If you’re setting up bio controls, should they be measured at a specific window because of diurnal changes in DLCO?
I would not necessarily recommend this approach when you are first setting up because you should be using your bio controls both on a weekly basis but also whenever an issue is suspected. So, you want to know the breadth of variability in your bio control’s DLCO measurements throughout the course of the day.

Do you recommend DLCO done post-BD? Why?
An older study had suggested that bronchodilation may influence the DLCO measurement by up to 6% but more recent studies have shown no impact of bronchodilator administration in routine doses on DLCO measurement for normal subjects and in patients with reversible or incompletely reversible airflow limitation. So, the 2017 technical standard suggests that it is likely irrelevant whether or not the DLCO measurement occurs before or after bronchodilator administration. What is important is the overall test order with respect to lung volume measurement if you are doing nitrogen washout; the new technical standard recommends that you do DLCO measurements before any multiple breath nitrogen washout testing.

Any perspective on intrabreath DLCO
The 2017 ERS/ATS technical standard focuses on the single breath technique, so I believe it is here to stay. A nice look at the intrabreath DLCO measurement can be found on this website – https://www.pftforum.com/blog/one-more-dlco-technique-dlco-measured-during-exhalation-intrabreath-dlco/

What are your thoughts regarding the use of hemoglobin concentration from the newer models of pulse oximeters as a substitute for lab derived values?
Most of the literature examining pulse oximeters for point-of-care (POC) hemoglobin monitors focuses on following hemoglobin in surgical or trauma/GI bleed patients, and there seems to be promise for oximeters as trend monitors to detect unexpected or sudden changes in hemoglobin. Although there is reasonably good agreement—from a statistical standpoint—between oximeter readings and laboratory measurements of hemoglobin, I worry that the agreement is insufficient to justify replacing an actual hemoglobin measurement when adjusting a highly sensitive and variable measurement such as DLCO, which is about equally sensitive to changes in diffusion properties of the lung as it is to changes in the reaction of hemoglobin and CO and pulmonary capillary blood volume. It would be great to see a study examining POC hemoglobin measurement with a blood sample and with oximeter to see the difference in adjusted DLCO between using the two values.

Which author’s predicted set for DLCO do you use in your PFT lab?
We use the Knudsen equations because they were established from a population-based cohort study of healthy individuals here in Tucson. However, because of the changes in technology since the time those normative values were obtained and because of the robustness of the methodology employed by GLI to establish DLCO reference values, we will be switching to the GLI DLCO predicteds once they are published.

Can you explain the end tracer gas reproducibility?
I think you are asking about the concentration of tracer gas at the end of the test and what is required before repeating the DLCO maneuver. The required interval between tests includes the recommendation that the tracer gas concentration at end exhalation should be ≤2% of inspired concentration (previous guidelines indicated 4 min minimum between tests, 10 min for severe obstructed lung disease).
I am at a facility in the California high desert, approximately 2,500 feet above sea level. Is there a certain limit at which we need to adjust for or be concerned about FiO2 issues?

Barometric pressure adjustment is recommended for all DLCO measurements in the 2017 ATS/ERS technical standard, and it is recommended that this value should be reported and compared to normative values. The new DLCO reference values from GLI will also account for altitude.

How do you perform calibration syringe leak test especially if there are no markings in the syringe shaft?

Do you have videos for guidance?

“The new 2017 ERS/ATS technical standard provides instructions on how to perform the syringe leak test: Each month a leak test of the 3-L calibration syringe should be performed. If the calibration syringe does not have a volume scale on the shaft, mark 50 mL below full by measuring the excursion of the shaft from 0 to 3 L and marking it at a distance that is 0.017 of the full excursion. Fill the syringe and place a stopper at the syringe input. Push the syringe in to the 50 mL mark (which generates a pressure of about 17 cmH2O), hold for 10 sec and release. If the syringe does not return to within 10 mL of the full position, it should be sent for repair. The procedure is then repeated starting with the syringe at 50 mL below full, applying the stopper and pulling the syringe to the full position.”

Are there any differences in acceptability/repeatability in pediatrics?

The 2017 technical standard does not provide different requirements for acceptability and repeatability for pediatric patients.

Will GLI have predicted values for pediatric DLCO as well?

Yes. The GLI equations will cover ages 3–95 years.

Are there circumstances that would make it advantageous to test an obese subject in a standing position?

It is not recommended to perform any of the PFT maneuvers, including DLCO measurement, in the standing position because of issues related to patient safety in the event of lightheadedness or falls.

Is there ever a reason to do supine DLCO testing?

Not to my knowledge—performing the test in the supine position will increase venous return and pulmonary capillary blood volume, thereby increasing the DLCO measurement. But, there are no normative values for comparison that were performed in the supine position, so it is challenging to make any conclusions about whether or not DLCO is actually within normal limits or not.

What normative reference set do you recommend using? Have the 2017 DLCO recommendations been validated in pediatric patients?

It is hard to recommend a set of normative values for any given lab without knowing more about the lab’s clinical referral population and other testing conditions. We use the Knudsen equations because they were established from a population-based cohort study of healthy individuals here in Tucson. However, because of the changes in technology since the time those normative values were obtained and because of the robustness of the methodology employed by GLI to establish DLCO reference values, we will be switching to the GLI DLCO predicteds once they are published.

Can you give a little more detail about the weekly biological monitoring?

According to the 2017 technical standard, you should make a biological control measurement for each piece of equipment each week or whenever problems are suspected (or you may also use a simulator, though these are expensive). The biological control standard subject should be a nonsmoker with a consistently repeatable DLCO (healthy lab personnel); repeat the test if DLCO varies by either >12% or >3 mL/min/mmHg from mean of previous values and consider further equipment evaluation before patient testing.

Will the GLI equations include pediatric subjects?

Yes. The GLI equations will cover ages 3–95 years.
What is the best set of reference values to use until the new GLI set comes out?

We use the Knudsen equations because they were established from a population-based cohort study of healthy individuals here in Tucson. However, because of the changes in technology since the time those normative values were obtained and because of the robustness of the methodology employed by GLI to establish DLCO reference values, we will be switching to the GLI DLCO predicteds once they are published.

Is it important to wait a period after a treadmill stress test before performing a DLCO maneuver?

Exercise can cause a temporary increase in pulmonary capillary blood volume followed by a decrease even relative to resting state as blood flow is preferentially distributed to the muscles during exercise recovery, so it is important to make sure DLCO measurement is performed pre-exercise or at least a few hours after any exercise testing.

Is a six-minute walk acceptable prior to testing?

No, because the test should be performed at a resting state and even if you consider a six-minute walk test to be submaximal (there is data to dispute this in COPD patients), it will impact your DLCO measurement. Exercise can cause a temporary increase in pulmonary capillary blood volume followed by a decrease even relative to resting state as blood flow is preferentially distributed to the muscles during exercise recovery, so it is important to make sure DLCO measurement is performed pre-exercise or at least a few hours after any exercise testing.

How often should DLCO testing be done for a typical COPD patient in their 50s to 60s? Every year? Every two years?

The recommended interval between DLCO tests is controversial but it certainly depends on the clinical indication. For example, some patients with COPD may have DLCO measured once or not at all and do not require any additional diagnostic tests if their symptoms are stable or follow a predictable course. For patients who are being routinely monitored for the impact of exposures on lung function, they may require more frequent PFT even in the absence of symptoms.

Does a six-minute walk test count as vigorous exercise?

Yes. There is data in COPD patients that suggests they attain the same or similar peak oxygen consumption (VO2) during a six-minute walk test and shuttle walk test as they achieve during a CPET.

Should you always have an ABG done with PFT for a patient with a diagnosis of dyspnea?

This is beyond the scope of the webinar but I do not think an ABG is always required when a patient is referred for evaluation of dyspnea. PFT alone can provide some information about gas transfer but also can provide information about other physiologic defects, such as obstructive or restrictive ventilatory defects, that may cause dyspnea even in the absence of gas transfer abnormalities.

How forceful of an expiration after the hold is recommended?

As described in the 2017 technical standard, the goal is to obtain a smooth, unforced and rapid exhalation without hesitation or interruption.

Why such tighter criteria for DLCO testing?

Major equipment manufacturers were surveyed and the equipment on the market today was very capable of performing higher quality testing than the prior guidelines called for. Moreover, clinical studies have shown that most patients are capable of achieving the recommended criteria for acceptability and reproducibility with appropriate coaching. So the goal of the 2017 technical standard was to set expectations for the quality of testing that the equipment and patients were both capable of meeting, rather than undershoot.

What is LLN and ULN on your PFT read outs?

LLN and ULN represent the lower limit of normal (5th percentile) and upper limit of normal (95th percentile) based on normative reference data (±1.645 z scores from the mean, which is the predicted value based on age, sex and height).
How often should you check DLCO on amiodarone patients?
I am not aware of any evidence-based guidelines that indicate you should check DLCO routinely on asymptomatic patients who are taking amiodarone. There is some evidence to suggest that serial lung function studies are not helpful for predicting pulmonary toxicity. See the reference by Gleadhill et al; Am J Med. 1989;86(1):4.

If a patient has difficulty getting the 90% vital capacity, would it be advantageous or acceptable to try again after giving a bronchodilator to see if this helps reach the 90% vital capacity?
An older study had suggested that bronchodilation may influence the DLCO measurement by up to 6% but more recent studies have shown no impact of bronchodilator administration in routine doses on DLCO measurement for normal subjects and in patients with reversible or incompletely reversible airflow limitation. So, the 2017 technical standard suggests that it is likely irrelevant whether or not the DLCO measurement occurs before or after bronchodilator administration. What is important is the overall test order with respect to lung volume measurement if you are doing nitrogen washout; the new technical standard recommends that you do DLCO measurements before any multiple breath nitrogen washout testing. To specifically answer your question, I don't know of any data to suggest that better quality DLCO maneuvers can be produced with bronchodilator administration, but if a patient would like to perform the test after bronchodilator administration, it is reasonable to do so.

How important is it to report historical trend data with every PFT report?
Reporting historical trend data is critical because when we report PFT values as normal or abnormal there is a wide range of normal, and there can potentially be very large drops in DLCO and other PFT values before the interpretation changes from normal to abnormal. In the absence of reporting trends in the absolute values, this change would not necessarily be recognized.

Do you use the Dinakara Equation for bone marrow transplant patients?
In our lab, we use the same reference equations and hemoglobin adjustment for all of our patients regardless of the reason for referral.

What is the biggest difference between the intrabreath DLCO and single breath DLCO?
The 2017 ERS/ATS technical standard focuses on the single breath technique, so I believe it is here to stay. A nice look at the intrabreath DLCO measurement can be found on this website - https://www.pftforum.com/blog/one-more-dlco-technique-dlco-measured-during-exhalation-intrabreath-dlco/

Is your PFT going to start utilizing the grading system and adding it to their tech comments on their tests?
Yes, we want to standardize our approach and this gives us a good platform for starting this. However, we recognize this grading system is not validated and will watch for new data that may be published in the future regarding the grading system and its validity.

How long is “shelf life” of hemoglobin results?
I think this depends on your clinical referral population. For example, if you are testing a lot of bone marrow transplant (BMT) patients or oncology patients requiring frequent transfusions, then the hemoglobin value can vary quite a bit. We prefer same day or ±1 day for our BMT patients. For other patients, we routinely accept values measured within 2-3 weeks. This is not ideal but certainly more practical. The new 2017 ATS/ERS technical standard does not establish an acceptable date range for hemoglobin values that are used to correct DLCO.

We sometimes see a patient that has an IVC that is perhaps 85% of VC with a higher DLCO than an IVC of 90% with lower DLCO. Which would you report?
This could happen because of other variability in the maneuver beyond the volume inspired (breath-hold time, Mueller/Valsalva maneuver during breath-hold, etc.) and does not necessarily mean the lower value or higher value is more valid. Since most intra-session variability is technical rather than physiological, the mean of acceptable maneuvers is reported. According to the 2017 technical standard, the average of at least two acceptable maneuvers that meet the repeatability requirement should be reported.
Dealing with a PFT, why/how would a patient go from being obstructive to restrictive?
There are many different reasons that this could occur. For example, a patient with obstructive lung disease could have initial spirometry show obstruction and then repeat spirometry appear restrictive if there was glottic closure even without any true change in lung function. The clinical context is really important in determining why this might be the case. When thinking about obstructive lung disease, you could also consider whether or not the restrictive pattern represents “pseudo-restriction” where the FVC is decreased due to reduced airflow, air trapping and increased residual volume.

We have used breath hold of 7 seconds... Is this a change of 10 seconds for ATS?
The single breath DLCO maneuver guidelines from 2005 and the newer guidelines from 2017 indicate the goal breath-hold time is 10 ±2 seconds.

For our COPD smokers, should we draw an ABG and report carboxyhemoglobin and Hgb using co-oximeter?
We do not routinely do this in our lab as it is not always necessary nor is it always practical from a time and patient experience standpoint. But, it can be useful to help explain a low DLCO measurement, depending on the clinical situation. I might recommend you consult with the referring provider to see if this information would help inform their decision-making or not. And remember, you can measure CO with your gas analyzer even in the absence of co-oximetry for carboxyhemoglobin.

What is the guidance for patients that are oxygen dependent and can not tolerate being off oxygen for DLCO testing?
Some labs choose not to perform testing on patients who cannot tolerate being off oxygen for the test. This is what we do in our lab. In this setting, most clinicians feel that the DLCO measurement offers very little additional diagnostic or prognostic information, and often the variability in intraindividual DLCO measurement is quite high, making it challenging to report reliable results anyway.

When can you decide to do manual adjustments on the sample volume and washout volume?
There are not specific recommendations for making manual adjustments in the 2017 technical standard and therefore you may want to defer to your manufacturer regarding this since the automation may be different by manufacturer. However, Figure 2 of the executive summary and Figure 4 of the full technical standard show differences between computer algorithm and manual adjustment for the alveolar gas sample.

In the example of DLCO test on patient with c/o dyspnea, it didn’t appear that testing was of A quality.
Was the VI 90% of VC?
You are correct, that was a real world example from our lab and the volume inspired was only 87% of the largest vital capacity. It was also performed in our lab before the new guidelines were published this year so our technicians are now aiming to obtain VI of 90% of the largest VC.

What is the acceptable variation of VI for pediatric patients? 5%?
The 2017 technical standard does not provide different requirements for acceptability and repeatability for pediatric patients.

What age Hgb value does your lab use? I understand our Hem-Onc patients hopefully have same day lab draws, but we are often faced with a day to two day delay.
I think this depends on your clinical referral population. For example, if you are testing a lot of bone marrow transplant (BMT) patients or oncology patients requiring frequent transfusions, then the hemoglobin value can vary quite a bit. We prefer same day or ±1 day for our BMT patients. For other patients, we routinely accept values measured within 2-3 weeks. This is not ideal but certainly more practical. The new 2017 ATS/ERS technical standard does not establish an acceptable date range for hemoglobin values that are used to correct DLCO.

Another variable in testing is patient level of being able to follow instructions and language.
You are correct, this is very important. A translator should be used whenever possible. Patients who are not able to follow instructions for various reasons (e.g. altered mental status, cognitive deficit, etc.) may not be appropriate for testing at all.
Can you comment on the evaluation of VA repeatability?
The 2017 technical standard does not provide specific recommendations for the repeatability of VA. Given the limitations of a single breath gas dilution measurement, I would anticipate that there would be greater variability in measurement of VA among patients with airways disease and bullous lung disease than those without, and greater variability in measurement of VA than you would see when measuring TLC by plethysmography or multiple breath washout or gas dilution.

Is there an impact in bariatric patients?
Morbid obesity is relevant in many regards. For example, with respect to estimating anatomical dead space, the 2017 technical standard provides the following recommendations for classical DLCO systems: If body mass index (BMI) is <30 kg·m^-2, the recommendation is to use an estimate for VDanat of 2.2 mL·kg^-1 body weight. In more obese subjects, or if the weight of the subject is unknown, VDanat (in mL) can be estimated using the following equation where height (h) is measured in cm: VDanat = ¼ h^2/189.4.

For RGA systems, the anatomic dead space is measured. In another example, there is also some literature to suggest obesity may contribute to increases in DLCO due to higher pulmonary capillary blood volume. Our understanding of PFT in general among morbidly obese patients remains somewhat limited, which is challenging given our increasing number of referrals for morbidly obese patients.

What is the recommended standard for amiodarone cardiac med? Do we continue to do DLCO testing to track lung side effects or is this no longer done?
I am not aware of any evidence-based guidelines that indicate you should check DLCO routinely on asymptomatic patients who are taking amiodarone. There is some evidence to suggest that serial lung function studies are not helpful for predicting pulmonary toxicity. See the reference by Gleadhill et al; Am J Med. 1989;86(1):4.

Can you touch on reportability criteria for children?
The 2017 technical standard does not provide different requirements for acceptability and repeatability for pediatric patients.

Why isn’t it mandatory to adjust for Hgb?
It is ideal to adjust for hemoglobin but it is not always practical if this information is not readily available or the patient declines phlebotomy. DLCO still provides important diagnostic and prognostic information independent of adjustment for hemoglobin, but you are correct that this would be best practice to adjust all reported values for hemoglobin measured in real time.

If KCO is (DL/VA) how is that reporting differently? We already are reporting DL/VA.
The 2017 technical standard recommends reporting DL/VA as KCO instead. They recognize these are the same but recommend using KCO preferentially if you choose to report these values at all so that referring providers do not mistakenly interpret this as DLCO “adjusted for lung volume.” As we discussed in the webinar, the relationship between KCO and DLCO varies depending on disease state, age, etc., so for example, one cannot simply interpret a KCO of 89% predicted as “normal gas transfer after adjusting for lung volume.”

I wanted to know how often or far apart you would do serial repeat DLCO testing?
The recommended interval between DLCO tests is controversial but it certainly depends on the clinical indication. For example, some patients with COPD may have DLCO measured once or not at all and do not require any additional diagnostic tests if their symptoms are stable or follow a predictable course. For patients who are being routinely monitored for the impact of exposures on lung function, they may require more frequent PFT even in the absence of symptoms.