body, so that's a tough one, I don't think anybody's officially addressed it. I tend to lean towards if your DNA says you're male, you're going to have to use that. I don't know, I don't, I don't know how to answer that exactly, but that's my best shot at it.

MACP: Thanks Bill, I think that's a great answer. I'm sure there's something in there about cultural competency and addressing the person and then also treating their symptoms, I'm sure that's a big topic for everybody in the healthcare field right now. We've got another question here. What's your technique for testing for exercise-induced asthma?

Mr. Pruitt: Well, for exercise-induced, there's other things you can do. One would be to, you can actually put them on a stationary bike and exercise them up to a point, and then the guidelines for that are addressed in the ATS criteria, if you want to find out about that, and there's also an excellent source that's a kind of a pulmonary function go-to for me, it's a textbook by a fellow named Rupal or Ruppel and it's now being edited by Carl Motrin who's up at Mayo Clinic in Rochester, Minnesota. But this textbook has got a really good description of exercise testing and how to do that. Generally, what you do with that is exercise them to the max, about 80% of their target heart rate, and then immediately afterwards, I think there's maybe a hold of a few minutes, but you start doing forced vital capacities and looking at FEV1, an FVC for a spirometry measurement.

MACP: Thanks so much, it looks like that's good, they said thank you for answering their question. Alright, anything else? We have time for maybe about one more. I'm not seeing anything pop up right here. So, just as a reminder, that eval email will come out tomorrow. We do have the Big Sky Pulmonary Conference coming up in March from the 16th to the 18th. Online registration for that is open, and our next webinar is tentatively scheduled for May 18th. Thank you so much, Bill, we really appreciate your time!

Mr. Pruitt: Well, thank you, I appreciate you guys letting me come and talk to you, and if you can do, if we can do a future one I'll be willing and able to maybe to do it again.

MACP: Ok, great, thanks so much! Everybody have a great day, thanks for joining us.