Sultan Qaboos University Med J, August 2022, Vol. 22, Iss. 3, pp. 400–404, Epub. 25 Aug 22
Submitted 13 Oct 20
Revisions Req. 7 Dec 20, 27 Jan & 21 Mar 21; Revisions Recd. 30 Dec 20, 21 Feb & 11 Apr 21
Accepted 5 May 21
https://doi.org/10.18295/squmj.6.2021.088

BRIEF COMMUNICATION

Pulmonary Function Test Outcomes in Adult Omani Patients

Preliminary findings from a single-centre study

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abstract: ***Objectives:*** This study aimed to document the distribution of PFT outcomes among adult Omani patients. There is limited information regarding the distribution of pulmonary diseases (PD) in Oman. Pulmonary function test (PFT) outcome patterns could indicate an indirect distribution of PD. ***Methods:*** This retrospective cross-sectional study was conducted from January to December 2015 at a tertiary hospital in Oman. A total of 1,118 adults referred for PFTs during this period were included. ***Results:*** There were 605 (54.1%) female and 513 (45.9%) male patients. The mean age of the patients was 47.11 ± 18.1 years. Most patients underwent spirometry with reversibility (36.8%) or full lung function testing with reversibility (29.7%). Among the 1,064 patients with conclusive PFT outcomes, 39.9% had normal findings, 26.1% had obstructive defects, 19.6% demonstrated restrictive defects and 10.6% had mixed obstructive/restrictive defects. ***Conclusion:*** This study generated important preliminary data regarding PFT outcomes (defects) in Omani patients.

Keywords: Pulmonary Function Tests; Spirometry; Pulmonary Diseases; Asthma; Chronic Obstructive Pulmonary Disease; Oman.

According to the World Health Organization, chronic obstructive pulmonary disease (COPD) will become the third leading cause of death by 2030.[1] It is therefore essential that all countries work towards practicing evidence-based policymaking and resource planning in order to tackle the increasing burden of non-communicable diseases such as bronchial asthma and COPD. Although the prevalence of chronic pulmonary diseases in the Eastern Mediterranean region (EMR) is rising, the overall research output in this field is still low.[2–4] A recent systematic review was able to substantiate this finding by noting a similar under-representation of data from the EMR and the Southeast Asian and African regions as well.[5]

Pulmonary diseases (PDs) can be monitored and distinguished using pulmonary function tests (PFTs).[6,7] Generally, PDs can be classified into obstructive or restrictive diseases. Obstructive diseases—asthma, chronic bronchitis and emphysema—are characterised by airflow limitations due to narrowing of the anatomic airway or loss of elastic recoil, thereby leading to partial or complete obstruction and increased resistance to air movement.[8] Restrictive diseases, including sarcoidosis, pneumoconiosis, acute respiratory distress syndrome and interstitial fibrosis of unknown aetiology, are all denoted by reduced total lung capacity. This is primarily due to factors such as pleural diseases, obesity, interstitial lung disease (ILD) or chest wall disorders that restrict the expansion of the lung parenchyma. In certain cases, obstructive and restrictive lung diseases can overlap as well.[6]

In Oman, there is limited information with respect to the burden of common respiratory diseases in the country. In particular, COPD remains underdiagnosed, undertreated and limited data are available regarding rates of restrictive diseases or asthma in adults.[9,10] PFT outcomes are typically corroborated by referring patients to clinicians to help confirm the presence of PDs. This study aimed to document the distribution of PFT outcomes as obstructive, restrictive and mixed obstructive/restrictive defects in adult Omani patients referred for PFTs to a tertiary hospital in Muscat, Oman.

Methods

This retrospective study of PFTs was conducted at a tertiary care hospital in Muscat from January to December 2015. All adult Omani patients referred by clinicians for PFTs to assess lung function were included in the study.

Patients underwent either spirometry using the Platinum Elite™ Body Plethysmograph (MGC Diagnostics Corp., Saint Paul, Minnesota, USA) and the PowerCube® System (Ganshorn Medizin Electronic, Niederlauer, Germany) or full lung function (FLF) testing using the PowerCube® System (Ganshorn Medizin Electronic). In the pulmonary laboratory of the

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Table 1: Characteristics of adult Omani patients referred for pulmonary function tests to a tertiary hospital in Muscat, Oman (N = 1,118)

Characteristic	n (%)			*P* value
	Total	Male (n = 513)	Female (n = 605)	
Mean age in years ± SD	47.11 ± 18.1	46.57 ± 18.8	47.57 ± 17.5	0.007
Mean BMI in kg/m^2 ± SD	-	26.95 ± 7.2	30.64 ± 8.80	<0.001
Type of PFT performed				0.061
Baseline spirometry	107 (9.6)	39 (36.4)	68 (63.6)	
Spirometry with reversibility	411 (36.8)	179 (43.6)	232 (56.4)	
Baseline full lung function testing	268 (24.0)	131 (48.9)	137 (51.1)	
Full lung function testing with reversibility	332 (29.7)	164 (49.4)	168 (50.6)	
Referring hospital				0.001
National tertiary hospital	854 (76.4)	356 (41.7)	498 (58.3)	
Other hospitals or health centres	264 (23.6)	157 (59.5)	107 (40.5)	
Referring specialty				0.002
Pulmonary medicine	586 (52.4)	243 (41.5)	343 (58.5)	
Other*	532 (47.6)	270 (50.8)	262 (49.2)	

*SD = standard deviation; BMI = body mass index; PFT = pulmonary function test. *Including cardiology, internal medicine, haematology, oncology, rheumatology, immunology, surgery and family medicine specialties.*

current study centre, spirometry includes estimation of forced vital capacity and forced expiratory volume in the first second, while FLF includes spirometry and estimations of lung volumes and diffusion functions. Reference equations standardised to an Asian population were used to estimate predicted values.[6] All patients were instructed to avoid bronchodilators the morning prior to the test to avoid altering any baseline spirometry indices.

All of the PFT results were interpreted by a specialist according to the criteria of the American Thoracic Society and European Respiratory Society.[6] Information regarding the patients' sociodemographic characteristics, referring physician, hospital, reasons for referral and PFT outcomes was collected. The PFT outcomes were categorised into the following groups: normal findings, obstructive defects, restrictive defects, mixed obstructive/restrictive defects and isolated diffusion impairment. The patients with inconclusive findings were excluded from the analysis of PFT outcomes.

Data were analysed using the Statistical Package for the Social Sciences (SPSS), Version 22.0 (IBM Corp., Armonk, New York, USA). The results were presented using descriptive statistics including frequencies and percentages and associations between gender and type of test, referring hospital, specialty and PFT outcomes were assessed using a Chi-squared test. Gender differences in age and body mass index (BMI) were calculated using student's t-test.

Ethical approval for this study was obtained from the Medical Research & Ethics Committee of the College of Medicine & Health Sciences, Sultan Qaboos University, Muscat, Oman (MREC 1326).

Results

A total of 1,118 adult patients underwent PFTs during the study period. Among these patients, 513 (45.9%) were male and 605 (54.1%) were female. Compared to female patients, male patients were significantly younger (P = 0.007) and had lower BMI values (P <0.001). Most patients underwent spirometry with reversibility (36.8%), followed by full lung function testing with reversibility (29.7%). The majority were referred from a national-level tertiary hospital (76.4%). Over half of the sample (52.4%) was referred from the pulmonary medicine department while the remaining patients were referred from other specialties [Table 1].

A total of 890 patients (79.6%) were referred for PFTs due to respiratory symptoms or conditions including asthma (41.2%), shortness of breath (17.6%), cough (15.5%), ILD (8.9%), COPD (8.2%), bronchiectasis (7.8%), wheezing (4.1%), obstructive sleep apnoea (2.5%), sarcoidosis (1.9%), systemic lupus erythematosus (1.3%), cystic fibrosis (0.4%) and lung carcinoma (0.3%). The remaining 228 patients (20.4%) were referred for other conditions, including presurgical assessment (11.8%), pre/post-

Table 2: Outcomes of various types of pulmonary function tests among adult Omani patients referred to a tertiary hospital in Muscat, Oman (n = 1,064)*

Outcome	Type of PFT performed, n (%)				
	Baseline spirometry	Spirometry with reversibility	Baseline full lung function testing	Full lung function testing with reversibility	Total
Normal findings	66 (15.5)	136 (32.0)	140 (32.9)	83 (19.5)	425 (39.9)
Obstructive PD	2 (0.7)	136 (48.9)	15 (5.4)	125 (45.0)	278 (26.1)
Restrictive PD	31 (14.8)	51 (24.4)	67 (32.1)	60 (28.7)	209 (19.6)
Combined obstructive/ restrictive PD	3 (2.7)	61 (54.0)	7 (6.2)	42 (37.2)	113 (10.6)
Diffusion impairment	N/A	N/A	25 (64.1)	14 (35.9)	39 (3.7)

*PFT = pulmonary function test; PD = pulmonary disease; N/A = not applicable. *Excluding patients with inconclusive findings.*

Table 3: Gender differences according to pulmonary function test outcomes among adult Omani patients referred to a tertiary hospital in Muscat, Oman (n = 1,064)*

Outcome of PFT	n (%)			χ^2	*P* value
	Total	Male	Female		
Normal findings	425 (39.9)	184 (43.3)	241 (56.7)	23.21	<0.001
Obstructive PD	278 (26.1)	142 (51.1)	136 (48.9)		
Restrictive PD	209 (19.6)	102 (48.8)	107 (51.2)		
Combined obstructive/ restrictive PD	113 (10.6)	59 (52.2)	54 (47.8)		
Diffusion impairment	39 (3.7)	7 (17.9)	32 (82.1)		

*PFT = pulmonary function test; PD = pulmonary disease. *Excluding patients with inconclusive findings.*

bone marrow transplant assessment (5.5%), genetic or immunological diseases (3%), pre/post-chemotherapy assessment (2.1%) and pre-hyperbaric oxygen therapy assessment (0.2%). A total of 271 patients (24.2%) suffered from two or more conditions for a PFT referral.

Overall, the PFT findings for 54 patients (4.8%) were inconclusive. Of the remaining 1,064 patients (95.2%) with conclusive results, 425 (39.9%) had normal PFT findings. However, 311 patients out of 425 suffered from respiratory symptoms or conditions. A total of 278 patients (26.1%) had obstructive defects, 209 (19.6%) had restrictive defects, 113 (10.6%) had mixed obstructive/restrictive defects and 39 (3.7%) had isolated diffusion impairment. A total of 48.9% (n = 136/278) of obstructive defects were evident from spirometry with reversibility. About 60.8% (n = 127/209) of the restrictive defects were identified through FLF testing; restrictive signs were evident through spirometry in 82 cases (39.2%) [Table 2].

The frequency of isolated diffusion impairment was significantly higher in females compared to males (χ^2 = 23.21; *P* <0.001) [Table 3].

Discussion

The current study aimed to consolidate relevant information regarding the obstructive and restrictive defects as outcomes of PFTs among Omani adults. The distribution of PFT defect patterns could indirectly indicate the distribution of PD patterns. It must be reiterated that although the majority of PFTs were done for respiratory symptoms or conditions, one fifth of the PFTs were provided for preoperative assessment, obesity, pre-drug and pre-bone marrow studies in which the presence of any defect may not have indicated a respiratory disease.

Researchers have proposed that spirometry can be incorporated into the assessment of airflow obstruction; however, estimates of spirometry-assessed COPD burden from epidemiological studies are often inconsistent due to variations in methodology and use of different spirometry cut-off values for interpretation.[11] In the current study, spirometry was considered in order to document obstructive defects using standard guidelines.[6] Alzaabi *et al*. conducted a review of prevalence studies from the EMR and Middle Eastern and North African regions, excluding Oman;[12] the researchers noted that the prevalence of COPD in these regions was likely underestimated due to an over-reliance on clinical diagnosis rather than spirometry findings or international diagnostic guidelines. In the current study centre, patients were usually referred for PFTs by a clinician based on suspicion of an obstructive disease. Spirometry indices allow for the objective assessment of obstructive impairment compared to reliance on a purely physician-diagnosed conclusion. In the Gulf region, lung function testing

is generally underutilised with one study reporting that up to 66% of patients had never undergone a PFT.[3] Moreover, peak expiratory flow is rarely used as an indicator of breathing difficulty.[13] Classifying PDs into restrictive, obstructive or other categories is only possible with full lung function testing. The current study utilised data based on both spirometry and FLF testing, including the assessment of lung volume and diffusion capacity.

The present study showed that obstructive defects were most prevalent, followed by restrictive defects in this limited sample. In 2012, the World Health Survey reported that the prevalence of physician-diagnosed asthma in the EMR region was considerably lower at 2.93%; however, data for this region were limited to a few countries, including Pakistan (3.12%), United Arab Emirates (5.30%), Morocco (2.76%) and Tunisia (2.74%).[14] A recent meta-analysis found that the pooled crude prevalence of spirometry-defined COPD in the EMR was 13.20%.[5] In their study, Masjedi *et al*. reported the pooled prevalence of asthma and COPD in the EMR to be 9.38% and 5.39%, respectively.[4]

In the present study, 39.9% of patients with conclusive PFT results demonstrated normal findings despite having been referred for respiratory symptoms or conditions. A possible reason behind this could be the fact that respiratory symptoms of such patients were being controlled with various pharmaceutical treatments or that the PFTs were performed to assess presenting symptoms. Further research to explore reasons for this finding is recommended since this was beyond the scope of the current study. In addition, a significant association was noted between pulmonary defect patterns and gender. In particular, the frequency of obstructive and mixed obstructive/restrictive pulmonary defects were significantly higher in males compared to females, whereas the opposite was true for isolated diffusion impairment. The reasons for these associations are unclear. Isolated diffusion impairment could be an indicator of restrictive pulmonary disease, suggesting an early lung disease or an infiltrative process. However, the restrictive defects and low diffusion shown in this study are similar to those from other studies in the region.[15,16]

A major limitation of the current study was that pulmonary defect patterns could not be meaningfully considered as PD patterns. Moreover, isolated diffusion impairment can be documented in non-pulmonary diseases such as cardiac failure; however, this issue was not considered in the current research. Furthermore, the present findings cannot be generalized to the country as the entire study sample belonged to a single center.

Conclusion

Given the recent increase in the prevalence COPD in the EMR, the present study was conducted to expand the availability of prevalence data in the aforementioned region. Among adult Omanis referred to a tertiary hospital for PFTs, obstructive defects were found to be present in one-fourth of the sample. Restrictive defects were observed in one-fifth of the sample while mixed obstructive restrictive defects were found in one-tenth of the sample. Finally, 4% of the sample had isolated diffusion impairment among the referred patients. These preliminary findings of distribution of defects could indicate an indirect distribution of PDs in this particular set-up. These statistics also provide baseline evidence and estimates for sample size calculations for future researchers.

AUTHORS' CONTRIBUTION

DSJ conceptualised and designed the study and drafted the manuscript. AAJ and RAH collected and compiled the data. RB and SAH provided technical assistance for spirometry procedure. DSJ and AAJ analysed the data and interpreted the results. HAR critically reviewed the manuscript. All authors approved the final version of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

FUNDING

No funding was received for this study.

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