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ReachMD
www.reachmd.com
info@reachmd.com
(866) 423-7849

Video Demo: Cardiopulmonary Exercise Testing in Pulmonary Arterial Hypertension - Part 1

Announcer:
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Dr. Cooper:
Good afternoon, everyone. Hope you all enjoyed lunch. Alex Sherman and I are going to present together. We originally had intended to do a live demonstration of cardiopulmonary exercise testing, but we had issues with getting equipment here, in order to be able to do that. So, as an improvisation, we've had prerecorded video of a cardiopulmonary exercise test, which we've tried to sort of weave into the presentation. So if you bear with us, we'll have sections of presentation and discussion and set little sections of video. And we're going through this first to show how we conduct the tests, what data we focus on, and how we interpret that data. And then we're going to round it up, Adam is going to give a case presentation of a PH patient that will illustrate some of the concepts that we have presented. So I'll let Alex begin.

Dr. Sherman:
So you know, when we're evaluating patients with pulmonary arterial hypertension, or even just with, you know, dyspnea of unexplained origin, and you're going through your diagnostic purposes, you know, as I think a lot of the other talks have alluded to, that, you know, getting sort of a dynamic assessment of exercise capacity can be really helpful. And one of the more well-validated methods of doing this, aside from the sort of the submaximal exercise test of the 6-minute walk test, which has incredible utility, you know, another method which has, you know, arguably a little bit more diagnostic resolution, is the cardiopulmonary exercise test, or the CPET.

And there's a few different ways to go about this; you can do what we call like a level 1 CPET, which is a noninvasive method, which we'll go into a little bit more details, which allows you to quantify aerobic performance as well as functional capacity, and also can lead you towards identifying some of the pathophysiologic reasons for that exercise limitation. Now, as we've talked about, PAH does cause a multitude of downstream effects, which can cause issues with cardiac function and gas exchange primarily. And exercise testing is a nice way of sort of bringing together all of those different individual organ problems and having the body integrate them to produce work and actually give a, you know, a more real-life day-to-day assessment of exercise capacity. And then, you know, beyond that, beyond sort of your noninvasive CPET, when you add in either an arterial line, or an arterial line along with a pulmonary artery catheter, you get your level 2 and level 3 CPETs, which can really aid in diagnosis and assessment not only of pulmonary hypertension, but other causes of exertional dyspnea that may be, you know, confused for PAH.

Dr. Cooper:
So, I'll add that the patient referred for cardiopulmonary exercise testing may already have a known diagnosis or several diagnoses. And the real question posed is, you know, what is the level of impairment? Because that has predictive value. And what are the specific path of physiological limitations to the performance of exercise? Because sometimes, you know, those can guide a therapeutic approach.

So, after this brief introduction, we'll take a look at the exercise physiology laboratory.

Let's begin by looking at the exercise physiology laboratory. Here we have a typical laboratory setup, with a choice of treadmill and cycle ergometers, a metabolic measuring system, and various screens to display the data. Actually, in the UCLA exercise physiology research laboratory, we have an interactive screen, where we can annotate the data in real-time as the experiment continues.

And in this setup, in the lab here at UCLA, we have had the option of treadmill and cycle, a garment of testing with the metabolic cart positioned between them. And of course, there are certain differences between the two. I'm not sure we have time to discuss those, but in general treadmill exercise elicits a somewhat higher maximum oxygen uptake. It's much more dependent upon patient bodyweight and gait and coordination than the cycle ergometry. So we prefer the cycle, really for diagnostic exercise tests because we have a more predictable relationship between the pedaling and the work rate.

Dr. Sherman:
So, in preparation for our cardiopulmonary exercise test, there are several steps that are, you know, really, you know, critical to go over with the patient and make sure that you're doing a reproducible study. So, you know, of course, like any other procedure, it starts off with subject consent, where you're explained, as well as really pretest preparation, ensuring the patient hasn't had any, you know, tobacco use or caffeine to influence some of their physiologic parameters. So that comes about from explaining the tests ahead of time. Of course, you're going to be monitoring for safety with ECG monitoring and vital signs monitoring to make sure that they don't have any acute issues. But in general, cardiopulmonary exercise testing is incredibly safe. You know, the rate of serious adverse events is quite low, less than 1 in 10,000.

Dr. Cooper:
Important points about the electrocardiogram are to carefully prepare the skin, light abrasion and decreasing with alcohol so as to get good electrode contact. But after that, it's important to snug down the leads and make sure that they're not swinging, they're attached to the belt so there's no artifact on the ECG recording during the test. If there is, it can sometimes be quickly troubleshot, you can pin the artifact down to one or two leads, secure the leads, or even quickly replace an electrode if that's the issue.

Dr. Sherman:
Making sure that you have an adequate patient machine interfaces was really important. You need to make sure that you're using the properly sized either mouthpiece or face mask, that you have a completely sealed system. For patients who have facial hair, if they're willing to remove that ahead of time, that certainly facilitates a better seal. If you're having some small issues, you can always use some water-soluble lubrication to try to seal small holes. But you know, having leaks in your system can really be detrimental to the quality of the data that you're getting.

Dr. Cooper:
The factor of mechanical efficiency is minimized on a cycle ergometer. I won't say it doesn't exist at all, but much less so than the treadmill. However, it is important, you know, to have the saddle height right, set right for a particular patient. And you can either bring that level to the greater trochanter with the patient standing next to the bike, or have them sit on the bike with the foot in the pedal, and make sure that there is a leg extension with an angle of about 15 degrees at the knee; that is optimal for mechanical efficiency. And this is important because if you retest a patient, for example, to see the possible benefits of therapeutic intervention, you want to make sure that the mechanical efficiency is the same the next time you do the test on that patient.

Now, I think before we start any exercise test, we really want to just take a quick view of the parameters of the test that we would expect if the test was going to be normal. And of course, we use reference equations to derive normal values. And the most important, of course, in the central measurement that we make in an exercise test is maximal oxygen uptake, and that can be reliably predicted using just the age and sex of the patient. We can use ideal body weight to convert a predicted VO2 maximum mils per kilogram per minute into liters per minute. And that would be truly an ideal and normal patient. The other reference values we have reference equations for predicted maximum heart rate; you often see 220 minus age, but the Tanaka equation, which is 108 minus 0.7 times the age, is actually a little better, it fits real-live data from Scandinavia. Ventilatory capacity is typically measured by doing a maximum voluntary ventilation maneuver. If you don't have that, you can calculate ventilator capacity from an FEV1. And if you haven't measured the FEV1, you could always use a reference FEV1 and to calculate a reference ventilatory capacity. And VO2 max, maximum heart rate, maximum ventilation, they kind of set the scene because during the conduct of the test we want to see whether aerobic capacity is normal, where the maximum heart rate is approached or achieved, and whether a maximum capable ventilation is approached or achieved.

Announcer:
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