Pulmonary Function tests - Interpretation and application in clinical practice

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Week 2
Lecture 4

Assessment of Lung Functions in Children

Good morning all myself Dr. Antony, professor of Pediatrics, Chettinad Academy of Research and Education and I am here to talk about assessment of lung function in children. So, we have spirometry, peak flow meter, forced oscillation technique or impulse oscillometry, diffusing capacity of lungs for carbon monoxide and Bronchial challenge test. So among that the spirometry and peak flow meter are commonly used test which can be performed in children. So, when we come to spirometry, spirometry can be performed easily in children older than 6 years of age. So not only 6 years of age, if the trainer is very good, so they can even train the child and then they can the child, of child at an age of 2 and half to 3 also can perform when the trainer is very good enough to give a command and then so that they can extract from them.

So, the main purpose of doing a spirometry is they it can diagnose airway obstruction, demonstrate reversibility of obstruction, grade the severity of obstruction and assessing response to treatment and follow up tool. So this can be used as an either as a demonstration of the first airway obstruction diagnosis and demonstration reversibility and grade of severity of obstruction, assessing response to treatment, as well as the follow up of follow up tool. Performing spirometry test, so how we are going to perform? So there are 4 steps of forced vital capacity maneuver. So to extract the forced vital capacity, so we should follow the 4 steps.

So one is like rapid and maximal inspiration with lips tightly around the mouthpiece and followed by a blast of expiration. So first thing is like maximal inspiration, lips tightly around and then followed by blast of expiration. Third thing is continued blowing of air fast as 6 seconds in children. So it may be 3 seconds in younger children and finally complete inspiration. So when you do this one, so you just take it like a full complete loop.

So this is how you have to perform. So here actually a maximum of complete 8 complete maneuvers can be attempted in one session. So how will you interpret a spirometry test? So spirometry test interpretation, so first thing to interpret it has to fulfill 2 criteria. One is like acceptability criteria and other one is reproducibility or repeatability criteria. The acceptable criteria, in acceptability criteria there should be all must be fulfilled like first it should be free from artifacts.

So when starting it should not be poor start or cough. So there should be double expiration and poor patient effort and must not have premature finish. Then there is like a glottic closure before 1 second itself, so that is called as a premature finish. So usually at least minimum of 4 seconds and maximum of 6 seconds it should go. The first blow should be very fast in the first seconds and after that it should go at least 3 to 5 or maximum for 6 seconds.

So suppose if there is like glottic closure it will stop by 1 second, so that is like an it is not an acceptable criteria. Fourth thing is back extrapolated volume which should be less than or equal to 5 percentage of forced vital capacity or 100 ml whichever is greater. Next thing is expiratory time at least for 3 seconds. So for older children it should be 6 seconds and there is no obstruction in the mouth flow, no flow on the graft. So if there is any obstruction in the mouthpiece then we will not get the proper flow and there should be no leak.

So if there is like any leak so it will lead to interrupted lines, so we will not get a proper graph. So repeatability criteria are applied to acceptable forced vital capacity and forced expiratory volume in 1 second values. So it again the repeatability criteria varies for age more than 6 years as well as age less than 6 years. For age more than 6 years the difference between the 2 largest forced vital capacity values must be less than 0.150 litres and the difference between the 2 largest FEV1 value must be less than 0.15 litre. For the children age less than 6 years the difference between the 2 largest forced vital capacity values must be less than 0.100 litre or 10 percentage of the highest value whichever is greater. And the difference between the 2 largest FEV1 value must be 0.100 litres or 10 percentage of the highest value whichever is greater. So this should this both the things should be fulfilled to say whether it is like a the interpretation should be begin.

So while interpreting so we have 2 graphs are very important. The 2 graphs in spirometry is like one is normal volume time graph the second one is flow volume loop graph. The normal time volume time graph has volume as well as volume as well as time so in which the first expiratory volume in 1 second is the first one and after followed by so it is like first expiratory volume till up to the 6 seconds. So this is one volume time graph the second one is flow volume loop. In the flow volume loop so the child first thing is like so first peak expiratory flow rate or first expiratory volume in 1 second and followed by an expiration so which almost takes up to the 6 seconds so and followed by an inspiration to form a loop.

So when the inspiration is complete it is called as total lung capacity. So when the expiration is complete so it is almost equal to the residual volume. So so so when this is complete we are able to get the first when between the 0 to 2 value it is called as a forced vital capacity. So these are the things we can do get as a flow volume loop. So this graph represents the obstruction.

So obstruction is nothing but an airway disease. So the normal spirometry has a normal loop which has an inspiration followed by an expiration and followed by an inspiration completely so which is like a which we get which we get as a complete loop whereas in an obstructive phase if we if we are able to make so the litre per second is actually reduced. So this is actually the obstruction phase. Now let us approach how to approach to interpret the spirometry and while approaching a spirometry the parameters mainly what we need is like forced expiratory volume in 1 seconds and forced vital capacity and the ratio of forced expiratory volume versus forced vital capacity. So there are even there are lot of other parameters like FEF, 25%, 50%, 75% so but these 3 parameters are very much important to say whether there is like an obstruction or any other restrictive patterns and finally how we are going to go for the evaluate for the lung volumes.

So when it comes to so first perform a spirometry as per standard procedures. The standard procedure is nothing but according to the ATS or ERS guidelines you are you do it with the standard procedures and is just having an acceptability and repeatability and okay. So if the test is acceptable if the test is repeatable or if the test is not acceptable if it is not acceptable even after the 8 maneuver or we do not get a 3 best of out of the 8 maneuvers then do not interpret and repeat after few days. So if the acceptable criteria is quite good enough now what you have to do is you have to check for FEV the ratio of FEV with FEV in 1 second with forced vital capacity and if the ratio of forced to expiratory volume in 1 second and FVC is less than 80% or 5th percentile then there is some sort of obstruction obstructive phases there. So okay so now again now what you have to do is like you have to calculate you have to see for the forced vital capacity.

If the forced vital capacity is more than 80% when the ratio is less but the forced vital capacity is 80 more than 80% then it shows obstructive pattern. So when it is obstructive pattern so you have to check whether it is truly an obstructive pattern you can do bronchodilator test and if the bronchodilator test is positive then it is suggestive of Asthma. If it is negative then it is suggestive of non-reversible airway obstruction. Suppose the FEV1/FVC is less than 80% and the forced vital capacity is less than 80%. So it seems to be a mixed pattern so you have to evaluate the lung volume okay.

Whereas the FEV1/FVC, the ratio of FEV1 and FVC is on a more than 80% or more than 5th percentile. Now you have to calculate see the FVC value and if the FVC value is less than 80% it is like restrictive pattern. So if the FVC is more than 80% when the FVC is when the ratio is less this is like obstructive pattern. When FVC is more than less than 80% it is restrictive pattern. So when all the things are on a higher side it is normal.

So if only the FVC pattern is on a lesser pattern it is like restrictive pattern then you have to calculate for the evaluate the lung volume. Now we are coming to a bronchodilator response. So this is the one we are doing it like in the obstructive pattern. When you find a obstructive pattern you can do a bronchodilator response to say whether there is any

reversibility. So before conducting a bronchodilator test you have to ensure patient has not used a short acting beta 2 agonist in the last 4 to 6 hours because for a bronchodilator response we are going to give a short acting beta 2 agonist to have a bronchodilatation.

Also we should not use a short acting muscarinic antagonist, Ipratropium bromide in the last 12 hours, a long acting beta 2 agonist in the last 24 hours, a long acting muscarinic antagonist in the last 36 to 48 hours. Inhaled corticosteroids and leukotriene modifiers like Montelukast need not be withheld. So how will you do? So bronchodilator response is assessed after 15 minutes of 4 doses of 100 mcg salbutamol. So 100 mcg salbutamol or albuterol inhalation using a metered dose inhaler with a spacer or nebulization. So what is the response you see? So if you see the response of more than 10% or 200 ml improvement in a forced expiratory volume in 1 seconds or 15 to 25% of improvement in forced expiratory flow in 25 to 75% suggest reversibility of airway obstruction.

So this is very essential part in the spirometry. Now let us come to the second commonest used methods of the lung function test, peak flow meter. So this is an inexpensive clinic instrument. So this is mainly used for monitoring asthma. So you can get this one and then the patient can take it to the home and then they can monitor their asthma status.

So how the medications is working. So they can do the peak expiratory flow, morning one time and then evening one time and then they can keep a track of it and then they can use it for a monitoring purpose. So main thing is like it helps in build confidence in the treatment. So suppose if the treatment is working very well then it builds confidence.

It is very simple to use. The only thing is like you just keep in a mouth with a mouthpiece, one hard and a fast blow. So what we have to do is like best of 3 efforts we have to take, measured volume compared with personal or predicted best. So how will you interpret on the peak flow is it is like keeping as a traffic light zonal system. The 3 zonal systems are the green, yellow and red. So as you see red is always on a higher side and we have to be very cautious with red.

Here the PEFR value for a green will be like 80 to 100 % whereas yellow it is like 50 to 79 % and red it is like less than 50 %. So signal here is for the green it is all clear, yellow it is caution. So red is a medical alert and asthma symptoms for a green it is there is no and for yellow it is present and red it is like 2 positive points. And then so it is like more and then medicine plan, continue the medicines as usual and yellow asthma not under control and for red take bronchodilator.

PEFR measurement for diagnosis. So when spirometry, so when we will use this PEFR, so PEFR measurement we can use it for the diagnosis purpose also when there is no spirometry not available. And then documentation of PEFR variability may be used to support diagnosis of the asthma. PEFR recording, that is why the PEFR recording is always maintained once in the morning as well as once in the evening with symptoms or under use

of an after use of an inhaled bronchodilator. So after use of a bronchodilator definitely you will have a some sort of reversibility or some if it is like an obstructive pattern the results will be on a better better side. So peak flow variability is measured in percentage.

The peak flow variability of a more than 20% correlate with symptoms of asthma. So that is how it is correlated. So the uses of peak flow meter are so it is commonly used for follow up of patients to determine effectiveness of therapy. So for how the therapy is effective. So because it is a simple mini peak flow meter so they can take it home and then they can do and then they can keep a track on that and identify factors which triggers or worsens asthma and diagnose occupational asthma.

So suppose in the industrial areas or occupational related so they diagnose occupational asthma you can do and measure control of asthma. So these are the main four uses of peak flow meter. So next comes forced oscillation technique or impulse oscillometry. So FOT/ IOS is used to assess the mechanical properties of the respiratory system like airways, lung, parenchyma and chest wall in a passive manner during the tidal breathing. So this is actually it does not need any cooperative methods like hot blow or fast blow and then take a deep inspiration it should be for six seconds and there should not be any artifacts.

It is not like that it is like a passive manner during a tidal breathing normal tidal breathing you can do it. So one thing is like so three waves are very important here that sound waves generated with the help of a loudspeaker are superimposed on normal tidal breathing. Three types of oscillation signals are used one is like mono frequency this is sound waves transmitted or a single frequency generating a sinusoidal waveform as in forced oscillation technique. In impulse oscillometry recurrent pressure oscillation are applied at a fixed frequency of 5 hertz generating a square wave pattern pseudo random noise PRN signals. So impulse of several frequencies are simultaneously applied.

So these are the three methods of frequencies of signals are applied. So how we are going to interpret. So according to law of physics the lower the airway resistance the higher the flow will be and vice versa. So therefore the higher frequency impulses like 15 to 20 hertz get reflected from the larger airways to the mouth whereas the lower frequencies like 5 to 10 hertz frequencies travel deep into the lung before returning. The recommended frequency range is between 4 to 30 hertz.

Studies have demonstrated comparable measurements of airway resistance by devices using FOT and IOS though FOT are more sensitive to airway elastase properties. The main advantage of FOT and so this is a picture showing the forced oscillation technique. The main advantage of FOT or IOS are that it is effort independent. It requires minimal patient cooperation. So even a 2 year old or a 3 year old we can perform is quick and easy and can perform in a children of 2 to 3 year of age to the elderly people.

So what are the main condition it is actually used or what are the condition. So it is mainly used when there is like a spirometry is contraindicated like a recent surgery recurrent pneumothorax, spirometry related bronchospasm or during pandemics where forceful blowing is discouraged. So these are the conditions we can use the forced oscillation technique to find out the obstructive pattern. Next comes diffusion capacity of lungs for carbon monoxide DLCO. So the main purpose is like how why we are doing it is because the ability because there is an ability of the lungs to transfer gas or oxygen from inhaled air to the red blood cells is measured.

Commonly used gas is carbon monoxide as it was as it has a high affinity for hemoglobin. Diffusion capacity of the lung is determined by the thickness of the alveolar capillary membrane and hemoglobin concentration. So indication for DLCO is for diagnosing restrictive lung disease like interstitial lung disease, hypersensitivity, pneumonitis, sarcoidosis and drug induced ILD. So even though these things are not common in pediatric population but even like if there is like a rare conditions then we can do the DLCO methods. So this can be performed even as a single breath maneuver, steady state maneuver or intra breath analysis method using standardized techniques.

So three maneuvers are do done one is like single breath maneuver, steady state maneuver or intra breath analysis method. Steady state maneuver is relatively easy to perform in children however it is not widely used due to its variability, lack of studies and unavailability of normative data. Bronchial challenge test so patient with symptoms of asthma but the spirometry seems to be normal. So this is how now because they will be on a long term or they may not have any triggers so but they are asthmaticus but we have to find out whether they are have an obstructive obstructive airway disease. So patient with symptoms of asthma but normal spirometry you can do this bronchial challenge test.

So it has two component one is like direct airway challenge the other one is indirect airway challenge. So direct airway challenge is by use of an inhaled methacholine or histamine challenge. So now we see fall in FEV1 from baseline of more than 20%. Indirect airway challenge is inhaled mannitol or exercise challenge. Exercise challenge is usually done for older children so they can do the exercise in a treadmill or run for about 6 minutes and after that you can check up fall in FEV1 from the baseline of more than 15%.

So this is called as bronchial challenge test. In conclusion in summary actually the PFT a pulmonary function test is an essential tool for pediatrician and pulmonologist. The availability of standardized devices and reference values for children remains challenging. The results of any test should be interpreted in conjunction with clinical condition. This is most important so we have to interpret in conjunction with clinical condition.

So initially it was followed as a GINA. The GINA has changed to GLA which is nothing but global lung function. Initiative network reference equations are available for

spirometry, DLCO and lung volumes that that should be used while interpreting these conditions. The follow up test helps monitor the disease progression and response to therapy.