31st A C E Koch Memorial Oration

18th November 2018

Air and Lungs : Health and Disease

Good Evening!

Professor Priyadarshika Hettiarachchi, The President Physiological Society of Sri Lanka, Our Chief Guest, Prof. Surangi Yasawardena, Guest of Honour, Prof. S. D. Jayaratne, Prof. Yoshihiro Ishikawa, Orator to the Prof K. N. Seneviratne Memorial Oration, Prof Susirith Mendis Orator of the pValentine Basnayake memorial oration, Prof. Carlo Fonseka founder member of the PSSL , Mrs Indra White, and Mrs Lani Foenander, the extended family representing the Anne and Graham Koch, the children of late Prof AC E Koch, Executive committee members and members of the PSSL, distinguished invitees, my dear students, ladies and gentlemen ;

It is a great privilege and honour to deliver the 31st A. C. E. Koch Oration held annually in memory of the late Prof. A C E Koch the first Ceylonese Professor of Physiology of the Faculty of Medicine, University of Ceylon.

I am humbly proud to present a brief narration of this great academic, a humane personality who has been the founder father of Physiology in Sri Lanka. Prof. Arthur Cecil Elsley Koch was the first Ceylonese Professor of Physiology. He was born on 20th November 1903, and if he lived he would have been 115 years old today. Born to an affluent Sri Lankan family, he had his primary and secondary education at Royal College, Colombo, where he excelled in his studies as an A grade student.

He then entered Ceylon Medical College in 1922. He had a brilliant academic record as a student of the Colombo Medical School, a part of University of Ceylon. He passed all his professional examinations with a first class and obtained a total of six distinctions and five medals in his undergraduate medical career. He chose Physiology to be his career path and joined the Department of Physiology as a demonstrator in 1935. He then proceeded to the University of Oxford, UK to pursue post graduate studies. He had the great privilege and honour to conduct research with Prof. C.G. Douglas FRS, the great respiratory physiologist who invented the famous "Douglas bag".

The pioneering research work at Oxford was published in 1951 jointly with Professor Douglas was titled - "Carbohydrate metabolism and muscular exercise" in the prestigious " Journal of Physiology". On his return to Ceylon he was appointed to the distinguished post of chair in Physiology in 1952. He was the first citizen of Ceylon to be appointed the Professor of Physiology in the University of Ceylon. He was a great kind man who excelled in his commitment to teach. During his academic life he held several notable positions; from the years of 1952 to 1957, he served as the General Editor of the Ceylon Journal of Science.

During the years of 1953 to 1959 he served as a Co-Editor of the Ceylon Medical Journal. In 1966, he was elected a Fellow of the Royal College of Surgeons of England.

The greatest impact of Prof. Koch was as a teacher in Physiology. He taught Physiology for one-third of a century with an amazing enthusiasm. Above all, Professor Koch's immense popularity as a teacher was because he tried to take a personal interest in his students. He was hearty in his encouragement of students and lavish in his praise of them. His students loved his quiet soft voice and the physiology he taught is remembered by many of his students as some of the most interesting lessons they had learnt in medical school.

He was elected an Emeritus Professor on retirement. He remained in touch with the Physiology Department - which was then staffed entirely by his pupils even after retirement. In his retirement he tried to find fulfilment in his life-long avocations – photography, literature, music and the repairing of watches and clocks. Within an year of retirement he passed away at the age of 65 years .

He is succeeded by his son and daughter Graham and Anne Koch who have graced this oration many a time and this year are graciously represented by Mrs. Indra White and Lani Foenander.

Each year the Physiological Society of Sri Lanka conducts this academic tribute in his memory, the A. C. E. Koch oration, and I am humbled by the honour bestowed on me and privileged to deliver this oration. I thank the president and the executive committee of the Physiological Society of Sri Lanka for awarding me the opportunity to be the orator this year.

I hope this oration on "Air and Lungs : Health and disease, would be a fitting tribute to a great physiologist who has engaged in pioneering research also on respiratory and exercise physiology.

Physiology of respiration

As soon as we are born, we take our first breath. It is the first sign of life, and the beginning of breathing. We continue to breath from then on until we die. We often use the word "expired", to convey the meaning of end of life ; death, or the absence of life. Thus, it is essential for us to breathe to sustain life, but, how many of us think about breathing ? We take breathing for granted as a voluntary process that continues through-out our life, until we are unable to breathe!. Then the effort of breathing becomes a terrifying experience!

What are the main functions that happen through the respiratory system when we breathe? *Ventilation* is the main process by which oxygen (O_2) containing air from the atmosphere enters into the lungs by movement of respiratory muscles. This air is now available in the alveoli to be supplied to the blood. The second is the process of *Perfusion* where deoxygenated blood travels from the right ventricle of the heart to the alveoli in the lungs to be oxygenated. The third main process of respiration is *Diffusion of gases*, where Oxygen (O_2) acquired from the atmospheric air that is in the alveoli crosses the alveolar capillary membrane to be taken up by the Haemoglobin in the red blood cells and to dissolve in the plasma. Further Carbon Dioxide(CO_2) diffuses from the blood into the alveolar air. Then comes the 4^{th} process of respiration, ie. *Transport* where Oxygenated blood is transported

from the alveolar capillaries, back to the left side of the heart. Then this oxygenated blood is pumped to supply O_2 to the 100 trillion cells of the body. Further the CO_2 produced by the tissue cells is removed into the blood and sent back to the right heart through the venous system. In order to perform this function of rapid gas exchange we have 300 million alveoli in our lungs. If we stretch out all the alveoli and spread them on a flat surface, the surface area that it covers is equivalent to about 60 square meters, the size of a tennis court! Further, if we spread 100 ml of blood on the surface of this area of a tennis court we will form a super thin layer of blood, ie. the blood layer that is in contact with the air in the alveoli, and this is the surface area that is available for gas exchange. It is via this marvelous action of diffusion that we can live our lives!

Now what about the atmospheric air we breathe? The air we breathe has an atmospheric pressure of 760 mm Hg, and the concentration of O_2 in this air is about 20%. What happens to the air when it enters into the respiratory passages? When the air enters through the nose it is saturated with water vapour, filtered and humidified. Once it mixes with the air in the respiratory passages, the partial pressure and the O_2 content of air decreases, and the partial pressure CO_2 content of air increases. Therefore the air reaching the alveoli has a partial pressure of 100 mm Hg for O_2 and a partial pressure of 40 mmHg for CO_2.

Although we maintain the process of breathing throughout life, the measurement of the function of the respiratory system was difficult. In the early days, most scientists observed that air moves in and out of the body. Further they observed that, expired air was poisonous to animals. However quantification of the volumes of air that are breathed in and out was difficult other than to determine the respiratory rate.

Measurement of respiratory function by Spirometry

In Latin, '*spirare'* means to breathe; 'metry' – means to measure; hence, spirometry deals with the measurement of breath, which is the most common way to evaluate pulmonary function. The 1st spirometer was generated as early as the second century. Galen (Claudius Galenus of Pergamo, A.D. 129 –circa 200–216), the famous Greek physician, tried to determine respiratory volume by having a boy breathe into a bladder. However he found that the volume did not change. The experiment proved inconclusive.

In 1800, Humphry Davy (1778–1829) measured the residual volume of his own lungs in 1800 by inhaling a hydrogen mixture contained in a mercurial air holder. Using the same principle, Nestor Grehant (1838–1910), in 1864, determined the functional residual capacity and the dead space volume; both used forced breathing. A schematic of the oldest unit we could track, called the *gasometer*, is depicted in the figure on your left.

The true beginning of modern pulmonary function testing (PFT) is dated to 1846, when John Hutchinson, an English physician, invented the spirometer by taking a common gasometer and turning it into a precision instrument able to measure the volume exhaled by human beings. Hutchinson was a genius, and a source of inspiration for those who followed him as he performed vital capacity measurements on 2,130 individuals, showing a correlation

between height, age, and the volume of the vital capacity. He coined the term expiratory vital capacity. His work inspired other researchers and inventors. Within a few years, improved versions of the spirometer evolved across Europe and the United States ie the Figure on your right. Indeed we are thankful to him for the invention of the modern spirometer. The device (which was as tall as an adult patient) was essentially a calibrated bucket that was placed upside down in water. The volume of exhaled air from fully inflated lungs could accurately be measured by exhaling into a tube leading into the bucket. Dr. Hutchinson coined the term "vital capacity" i.e., capacity for life, when he realized that compromise of this crucial measurement was predictive for premature mortality. Because of the strong correlation between vital capacity and mortality, Hutchinson argued that it should be utilized in actuarial predictions for life insurance policies. Neither the spirometer nor its measurements were accepted by the insurance industry and the device was used primarily in a limited function to measure usable lung volumes in patients at tuberculosis sanitariums.

This changed around 1950 when it was determined that 90% of the predominant respiratory disorders (asthma and COPD) were obstructive (limited flow rate) in nature whereas vital capacity measurements were affected mostly in restrictive respiratory disease. In 1950 Dr. Tiffeneau of France introduced the forced measurement of air volume during a given time frame, i.e., forced expiratory volume in 1 second, FEV_1.The FEV_1 became a popular measurement of respiratory dysfunction especially in people with respiratory disease.

Through the years the technology of spirometry has been developed and it is now a good robust machine. Modern spirometry tests are carried out by computerised, light weight, easily calibrated, portable, machines. The volumes of air that are breathed and the capacities that are formed by the combination of the air volumes are the results generated by spirometry. These volumes of air have been the basis for clinical investigation of respiratory function in health and disease for many years.

Along with the easy availability of spirometry, its clinical use too now has expanded. The tests are commonly used now to evaluate the symptoms and signs of lung disease, to assess the progression of lung disease, to monitor the effectiveness of therapy, to pre-operatively evaluate patients in selected situations and to screen people at risk of pulmonary disease, eg; smokers or people with occupational exposure to dust or toxic substances in occupational surveys.

A standard pulmonary function test report contains the patient's data, spirometry results of lung volumes and capacities with predicted values, a flow volume loop and the diffusing capacity of CO (DLCO) values.

My fascination with respiratory function commenced in 1992 in the early part of my career, when I started training to test for respiratory function as a junior demonstrator in the Faculty of Medicine University of Ruhuna.

The early spirometer gifted by the Japan International Cooperation Association, to the Department of Physiology, was a large box like machine similar to a washing machine. However the wonderful data it produced in healthy persons and in diseased generated a fascination in me for clinical physiology which I have taken up as my career path. The interest

was furthered when I joined as a junior lecturer in the department of Physiology of the Faculty of Medical Sciences, at the University of Sri Jayewardenepura, I was so happy to receive the 1st piece of large equipment that was purchased for the department, a Vitallograph spirometer in early 1994.

I conducted a small research project on smoking army officers working for the military and discovered that each officer was given 1000 cigarettes a month free!!! …..so that he can becomes tobacco smoker whilst in serving in the military! One of the out comes of the research was that I managed to convince the army hierarchy that giving free cigarettes to an army official seriously harms the health and well being of the officer; and if the military powers need healthy officers they should stop issuing free cigarettes. I'm glad to inform that after the findings of the study were intimated the army decided to give the officers monetary compensation instead of free cigarettes…

Through the years the fascination of testing lung functions by spirometry and the results it yields has enhanced my curiosity to study respiratory function in various settings. I briefly outline some of them here under the motto of the Physiological Society,"Search, Teach, Serve".

Reference Norms of Lung Function Parameters for Sri Lankan Tamils Living in Northern Province of Sri Lanka

In Sri Lanka, spirometry was not a common clinical investigation in clinical practice in the past due to the inconvenience of using the manual spirometers. Further to the development of the modern spirometer, flow and volume sensing turbine flow meters which are portable became easily accessible. These modern spirometers generate computerized data sheets immediately upon measurement. These aspects greatly facilitate the use of modern spirometers as a useful assessment tool in primary and secondary respiratory care.

Ethnic specific reference equations are necessary in interpreting lung function parameters (LFP) as ethnic variations have been reported by previous studies (Bandiopadhyay, Knudsen,Mary IP, Uduphille). The first set of reference norms for respiratory function of the Sinhalese ethnic group derived by Professor Malini Udupihille a senior academic of Physiology, derived the first set of reference norms and her reference values are still in use today (Udupihille et al 2004). Subsequently considering the Sri Lankan studies, reference norms have been derived for several groups namely the Sinhalese ethnic group, (Uduphille, et al.), for children aged 8-16 years (Liyanage et al, 2017) and for Sri Lankan Tamil young adults aged 20-28 years.(Balasubramaniam et al, 2014). However using these equations in interpretations are also not completely appropriate as the study in the Sinhalese ethnic group was done nearly two decades before with bellows type spirometers. Other equations do not cover a wide age range of representative samples. Hence, Sri Lankan equations are thus still not incorporated into modern pulmonary function machines and at present, the South Indian values are used to generate the predicted percentage of these parameters in computerized lung function reports in Sri Lanka. Global Lung Initiative (GLI) has produced spirometric prediction equations that can be used in all ages globally. However data from South Asians

are scarce in the GLI data base (Quanjer et al 2012).Equations derived for South East Asians over predict the values for Sri Lankans (Liyanage, 2017). Hence, establishment of reference norms with new turbine spirometers and validating the spirometry results in Sri Lanka is essential. Therefore, this study was undertaken with the aim of establishing reference norms for LFP of Sri Lankan Tamils. As Northern Province has the highest percentage of Sri Lankan Tamils than other provinces in Sri Lanka, this study was carried out in the Northern Province.

A descriptive cross sectional study was carried out in all 5 districts of Northern Province, Sri Lanka. Participants were selected by cluster sampling. we studied 1600 males and females stratified to age and gender.

Base line data were obtained by a questionnaire. Height, sitting height, weight, arm span, mid arm circumference and chest expansion were measured. Respiratory functions were assessed by a Wright compatible peak expiratory flow meter and by a calibrated spirometer (Cosmed Micro Quark, Italy).

Marked changes in lung function parameters of males from 14 to 15 years is associated with changes in anthropometric characters between these age groups. However the changes were minimal in females. This agrees with the findings of Neve et al. that the lung development in males continues until the end of puberty whilst lung development in females were completed at menarche. (Neve et al, 2002). As females attend puberty earlier than males and this study population didn't have participants < 14 years, the changes were not observable. This is also consistent with data of Uduphille et al. that young males achieved pulmonary maturity about 5 years later than female counterparts .

Correlations of lung function parameters with anthropometric characteristics are shown in these slides. The greatest correlation observed with height is in agreement with other studies. (Kivastik, Nku)

Comparison of lung function parameters with other ethnic groups when adjusted for age and height (Table 8) shows that the normal lung volumes of males in this population were lower than the values obtained for Indian, Pakistani, Chinese, Jordanian and Canadian populations. FVC was similar to Sri Lankan Sinhalese but was higher than the Malaysian population. However amongst the females, the lung volumes were higher than Sri Lankan Sinhalese, and Indians from Calcutta and lower than South and North Indians, Pakistani, Chinese and Canadian female subjects. PEFR of this population was lower when compared to Sri Lankan Sinhalese, Indians from Calcutta and Brazilian populations. Both male and female Malaysian subjects had lower values than Sri Lankan Tamils.

Although Sri Lankan Tamils and Sinhalese had almost similar mitochondrial genetic patterns(Ranaweera, et al) the study instruments, sample selection, and environmental changes in 2 decades may have contributed to the small differences observed amongst females. Multi ethnic reference equations of Global Lung Initiative (GLI) 2012, for South East Asians didn't accurately predict the lung function parameters of Sri Lankan Tamils. Lack of data from South Asians for GLI equations (Quanger et al, 2012) may explain these differences.

In conclusion, need for the ethnic specific equations for lung function parameters are revalidated and equations for Sri Lankan Tamil population were formed by this study. The study was done by including samples from all over the Northern province of Sri Lanka and ATS criteria were followed in conducting lung function tests. Hence, this can be useful in assessing the respiratory function in Sri Lankan Tamil population as there are no already existing reference equations. It is anticipated that these study results will provide the data for GLI equations too. Thus providing reference norms for Sri Lankan Tamil population.

Assessment of Cardiopulmonary Exercise fitness of athletes in Sri Lanka.

Tests of Cardiopulmonary function (CPET) during exercise have been used for over 50 years. However, its versatility and clinical use for patients with cardio vascular and pulmonary disease has emerged only recently. The clinical use of CPET has been enhanced further with the development of technology over the years. The addition of ventilatory gas exchange measurements during exercise testing provides a wide array of unique, clinically useful information that had been poorly utilized by the practicing clinician. Therefore CPET is now being recognised as a valuable testing method that can provide important results for physical training of healthy adults, and patients with cardiovascular and pulmonary disease.

CPET has long been used in the assessment of athletic performance. In sports medicine research CPET data provide valuable inputs to trainers and sports personnel as an effective test of endurance.

Our Sri Lankan athletes perform poorly in the international arena despite regular training provided by the ministry of Sports for these elite athletes. Physical performance depends on the physical fitness and technical training. Cardio Pulmonary Fitness testing (CPET) objectively measures the physiological parameters that can test physical fitness, Further there are no normative data on cardiopulmonary fitness parameters of athletes in Sri Lanka. establishment of these parameters will be beneficial to improve the performance of athletes to perform optimally in the international sports arena.

Considering the above factors we decided to study the cardiopulmonary function of athletes competing at university level and at national level with healthy control subjects. the project was granted funding by an University research grant which was used to purchase a modern cardio pulmonary exercise testing machine with a bicycle ergometer (COSMED – Italy).

I will outline the investigations that we have conducted using this modern CPET machine and the results generated with the machine. Madam president, I am happy to inform you that this is the first time that CPET has been conducted on Sri Lankan sports men and women. Our study was to assess Cardiopulmonary function of 300 subjects in our pulmonary function laboratory. The objective was to assess the cardio pulmonary exercise function of these athletes in comparison with the control subjects. Cardiopulmonary exercise fitness (CPET) parameters and Lung function parameters were obtained with a Cardiopulmonary fitness assessment apparatus with automated cycle ergometer (COSMED – Italy). Tests were conducted in a fully air conditioned laboratory at the faculty, where the room temperature was maintained at 23˚C.

The CPET machine was calibrated daily and continuous Ramp protocol with an average total duration 10- 20 min. After a warm up cycle, exercise intensity was increased by 30 W/ min through out the test. The test was continued until the player reached the peak VO2max level or physical fatigue.

The data reveal that there were no significant difference of anthropometric parameters and the training data between national and university runners. The peak O2 consumption of the national and university endurance runners in comparison to Asian runners is very poor. The VO_2peak (mean 60.1 ± 9.2 SD, L/Kg/min) of the national runners is significantly higher than the VO_2peak of the university runners (mean 50.7 ± 7.5 SD, L/Kg/min) . However when our national runners are compared with the Asian counterparts, the other Asian athletes had a very high mean VO_2 peak (mean 80 ± 9.2 SD, L/Kg/min)than our national runners. Further the Anerobic threshold of national and university runners were also significantly tilted towards the anaerobic level than aerobic level. The anaerobic threshold (AT) describes the point where the anaerobic glycolysis starts during the activity. Therefore Endurance runners must have high AT favoring late onset of anerobic glycolysis. However Our national runners had no significant improvement of AT over university runners. Further the AT of both national and university runners showed the tendency towards more anaerobic level rather than aerobic level. However the Asian counterparts shows significantly higher AT than our national runners, thus indicating the greater endurance capacity of the Asian runners. When the peak blood lactate level of endurance runners was assessed the national and university runners had higher level of peak blood lactate levels. Asian endurance runners have a much lower peak lactate level thus giving them a greater ability to perform aerobic exercise before converting to anaerobic exercise patterns during athletic activity.

Blood lactate response (LA and AT) to training of national endurance runners was not improved significantly when compared with university runners. The remodeling of the peak oxygen consumption and blood lactate response to training amongst the Sri Lankan national runners is far lower than the Asian counterparts (*A.K.Gosh, 2004)* This explains the poor performance capabilities of our athletes, and need to be urgently addressed.

In conclusion routine monitoring of athletes should be mandatory before commencement of training and after training to determine the effectiveness of the training protocols. Further, depending on the physical fitness of the individual athlete, the training should be adjusted to obtain the peak Vo2 max and the most appropriate lactate threshold for the individual athlete. These aspects are being further addressed in our laboratory as a follow up study.

Now ladies and gentle men, I wish to draw your attention to the effects of tobacco smoking.

Respiratory effects of Tobacco Smoking and novel methods to monitor the compliance to Tobacco Smoking Cessation

Tobacco is the only legal drug that kills many of its users when used exactly as intended by manufacturers. Tobacco smoking accounts for about six million deaths per year (World Health Organisation (WHO). The death rates are due to direct exposure and second hand smoke. Further smoking among females is known to contribute to many premature deaths. Smoking is often associated with ill-health, disability and death from non communicable and

communicable chronic diseases. Therefore smoking is well known to contribute to severe serious disease.

What is the smoking status in Sri Lanka? According to the WHO statistics of 2017 (WHO,2017) approximately 29.4% adult males are smoking. However, we are lucky that most of the females in Sri Lanka do not smoke and therefore the disorders that occur in pregnancy such as premature deaths due to smoking are rare in the Sri Lankan setting. The health problems quantified by the WHO as the estimated annual mortality from tobacco-related illness is about 20, 000 deaths for Sri Lanka. Further the Alcohol and Drug Information Center (ADIC) reports that Sri Lankans spend approximately Rs.208 million on cigarettes per day (ADIC,2018). Therefore there is still a problem of smoking in the country and its health issues are a burden to the health ministry that provides free health care to the patients.

Although the WHO estimated that smoking rate was 29% for men ie. 15% of population in 2010, we expect the rate to decrease over the years. However the WHO estimates that the prevalence of smoking will remain at the same 29% even after 15 years in 2025; due to the increase in the adult population and the proportion of adults that would be increased in the country by 2025. This should make us the health care providers be more proactive to establish smoking cessation activities in the country. We have come up with adopting new technology to measure smoking intensity by measuring breath carbon monoxide levels to monitor smokers.

Now I will explain the relationship of carbon monoxide (CO) & carboxy-haemoglobin (COHb) with tobacco smoke. During smoking, when tobacco burns, it produces CO. CO has a very high affinity to haemoglobin, therefore, it binds to haemoglobin irreversibly to form carboxy -haemoglobin. Carboxy -haemoglobin is a toxic compound and cannot bind with oxygen. The main function of haemoglobin is O_2 carriage. However this function cannot be performed when carboxy–haemoglobin is formed; resulting in serious impairment of O_2 carrying capacity of blood.

Recently a novel testing mechanism has been derived to measure the breath CO levels in expired air. Measurement of CO levels in expired air helps to monitor smoking severity and can be used objectively to monitor smoking cessation as well. The breath Carbon Monoxide (BCO) and Carboxyhemoglobin (COHb %) levels are an index of the number of cigarettes a person smokes per day. The test measures of Breath Carbon Monoxide (BCO) and Carboxyhemoglobin (COHb %) levels are good indicators of smoking intensity amongst smokers. CO levels are detected as carbon monoxide molecules in a million parts (ppm) of air.

The above measurement technique was used in the present study. Therefore the objectives of the study were to determine the cardio respiratory function amongst male smokers in Colombo District of Sri Lanka and assess the compliance to a smoking cessation programme. The Specific Objectives were to determine the smoking frequency, and smoking pattern of current smokers of the selected population; to determine selected cardiovascular and respiratory function parameters amongst the smokers and non-smokers.

We studied 90 smokers with non smoking healthy adult control subjects. The mean breath CO level of smokers (mean 12.60 ppm ± 9.21 SD) was significantly high when compared to the

mean breath CO level of non smokers (1.87ppm ± 0.63 SD) ($p < 0.001$). Further the mean COHb% of the smokers (mean 2.64 ± 1.48 SD)was significantly high when compared to the mean COHb % (mean 0.96 ± 0.11 SD) of the non smokers ($p < 0.001$). In the study when the smokers abstained a decrease in the BCO levels and the COHb% was observed in propotion, indicating that both measurements can be used to monitor the smoking levels in the population. To the best of the our knowledge, the present study is one of the first to test the BCO levels and COHb% levels to determine the smoking severity in Sri Lanka.

Respiratory function and Exposure to Bio mass fuel

The severity of exposure to bio mass fuel and the respiratory dysfunction in very deprived socio economic status countries is well known. However the effect of respiratory dysfunction amongst Sri Lankan women exposed to biomass fuel smoke are unknown. Thus a study was conducted to assess the effects of kitchen and stove characteristics on respiratory health of women exposed to biomass fuel smoke by measurements of peak expiratory flow rate (PEFR), fractional exhaled nitrous oxide (FeNO) and exhaled breath carbon monoxide (BCO). The study revealed that exposure to bio mass fuel is associated with a rise in FeNo and BCO levels and a decrease in PEFR. Further the availability of a window in the kitchen did affect the FeNO of BCO levels of these women. The availability of a chimney contributed to the reduction of BCO levels of the exposed women.

Respiratory function and Disease

Now I will discuss some of the studies to assess respiratory function of disease. Prevalence of preventable chronic respiratory diseases is increasing worldwide and affects the quality of life of affected individuals (WHO, 2007). Early diagnosis is important to reduce morbidity and mortality due to respiratory diseases. Spirometry is the gold standard for diagnosing airway disease (GOLD, 2018)

Spirometry and Peak Expiratory Flow Rate (PEFR) are important measurements in diagnosing asthma and are the commonest investigations in asthma. The study to assess the "Peak Expiratory Flow Rate, Markers of Air Way Inflammation and Medication Adherence among Adult Asthma patients attending a hospital clinic" used novel methods to determine the severity of inflammation. The second study addresses the hazard of occupational exposure to a dusty environment, where the " clinical features, lung functions and factors associated with respiratory dysfunction and preventive methods adopted by construction workers" working in Colombo area were studied.

Many studies have been conducted at the community level on the burden and severity of asthma. Despite treatment many asthma patients complain of poor control of the disorder, thus impacting their daily lives. Asthma patients form the bulk of the patient load in respiratory clinics in a Sri Lankan hospital setting. Although the benefits of drug therapy are established, adherence to medication is poor, and this may contribute to an increased risk of asthma exacerbations.

Asthma is characterized by airway inflammation contributing to airway obstruction. Proper anti inflammatory treatment requires accurate assessment and monitoring of the underlying

inflammatory state of the airways. Until recently, there has been no way of measuring and quantifying the airway inflammation in asthma. The adequacy of anti-inflammatory control is commonly assessed subjectively. Often control is determined by clinical improvement (ie, resolution of symptoms and physical findings), of the patients, however the improvement in response to treatment cannot be quantified. It is now possible to assess airway inflammation and determine the severity of inflammation in asthma patients by measuring the fractional concentration of exhaled nitric oxide (FeNO) during a visit to the clinic.

Nitric oxide (NO) is an Inflammatory mediator found in animals and humans. The mast cells, T- lymphocytes and the airway mucosal cells release nitric oxide (NO) when there is inflammation of the airways. The released NO is exhaled in the breath and can be used to determine the level of airway inflammation. Measurement of FeNO can provide vital information on the extent of airway inflammation; further it can be quantified to detect the severity of the inflammation.

Breath FeNO levels; an index of airway inflammation can be measured by a sensitive analyzer (Bedford, UK) with a sensitivity of 1 ppb by single breath technique. The machine measures the levels of FeNO against time expressed as parts per breath (ppb).

The Peak Expiratory Flow Rate (PEFR) and Fraction of Exhaled Nitric Oxide (FeNO) are both very simple, low cost, important bedside tests that can be performed in assessment of respiratory function. PEFR is a useful bedside test to assess the velocity of expired air. It is commonly used in hospital settings to determine severity of asthma/ obstructive airway disease. The FeNo is a good indicator of airway inflammation and it too can be used as a bedside test. Thus even in the absence of spirometry, these two tests can be used to monitor respiratory disease even in low resource settings.

Assessment of pulmonary function by spirometry will always remain important, however it cannot quantify the main problem, that is, airway inflammation especially during an exacerbation. Thus, FeNO measurements provide relevant complementary information that can be applied in routine chest clinics. FeNO measurements are highly correlated with eosinophilic airway inflammation. Further eosinophilic airway inflammation is associated with a positive response to steroid treatment. Thus in patients with non-specific respiratory symptoms, the raised FeNO levels predict steroid responsiveness. In these patients steroids can be effectively used to treat exacerbations.

To the best of the our knowledge, the present study is one of the first to test the FeNO levels to determine airway inflammation in Sri Lanka. Further, the study results indicate the severity of deterioration of lung function. The PEFR and the FeNo results are negatively correlated so that an increase in the disease severity is detected by a decrease in the PEFR. Thus FeNo can be considered a good index of airway inflammation amongst asthma patients especially when eosinophilic inflammation of the airways are common.

A descriptive cross sectional study was conducted to assess the respiratory function of construction workers engaged in the construction industry . After obaining informed written consent the base line data of the subjects was obtained, clinical examination was conducted and respiratory function was assessed by spirometry and FeNO and BCO analysis.

The spirometry results of the study confirm that there is serious small airway disease in over 61% of construction workers that need to be urgently addressed to prevent serious respiratory dysfunction amongst these workers. We recommend that use of protective masks be made compulsory in the construction industry and a 'No Smoking Policy' be seriously implemented amongst these workers as serious decline of respiratory function was more amongst smokers than non smokers

In conclusion, proper function of the respiratory system is essential to maintain health. Our studies have established important normal respiratory function parameters and regression equations to derive normal respiratory function values of the Tamil ethnic population of Sri Lanka. The study is a useful adjunct to validate the results of Prof Malini Udupihille a senior physiologist of the PSSL, who has established the normal respiratory function parameters for the Sinhala ethnic population (Udupihille et al. 2004). Combined together they would contribute to the normal values for the Sri Lankan population through the Global Lung Initiative.

The study on cardiopulmonary testing is useful to determine the health status of the athletes in the country and will be expanded to enhance training protocols of athletes.

The novel techniques of breath CO and COHb levels were used for the 1st time to monitor the smoking intensity of tobacco smokers and could be used to monitor smoking cessation amongst tobacco smokers. The FeNO and BCO are both useful to monitor the airway inflammation in asthma and the occupational exposure to dust in the working environment.

Madam, president, respiratory disease is the commonest reason for health care seeking behaviour in the world. Prevalence of preventable chronic respiratory diseases is increasing worldwide and affects the quality of life of affected individuals. I have briefly outlined several simple measures of lung function that can be employed to monitor the function of airways and the progression of respiratory disease. In this tech savvy age, Clinical Physiologists of the 21st century would receive more and more simple test procedures that can be easily employed in the early diagnosis and monitoring of health and disease. It is up to us to adopt and innovate for the betterment of health in our country.

The work described in this oration has been disseminated as publications, and presented at several conferences & scientific fora. They are as follows.

Publications

- Mathanki Sooriyakanthan, Savithri Wimalasekera, Kanagasabai Sivapalan Establishment of reference norms for lung function parameters of healthy Sri Lankan Tamils (submitted for review, Pulmonary Medicine)

Scientific communications

- M Balasubramanium, S W Wimalasekera, K Sivapalan, Peak expiratory flow rate of Sri Lankan Tamil adults aged between 20 to 60 years in Jaffna district- A preliminary

finding. Proceedings of the Scientific sessions 2016 FMS, USJP in collaboration with SJGH, pp 8.

- M Balasubramanium, S W Wimalasekera, K Sivapalan, A preliminary result on lung function parameters of healthy Sri Lankan Tamils in Northern Province of Sri Lanka. 5th Biennial conference of South Asian Association of Physiologists (SAAPCON) at Kathmandu University in November 2016

- M Balasubramanium, K Sivapalan, **S W Wimalasekera**, Spirometric values of healthy Sri Lankan Tamil children aged 14-20 years in Northern Province of Sri Lanka: A preliminary results.1 st IPCRG South Asian Scientific Conference. 3-5 th August 2017.

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Awards received

Awards for the best oral presentations at conferences

M Balasubramanium, K Sivapalan, S W Wimalasekera, Spirometric values of healthy Sri Lankan Tamil children aged 14-20 years in Northern Province of Sri Lanka: A preliminary results. 1st IPCRG South Asian Scientific Conference. 3 - 5th August 2017.

Young investigator travel award to HMP Herath, at the Federation of Asian Oeanian Physiological societies conference held in Kobe Japan April 2019 for the communication on "

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