**Course Name: Pulmonary Function Test - Interpretation and Application in clinical practice**
**Professor Name: Dr Ramya Priya**
**Department Name: Respiratory Medicine**
**Institute Name: Chettinad Hospital and Research Institute**
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**Lecture - 03**

W4_L3_Interpretation of PFT in Obstructive lung diseases

Greetings everyone, as part of this course on Spirometry, the next session will be on the interpretation of obstructive airway diseases. I am Dr. Ramya Priya, Pulmonologist from Chettinad Hospital and Research Institute and we will start the session. So, my objectives for this session are to recall about the spirometry parameters and to talk about the lung diseases which are the, which are present with the obstructive pattern. The obstructive changes in spirometry, how to interpret it and what is bronchodilator reversibility testing and what is bronchodilator responsive testing and the interpretation of it and a little bit on the extra thoracic, intra thoracic obstruction also because that also comes under our obstructive artery diseases. So, what are the spirometry parameters? I am sure my colleagues would have thought about the normal spirometry.

So, we are going to see what is this FEV1, ok. So, this is just a recall session. So, FEV1 is the maximal amount of air which is exhaled in the first second and your forced vital capacity is the maximum amount of air that can be exhaled after maximal inspiration and your peak expiratory flow is the maximal flow that can be exhaled after inspiration and the forced expiratory flow which is also known as the mid expiratory flow is the, for example, if the, if this is the expiratory limb then from the 25 to the 75 portion of your expiratory limb this flow forms your forced expiratory flow which is between the 25 to 75 percentage of your total expiration. So, now comes the question, what is the difference between the volume and the flow, ok.

So, the flow is nothing but your volume which is expressed in unit time, ok. So, if at all we are measuring these volumes there the unit will be liters, ok. So, if we talk about the flow then the unit will be liters per second. Also, I just want you to sensitize for the formula that is the air flow is directly proportional to the changes in the pressure divided by your airway resistance, ok. So, I just want you to remember this formula because this is what we are going to apply in the next subsequent slides, ok.

So, you are to recall this flow is nothing but the volume which is expressed per unit time. So, your unit will be liters per second and your volumes will be expressed in your liters, ok. So, now the new update is that for the spirometry the low values are considered abnormal. So, the lower limit of normal is actually defined as the fifth percentile. So,

what they mean to tell is that because your spirometry values vary according to your gender, height, race, age and all.

So, what happens is that the spirometry values which have been expressed is not standard for everyone. So, now previously they used to define that as like cutoffs of like 70 percentage and everything. So, now we are changing our paradigm towards to the lower limit of normal, ok. What they mean by this is that up 50 to 95th percentile if the values fall it may be normal or clinically if suspected then we can like evaluate further, ok. So, if the values are below this fifth percentile, then it means that definitely some abnormality is present, ok.

So, if at all the false positive rate for this for the values below fifth percentile is very less that is that 5 percentage. What I mean to tell is that what is false positive means that means test is becoming positive and disease is negative that is what the false positive means, right. So, that means the person is not having disease, but the test is telling that the person is having the disease, ok. So, this false positive rate if we take this lower limit of normal cut off of fifth percentile then if the values fall below this fifth percentile, then the chances for this being false positive is very low as 5 percentage, ok. So, I will try to explain this in the for the subsequent slides also you just do not need to worry.

So, what we at the paradigm shift of what we are trying to achieve by this lower limit of normal is to reduce our false positive rates, ok. So, the next is that so as I told previously so your volumes are expressed in your liters and your flow is expressed in your litter per second. If you see FEF 25 to 75 and your peak expiratory flow so the flows are expressed in your liter per second. So, this is what I try to mean by this and then we have something called this graph and something called this loop, ok. So, the graph is something where the volume is plotted against time where the loop is something where the volume is plotted against flow.

So, here time is not same. So, whether the person has really done the six seconds of expiration we will know this by this volume time graph, ok and then we will interpret like whatever we want from the flow volume loop, ok. So, the graph is different, loop is different, volume plotted against time is your graph and volume plotted against low is your loop, ok. This is just a recall for you. So, next what are the lung diseases which present with the obstructive pattern is very well known to us one is the chronic obstructive pulmonary disease.

So, the next one is your asthma, the next one is your bronchitis and also early silicosis. These are all some diseases which may present to you with obstructive pattern. Ok. So, next we will see about what is the obstructive changes in spirometry. So, what I mean to try by the tell by this term obstruction is that it is characterized by air flow limitation in case of spirometry.

So, what do I mean by this air flow limitation is that that means that I already told that the volume that is the air flow is directly proportional to the change in pressure divided by your airway resistance, ok. So, in your obstructive airway diseases what happens is that this airway resistance increases and subsequently your flow decreases, ok. So, this is what is happening in your spirometry also, ok. So, and also what happens is that your forced expiratory volume in the first second will be affected so much to the extent that it has direct impact on your FEV1 by FVC ratio, ok. So, what are the obstruction characteristics are? You are there will be reduced FEV1 that is forced expiratory volume in first second, there will be normal or reduced FVC, there will be reduced FEV1 by FVC ratio and you will have a concave volume loop, ok.

So, I will try to explain this so do not need to worry. So, the thing is that for example, this is the normal curve, ok. So, this is your obstruction curve, right, ok. So, what happens is that for example, if you take this FEV1 value here somewhere near this 2.8 liters or something.

So, if you see your obstructive pattern, it will be near to some 1 liters, right. So, if you take this normal curve your FVC it will be near to some 4 liters or something here and your obstructive disease it will be near to some 3.2 liters or something, ok. So, if you see the difference between the obstructive curve between normal and your obstructive pattern in case of FEV1 the difference is almost like 1.8 liters whereas in FVC it is only like 0.8 liters. What I am trying to tell is that so in the initial stages especially these obstructive diseases will cause much impact on your FEV1 ratio, ok. That means the resistance which is offered against the air flow in the first second is more so that your FEV1 falls so much when compared to the FVC. It is not that FVC does not fall FVC also falls, but it may be normal in the initial stages also, but the proportionate of reduction in the FEV1 is very much more when compared to the FVC in case of your obstructive pattern. We all know that when we take a ratio if the numerator falls obviously the ratio also falls. So, if you take this FEV1 by FVC ratio because of a numerator is falling this ratio is also automatically falling.

So, this is the dictum for your obstructive pattern. So, there will be reduced FEV1 and there is a reduced FEV1 by FVC ratio whereas the FVC can be normal or reduced, ok. So, if we remember these points, it will be very good and also one more thing is that in case of emphysema we can have this residual volume which may be increased. So, because the residual volume is increased then your functional residual capacity is also increased, ok. So, this concave flow loop this point I am coming to you now.

So, what happens is that in case of your obstructive diseases what happens is there is one term called this scooping happens. What is this scooping is that for example if you take like 100 smokers and you follow them up for the development of this obstructive diseases. So, what is the first change which you can detect in the spirometry is that there

will be this part of this scooping which may occur they say like more than 70 percentage of your expiratory limb. So, once it crosses the 70 percentage of the expiratory limb then it what happens is that this scooping happens, ok. So, this is something which is like the earliest spirometry obstructive changes which can be noticed, ok.

So, what they mean by this is that because this is what is called your peak expiratory flow rate. The peak expiratory flow rate indicates that the maximum acceleration and it represents your large airways whereas this terminal portion of the loop represents your smaller airways, ok. So, why this scooping happens is that I want you to recall the formula that the airway flow is directly proportional to the pressure changes and indirectly proportional to your airway changes, ok. So, why the scooping happens is that because this portion of the limb mainly like it represents your small airways whereas your PEFR it represents most times it is the large airways whereas our COPD is a heterogeneous this is which can affect the large as well as the smaller airways, ok. So, at the beginning of the expiration because the total cross-sectional area of the small airways is very large, they offer only the little resistance to the airflow, ok.

So, when there is only like little resistance this airway flow is not much affected even though it is inversely proportional, ok. But as exhalation proceeds what happens is that the small airways collapse because you know that the small airways are something which is less than 2 millimeter in diameter without any like muscular support, ok. So, as exhalation proceeds so what happens is that the small airway closes, ok. So, if the small airway closes what happens is that this your resistance increases, ok. So, if the resistance increases because your flow is inversely proportional the flow decreases.

So, this is what is happening in the early changes of your obstructive airway diseases. So, this is what is responsible for your coving pattern in your flow volume loop, ok. So, the scooped-out dog's leg appearance. So, these are all so what is the pathology behind this is that this is simply your formula because the resistance increases the flow decreases that is it, ok. So, as it proceeds so what happens is that your PEFR is also reduced your coving is also happening, ok, very good.

Then so now we move on to the interpretation. So, what we first see is that FEV1 by FVC ratio as I told you previously. So, the FEV1 by FVC ratio is reduced as per the update it means that the it is below your lower limit of normal, ok. So, if at all you observe this as the first step then it means that the person is having obstructive defect, right, ok. So, next what we have to see is your FVC, ok.

So, if the FVC is above 80 percentage or above your lower limit of normal in the beginning stages I told like your FVC will be preserved, ok. So, what happens is that so if at all the ratio is reduced and the FVC is preserved then it means that the person is having your only your pure obstruction, ok. So, the ratio is reduced, but the FVC is fairly

normal it means that the person is having pure obstruction, ok. So, if the FVC is also reduced then what does it means then that person might be having the combined obstruction with restriction pattern also or it may be a severe obstruction also. So, that time also severe obstruction may manifest as restriction also because as obstruction proceeds and proceeds your FEV1 also falls and your FVC also is going to fall at one point of time they may be proportionately reduced.

So, that is why so what happens is that the ratio is reduced and your FVC is also falling. So, severe obstruction can also present as restriction. So, there comes our important test that is this bronchodilator responsive testing. So, what is the update tells us that so from the individual's predicted value. So, this is what we have been stressing recently that everything has to be like accustomed to the individual predicted value so that the height, age, gender it does not affect these values, ok.

So, from the individual's predicted value if at all from the pre to the post, ok. So, I am sure my previous colleagues might have told you what does this challenge with the bronchodilator means it means that we give the beta agonist and then 15 minutes later we again repeat the test and find out what is the changes in the volumes and flows, ok. So, after challenging with the beta agonist if at all the FEV1 and the FVC values is increased more than 10 percentage it means the positive response is present, ok. Positive response to the bronchodilator is present in the person with the obstructive airway diseases. So, what does it imply is that the person may benefit from your medication, ok.

So, that is one of the interpretations which we can derive from this, ok. So, now next we will see one example. So, that means like so how we assess the bronchodilator response is that we subtract the post bronchodilator value from the pre value and divide it by the predicted value into 100, ok. So, in this case if we if you take the pre bronchodilator value is your 2, ok and the post bronchodilator value is your 2. 4 liters, ok. So, if at all we want to predict this bronchodilator response then it means that post minus pre and this individual's predicted value is 3.32. So, if we get more than 10 percentage then it means that the person's responsiveness to bronchodilator is present, ok. So, previously sometimes some people used to say only FEV1 it is not only FEV1. In FEV1 and in FVC also if you find these changes then it means that the person may respond to your bronchodilators, ok.

So, next comes the important questions in your old textbooks they might have mentioned that there is something called this bronchodilator reversibility testing. So, what why I have not used this term reversibility testing is that what bronchodilator reversibility means is that after giving bronchodilator that the person's spirometry value should become normal that is what the reversibility means. But that is not what we are trying to establish now. We are trying to establish whether this person's obstructive condition will respond to the bronchodilator or not. So, that is what is mean by your bronchodilator

responsive testing and previously they were using this terminology called reversibility testing which means that your spirometry value should revert to normal after bronchodilation.

So, previously they were telling that this bronchodilator if at all this bronchodilator reversibility is present then it means that the person is having asthma. So, for this they used two values one is the relative change and absolute value change. So, the relative change is if at all there is 12 percentage increase above the baseline and absolute change of like 200 ml and both of this should be present to call it as a bronchodilator reversibility. But if you take like your asthma definition also so they might have mentioned that most of the times they will be having this reversible airflow obstruction. So, they also mentioned like often it is not like mandatory thing.

So, that is what I want you to take home from take home point from this is that we have we are now changing towards this terminology called this bronchodilator responsive testing or bronchodilator challenge testing. So, now we will add some more to our interpretation algorithm. So, we have already seen that if FEV1 by FVC ratio is reduced that is less than 0.7 or less than lower limit of normal that means that the person is having obstructive defect and your FVC is more than 80 percentage of predicted or more than lower limit of normal then the person is having pure obstruction. So, if the person is having pure obstruction, then we will see whether this condition improves with the beta agonist or not.

So, the similar thing for this. So, we have established that the person is having obstructive disease and it is a little bit like it improves with the beta agonist also then it is our responsibility to determine the severity also. So, for determining the severity we use this something called this grading. After post bronchodilator value this FEV1 with the predicted value. So, if it is like more than 80 percentage of the predicted value it is like mild obstruction. Now, you may get some doubt like in normal spirometry they might have mentioned you that the FEV1 more than 80 percentage is normal right.

So, but I am telling that here more than 80 percentage mean mild obstruction. What I am trying to tell is that so if FEV1 by FVC ratio is reduced then you subject them to bronchodilation and then the post bronchodilator FEV1 value is more than 80 percentage of predicted then we call it as mild obstruction ok. I am sure it is clear to you. So, if at all the ratio of this post bronchodilator FEV1 value falls between 50 to 80 percentage then it means that moderate obstruction is present. If at all it falls between 30 to 50 percentage that means severe obstruction is present and if at all it falls below 30 percentage it means very severe obstruction is present.

So, this is what the severity grading I am sure you should know ok. So, now we are one more update is that because there is something like you must know and it is good to know

ok. So, here we are moving towards this Z score ok as I told you it is like based on this taking into account of the patient's gender height and age also, we are establishing something called this Z score. So, if at all it the person's value falls between minus 1.65 to minus 2.5 then it means that the person is having mild obstruction. If it is between minus 2.5 and minus 4 it means that the person is falling under moderate obstruction and if it is less than minus 4 then the person is falling under severe obstruction ok. So, this is just a recall.

So, if your FEV1 by FEC ratio is less than 0.7 or lower limit of normal and your FEC is more than or equal to lower limit of normal or 80 percentage of predictive then we subject them then we establish that the person is having aN obstructive impairment then we subject them to bronchodilator testing and after that we are trying to determine the severity regardless of the reversibility present or not ok yeah. So, so this is the new update that is your good to know path ok. So, with the FEV1 by FEC ratio low to normal ok. So, even if FEV1 by FEC ratio is normal, but you find that your forced expiratory flow between 25 to 75 percentage of your expiration is only less than 60 percentage of the predictive then it also means that the person is having this obstructive impairment. So, because because most of your airway diseases are heterogeneous ok.

So, if at all it affects only your small airway diseases then it will be likely to be picked up by your FEF 25 to 75 percentage. So, that is why this update has come. So, even though the FEV1 by FEC ratio seems fairly normal, but your FEF of 25 to 75 percentage is falling below 60 percentage of predictive then it also means that the person is having obstructive impairment and we should treat the patient and make a note that the person is having this reduced FEF value right ok. And we would like to tell recall again that this bronchodilator responsive testing means it is just that from the person's predicted FEV1 and FEC value if at all 10-percentage increase is noted after bronchodilation then the person is having good bronchodilator responsiveness is that clear? I hope it is. So, now we move on to the interpretation of the obstructive airway disease ok.

So, here we have this lower limit of normal and this predicted also. So, we will try to interpret by both the previous form and this current form also and in in our small age groups and all we used to like if the teacher asked like 2 is 2 into 2 what is that we all shout 4, but now we are moving towards the technology era even then if at all possible if you are alone. So, you can like try to interpret along with me out loud right ok. So, so here we are seeing this FEV1 by FEC ratio is your 80.9 percentage. So, according to this value the percentage of predicted is 64. So, that means your FEV1 by FEC ratio is less than 70 percentage right. So, that means the person is falling under your obstructive pattern then you are moving and seeing your FVC value. So, first you have seen this.

So, next you are we will see what that is FVC. So, the FVC we are seeing it is fairly normal ok. So, if we will take more than 80 percentage is normal. So, here it is like 77

percentage it is fairly normal. So, you will take this as FVC is almost normal right ok. So, that means the person is having what is this pure obstruction ok.

Next what we will try to establish our bronchodilator responsiveness. So, after bronchodilation you can see in FEV1 the percentage of change is found to be like 36 percent ok. So, that means the bronchodilator like 12 percentage and 200 ml we see.

So, here what happens is that from 1.08 to 1.47. So, fairly like some 390 ml or something and here some 36 percentage. So, if we take the relative and the absolute changes 12 percentage and 200 ml. So, that also it like it satisfies right ok fine. So, we have established this bronchodilator reversibility sorry response also this is third point ok.

Then the fourth point will be that determining the severity ok. So, if at all the post bronchodilation is like 79 percentage ok. So, we all know that 50 to 79 percentage is your moderate obstruction. So, that means the person is having this moderate obstruction ok. So, this is what we try to establish from our old things ok.

So, now we will now try to like interpret like our new update ok. So, if at all it is fairly not fairly the same only just the terminologies changes into like instead of predicted we just go into this lower limit of normal. So, if we take this FEV1 by FVC. So, the lower limit of normal is here 70.3, but we got something called this 52.

That means this FEV1 by FVC is less than your lower limit of normal right. Next, we are seeing this FVC. So, FVC lower limit of normal is 1.97 and we are getting like 2.07. So, if your FVC is normal ok and then please try to like derive the bronchodilator responsiveness for this thing by post minus pre divided by predicted into 100 because I am not having time to do that ok.

So, if you go by this formula also you will find that the person is having the obstructive pattern with your bronchodilator responsiveness is present right. So, this is what this new update algorithm is. So, since FEV1 by FVC is less than lower limit of normal and your FVC is more than lower limit of normal then we will try then it means that the person is having obstruction. So, the rest of the part will be taken up by my colleagues.

So, I am not touching this, but you can have this algorithm. So, next I would like to like briefly tell you what is this extra thoracic and intra thoracic and the central RV obstruction. So, the central RV obstruction is that for example if you have this tracheal stenosis or tracheal papilloma something of that sort. So, it can produce something of this kind of loop that means that the flattening is present both in the expiration and in the inspiration ok. So, how to detect is that one is by this flow volume loop and also if you take this FEV1 by PEF ratio it will be more than 8 ml per liter per minute ok. So, that means what they are trying to tell is that in the central RV obstruction it impacts more on the PEF ratio than on the FEV1 ratio.

So, this is what is like causing this value to be more than 8 ml per liter per minute ok. So, what and the next will be your variable extra thoracic obstruction. So, some examples for this will be your vocal cord paralysis and all ok. So, they in case of this variable extra thoracic obstruction there will be flattening of limb in your inspiratory limb ok whereas, in your variable intra thoracic obstruction your flattening happens in your expiratory limb.

So, I will just try to explain what happens in the extra thoracic. So, we all know that the flow is inversely proportional to the sorry directly proportional to your pressure and indirectly proportional to your resistance we saw about the resistance part. So, now we will concentrate on the directly proportional part. So, what happens is that in case of your extra thoracic obstruction. So, if at all the person is like having this inspiratory flow.

So, what happens is that there will be like a drop in the intra luminal pressure ok. So, because of this drop in the intra luminal pressure what happens is that your flow is also getting reduced ok. So, that is why your inspiratory limb is flattening in case of your extra thoracic obstruction and your expiratory limb will be flattening in case of intra thoracic obstruction. So, it is like similar to this explanation only ok. So, what happens in your extra thoracic obstruction is that your inspiratory flow is getting decreased. So, if you take this FIF 50 to FIF 50 divided by FEF 50 that is forced inspiratory flow at 50 percentage divided by forced expiratory flow into 50 percentage we all we all already saw that if at all the numerator falls the ratio also falls ok.

So, in case of your variable extra thoracic obstruction what happens is that this value because the numerator is falling. So, it is your ratio is also falling whereas, in case of your intra thoracic obstruction what happens is that there is your flattening in your expiratory limb. So, because your denominator is falling your ratio is getting increased whereas, in case of your fixed obstruction what happens is that. So, because there is proportionate reduction in both inspiratory as well as your expiratory limb what happens is that this ratio is fairly like approximately related to 1 ok because there is proportionate reduction in both inspiratory and expiratory flow limitation is that clear I hope it is ok.

So, this is my last slide. So, I just want you to tell these two points it is like very good to know ok. So, what happens is that so we all, but your spirometry is not like standard right. So, it may like vary. So, what happens if at all you get a spirometry where your FEV 1 is fairly within normal limits, but your FEV 1 by FVC ratio is low. So, what happens is that there are some individuals who have this unequal growth between your lung parenchyma and in those kinds of individuals you can get this kind of your spirometry reports.

So, what happens is that these people are prone to develop the obstructive airway disease later ok. So, next possibility is that we have this FEV 1 by FVC ratio which is normal, but your FVC is reduced ok. So, what are all the possibilities for that ok. So, that means, the person is might be having this reduced effort also or the person may be having this airway obstruction or occlusion also or the person may be having this respiratory y restrictive ventilatory impairment also ok. So, these are all some conditions where the person will be having this normal FEV 1/FVC ratio whereas, they will be having this reduced FVC ratio ok.

So, these are my references and if possible, try to go through this second one which is like the technical standard which the update came in like 2021. So, here we are moving more towards these scores on the lower limit of normal and kindly go through this algorithm which I have projected before because that is what the subsequent things our spirometry reports will be interpreted in future like this because we will be having this lower limit of normal things also ok. So, I hope I have like touched upon on the updates and whatever you need to know basis also. So, if at all any queries just let me know I wish you all the best for your future endeavors. Thank you.