Course Name: Pulmonary Function Test -Interpretation and Application in clinical practice
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W3_L2_Interpretation of Normal Pulmonary Function Tests

Greetings to one and all on this forum. Having understood the basic principles of pulmonary function so far, I take this opportunity to bridge what you have learnt on to the clinical sessions that are going to follow. And so, in this presentation I will talk to you about the interpretation of normal pulmonary function tests. The objectives of my session are as follows. I shall begin by giving you an overview of the interpretation of a spirometric evaluation of pulmonary function and then I will talk to you about the gestalt approach in interpreting the flow volume loop and then I will talk to you about the interpretive significance of the dynamic lung volume followed by the static lung volumes. And then the last slide will give you a highlight about the value of spirometry in the diagnosis of pulmonary disease.

So, first we shall have an overview on the interpretation of normal pulmonary function tests. This slide shows that the primary goal in interpreting a spirometric analysis of a person's pulmonary function is to assess if the person's lung function is within normal limits suggestive of an obstructive lung disease, suggestive of a restrictive lung disease or suggestive of a mixed pattern of lung disease. This slide gives you an overview of the obstructive lung diseases. An obstructive lung disease is one in which limitation to air flow is primarily due to obstruction in the airways.

There are airways in the conducting as well as the respiratory zones of the respiratory tract. Such an obstruction may be due to bronchoconstriction, mucus plugging of the airways, airway inflammation and easily collapsible airways. Examples of two widely prevalent obstructive lung diseases include bronchial asthma and chronic obstructive pulmonary disease or COPD. Here is an overview of restrictive lung diseases. Restrictive lung diseases are a category of extra pulmonary, pleural or parenchymal lung disorders that restrict air flow and thus also restrict lung expansion.

Examples of restrictive lung diseases can be categorized as being either intrinsic or extrinsic. Pulmonary fibrosis and occupational lung disorders are examples of intrinsic restrictive lung disease. As far as the extrinsic restrictive lung disorders are concerned, abnormalities of the bony thorax are vertebral column, pectus carinatum, pectus excavatum or kyphosis, obesity, pleural thickening and ascites are all examples where restriction can

occur due to an extrinsic cause. Lung function is clinically interpreted using the flow volume loop and analyzing this flow volume loop can give an idea of a person as a normal pulmonary function or one suggestive of an obstructive, restrictive or mixed pattern of disease. The flow volume loop is a curve in which the flow of air is plotted on the y axis and the volume of expired or inspired air is plotted on the x axis.

So, usually the flow volume loop has an expiratory component which is the flow volume loop over the baseline and an inspiratory component which has which is the flow volume loop below the baseline. Data for three pulmonary function tests can be derived using the flow volume loop namely the force vital capacity, the peak expiratory flow rate and the expiratory flow rates namely the FEF 25, the FEF 50 and the FEF 75. This is a normal expiratory flow volume loop and here you can see that the volume of air which is plotted on the x axis and the air flow rate is plotted on the y axis. So, by analyzing this curve you can have an idea about the force vital capacity, the peak expiratory flow rate and the FEF 25, 50 and 75. The gestalt approach in interpreting the flow volume loop is widely followed by many clinicians and we shall have an overview of the gestalt approach over the next few slides.

Before we go to understand the gestalt approach in interpreting the flow volume loop, we should try to understand why we prefer the gestalt method in interpreting the flow volume loop. A mathematical detection of pulmonary function using the flow lung parameters is tedious and it requires memorization of values which can be associated with a higher incidence of errors and that and for that reason we do not mathematically interpret the flow volume loop as was previously done many years ago. And to begin with let us understand the few core principles of interpreting the flow volume loop using the gestalt method. In this method of interpreting the pulmonary function the normal predicted flow volume is compared with the individual's flow volume curve. So here you can see a normal flow volume loop of a person.

You can see the outline and always note at the area below the outline. So, whenever you look at the flow volume curve, we are supposed to look at this area because this area represents the functional respiratory reserve of a person. So, this must be always kept in mind whenever we look at the flow volume curve. A normal flow volume curve can be viewed as defining the maximal expiratory flows and volumes and in short this is the mechanical limit to ventilation. So, whenever we look at a flow volume curve and try to interpret it, we are trying to assess the mechanical limit of the person's ventilation.

So now let us look at the flow volume curve in obstructive lung disease. So, here is a normal flow volume curve and here is a flow volume curve of a person with an obstructive lung disease. So, you can see that so much of the respiratory reserve is compromised in a person with obstructive lung disease. A person with obstructive lung disease has only a

respiratory reserve of so much. And the concave shape of the flow volume curve with a low slope usually indicates an obstructive lung disease.

And this is correlated with a decrease or increase in some of the respiratory parameters namely the force vital capacity FEV1, the FEF flow rates and the maximum voluntary ventilation. So always whenever we look at the flow volume curve, I repeat look at the region below the outline of the curve and that will give you an idea about the mechanical limitation of respiration in the person. This slide shows the flow volume loop in a person with restrictive lung disease. So here you can see the outline of the predicted flow volume loop and here you can see the outline of the restricted flow volume loop. And this area shows the respiratory reserve that is compromised in this patient.

Also note that the curve in this instant shows a steep slope with the FEV being considerably reduced. This is the characteristic feature of the flow volume loop in a person with restrictive lung disease. So, using the gestalt approach the degree of ventilatory limitation can be defined based on the loss of area under the normal predicted flow volume curve as I said. And from a functional point of view an area loss of 25 percent is greater as mild, 50 moderate and 75 as severe ventilatory limitation. Take a look at the interpretive significance of certain dynamic lung volumes.

A dynamic pulmonary function test measures the volume of air exhaled during a forced effort. The forced expletive vital capacity is a dynamic pulmonary function test that is very sensitive to diseases that alter the mechanical properties of the lung. Example emphysema where the FEC is reduced, asthma where the FEC is reduced again, chronic bronchitis where the FEC is reduced and pulmonary fibrosis the FEC is increased. The forced expletive reserve volume in one second is the volume of air exhaled in the first second of FEC test and obstructive lung diseases cause the FEV1 to reduce. It is interesting to note that FEV1 is also reduced in certain restrictive lung diseases for example, pulmonary fibrosis.

So, the FEV1 per say cannot actually differentiate an obstructive lung disease from an restrictive one. So, what do we do to make out whether a person is having a restrictive problem or the or an obstructive problem. So, here we use a ratio called the FEV1 by FEC ratio which is a valuable index to differentiate obstructive lung disease from restrictive lung disease. The FEV1 by FEC ratio is expressed as a percentage and normally this index ranges from 75 to 85 percent. When this ratio the FEV1 by FEC ratio falls below the normal range it is highly suggestive of an obstructive lung disease.

Restrictive lung disorder on the other hand is associated with the FEV1 by FEC ratio that may be on the higher side of a normal or even moderately elevated. Let us see the interpretive significance of certain static lung volumes. What is a static lung volume? A static lung volume refers to the absolute lung volumes and this primarily includes the slow

vital capacity, the residual volume and the total lung capacity. In this presentation I will talk to you about the interpretive significance of the slow vital capacity and the residual volume. The residual volume clinically deflects the state of lung collapse and this can be actually visualized by comparing the inspiratory and expiratory chest radiographs.

Normally the lungs do not collapse on full inspiration and there is a residual volume of 1500 ml of air in the lungs. Now it is also interesting to note that from a physiological point of view it must be appreciated when the lungs collapse significantly venous blood in the pulmonary circulation would have no oxygen to pick up and a fall in tissue oxidation will result. The forced vital capacity is the volume of air expired following a maximal inspiration followed by a forceful and maximal expiration. While the slow vital capacity on the other hand is the volume of air expired following a maximal inspiration and a complete but slow expiration. So you can see that the difference between the forced vital capacity and the slow vital capacity is the expiratory phase which in the forced vital capacity is more powerful while in the slow vital capacity it is more gentle.

So, whenever we observe the spirogram and try to compare these two vital capacities that is the forced vital capacity and the slow vital capacity we must note that in obstructive lung disease the forced vital capacity is considerably smaller. So here you can see this graph shows a normal comparison of the slow vital capacity with the forced vital capacity and here you can see that the forced vital capacity is compromised in obstructive lung disease. This diagram shows a normal flow volume loop and a flow volume loop seen in obstructive lung disease and restrictive lung disease. So, you can see that the static lung volumes are shown on the side and they are noted to be altered in obstructive lung disease as well as restrictive lung disease. And this is the last slide of my presentation which shows the value of spirometry in the diagnosis of pulmonary disease.

We have taken COPD as an example chronic obstructive pulmonary disease because this is one of the widely prevalent lung disorders in the world. So here you can see in this box the chest x-ray shows hyperinflation in a person with COPD only after 55 years. The arterial blood gas shows hypoxemia only after about 50 years. As far as the symptoms are concerned, excessional dyspnea which usually brings the patient to the hospital is seen only after 50 years. But with regards to the spirometric analysis we can see here that airway obstruction can be picked up less than 45 years around 44, 43 to 45 years.

And at this point if necessary medical management is given the patient morbidity can the morbidity of the patient can be decreased. So always spirometry has a very very important role in pulmonary disease in reducing the patient morbidity and giving the patient a better lifestyle. And having given you a brief overview on the interpretation of pulmonary function from a functional point of view, the clinicians will take over from here and give you added inputs on how to interpret pulmonary function in disease. Once again, I thank

one and all for giving me this opportunity to address you all in this forum and I continue to wish you happy learning. Thank you.