Impulse Oscillometry – A reasonable option to monitor lung functions in the era of COVID-19 pandemic

Neeraj Gupta[1], Anil Sachdev[1], and Dhiren Gupta[1]

[1]Sir Ganga Ram Hospital

October 5, 2020

Abstract

Spirometry, a gold standard technique for measuring lung functions, has been restricted to a select cohort of patients in current COVID-19 pandemic due to the enhanced risk of disease dissemination. To monitor pulmonary functions in various obstructive (e.g., asthma) and restrictive diseases (e.g., COVID-19 pneumonia) on in- and out-patients serially, there is an urgent requirement of an alternate reliable test. Impulse Oscillometry (IOS) measures lung functions by working at tidal volumes and thus reduces the risk of potential aerosol generation. Feasibility of IOS in smaller children and its ability to detect parenchymal and peripheral airway involvement are other advantages over conventional spirometry. IOS could be a potential solution to periodically monitor lung functions in current pandemic situation to keep a check on diseases affecting lung functionality.

Manuscript

To the Editor,

The current documented global prevalence of asthma is 300 million and is continuously rising due to rapid changes in gene-environment interactions[1]. Documentation of expiratory airflow obstruction at diagnosis and resolution in follow-up is necessary for its appropriate management. Pulmonary function monitoring is also desired in restrictive lung diseases, including COVID-19 pneumonia, at start and during subsequent visits. Spirometry, the widely used technique for measuring lung functions, has been questioned in recent times due to potential risk of outspreading COVID-19 apart from its restricted diagnostic utility for smaller airways and restrictive lung diseases. Another important drawback is requirement of patient's understanding and optimal performance during the procedure which makes this procedure a nightmare for pediatric population. With the pandemic progressing at current pace, we are far away from trivialization of the situation. With the limited utility of aerosol generating and strenuous procedures like spirometry, there is an immediate need for more safer alternatives to monitor lung functions in the indigent.

Procedures involving vigorous expiratory efforts like coughing, sneezing and spirometry can impose an enhanced transmission risk of respiratory infections among the healthcare workers and fellow pulmonology patients, due to increased aerosol generation[2]. Several studies have reported that forceful deep exhalation increased the particle concentrations as well as duration of suspension in the surrounding environment (Table 1). The phenomenon of increased aerosol generation during forceful breathing maneuvers can be explained by 'airway reopening hypothesis'[3]. During physiological conditions, apical portion of lungs is more ventilated than basal segments, the condition is further aggravated and mismatched during disease. A tidal breath, at low volume, will not disturb the dependent airways configuration whereas a forceful breathing effort will reopen the collapsed segments causing more turbulence and hence increased production of aerosols[3]. Any procedure involving forceful inspiration and/or expiration is highly likely to cause more airflow disruption and further aerosol generation.

As the procedure of spirometry requires cooperation and forceful respiratory efforts, it is cumbersome in children, elderly, patients with neuromuscular weakness and in those with learning difficulties. Moreover, its use has been restricted to minimum during current pandemic situation[2]. Using negative pressure rooms, HEPA filters, adequate ventilation, hand hygiene, complete personal protective equipments and social distancing will only reduce the spread and contamination but will not eliminate the aerosol generation[2]. The current COVID-19 pandemic has re-emphasized the unmet need of a more child friendly breathing operation with lesser aerosol production for monitoring pulmonary functions.

Impulse oscillometry (IOS), being tidal breath-based technique, satisfies most of the shortcomings of spirometry. IOS is simple, reliable and rapid method where requirement of patient cooperation is minimal. It detects airway characteristics (resistance, reactance and resonant frequency) by superimposing ultrasound waves (5-20 Hz) over tidal breath[4]. Different waveform frequencies define discrete segment of airways. Pressure and flow, measured at individual frequency, defines respiratory characteristics by using fast fourier transform technique[4]. Its potential, in detecting lung functions in children, ventilated patients and during sleep, has been tested previously. It requires minimal patient cooperation and can be used in preschool age group, overcoming a major limitation of spirometry. Gupta et al have recently demonstrated its utility for monitoring bronchodilator reversibility of asthmatic airways in children as young as 2 years of age[5]. As no forceful breathing effort is involved, the expected aerosol generation is much less than spirometry (Table 1), when used during active viral infections like Corona and Influenza viruses. IOS is more sensitive to detect peripheral airway obstruction and lung parenchymal diseases with its unique sonic detection technique. This distinctive feature may be more useful in serial monitoring of patients suffering from COVID-19 pneumonia. Pulmonary function measurements (either by spirometry or IOS) can vary with ethnicity and regional reference values should be referred for comparison. In the absence of available benchmark values for specific height, age or ethnicity, bronchodilator responsiveness can be compared with the baseline measurements[5].

Monitoring of periodic lung functions in both obstructive and restrictive disease is necessary for optimal disease control and improved quality of life. IOS seems to have a good potential in the current pandemic and afterwards to reliably monitor pulmonary functions with reduced risk of disease transmission, as compared to spirometry. Apart from universal inhaler (with mask and holding chamber) and individual filter use, when combined with other protective strategies like adequate room ventilation, air exchanges, equipment disinfection, self-isolation and staff protection, this technique can prove to be a real boon to pulmonologists and their patients.

References

1. Pawankar R. Allergic diseases and asthma: A global public health concern and a call to action. World Allergy Organ J. 2014;7:12.
2. Reddy KRBK, Basavaraja GV, Bhattacharya BG. Spirometry in COVID-19 Times – An Emerging Dilemma. Indian Pediatr. 2020;57(8):779-80.
3. Bake B, Larsson P, Ljungkvist G, Ljungstrom E, Olin A-C. Exhaled particles and small airways. Respir Res. 2019;20(1):8.
4. Galant SP, Komarow HD, Shin HW, Siddiqui S, Lipworth BJ. The case for impulse oscillometry in the management of asthma in children and adults. Ann Allergy Asthma Immunol. 2017;118:664-71.
5. Gupta N, Sachdev A, Gupta D, Gupta S. Assessment of airway reversibility in asthmatic children using forced oscillation technique – A single-center experience from North India. Lung India 2020. doi:10.4103/lungindia.lungindia_354_20.

Hosted file

`Table.pdf` available at https://authorea.com/users/346312/articles/484583-impulse-oscillometry-a-reasonable-option-to-monitor-lung-functions-in-the-era-of-covid-19-pandemic