Utilization of the Pulmonary Function Test Laboratory in the Evaluation of Respiratory Disorders in the Al-Amiri Hospital: A Secondary Medical Center

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Key Words

Asthma · Chronic obstructive pulmonary disease · Diagnosis · Pulmonary function test · Respiratory diseases

Abstract

Objective: The aim of this study was to describe the current use of pulmonary function tests (PFT) and the degree of matching between the diagnoses at referral and after the test. **Subjects and Methods:** A pre-test questionnaire was administered to 464 (5–88 years) patients referred to the PFT laboratory followed by a complete PFT test. The results of the patients' tests were analyzed in terms of the diagnosis before the test, its relation to symptoms, and the rate of concordance between the diagnoses before and after the test. **Results:** The most referrals were from the medical Outpatient Department; 61%) and the most frequent diagnosis before the test was asthma (31.8%). Of the 464 patients, 34% were currently smoking cigarettes, and the most common symptoms were chronic dyspnea (30.2%) and chronic cough (19.6%). The chronicity of symptoms showed some association with the diagnosis before PFT in the case of chronic obstructive pulmonary disease (COPD) showing the symptom of dyspnea ($p = 0.05$), and COPD and re-

strictive lung disease with cough ($p < 0.05$). The overall rate of concordance in matching diagnoses before and after the test was 60.4% by consultant physicians and 51.9% by non-consultants, with an overall rate of 55% by all physicians. **Conclusion:** Our findings show that there should be better utilization of the PFT laboratory by physicians in all sub-specialities and there is a need to facilitate its use to make a better functional diagnosis.

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Introduction

Pulmonary function tests (PFT) assist the physician in the diagnosis of a respiratory condition, measurement of disease progression or the effect of an intervention on pulmonary mechanics and in determining whether or not signs and symptoms such as dyspnea, cough and cyanosis are of a respiratory origin [1, 2]. In the last 20 years, PFT laboratories have been widely expanded and utilized in many secondary and tertiary care medical centers to facilitate assessment of respiratory problems. In 1979 the American Thoracic Society (ATS) established guidelines for the standardization of spirometry [3], which were updated in 1987 [4] and 1994 [5], to reflect changes regarding clinical emphasis and available technology.

Methods and techniques employed for PFT include peak expiratory flow rate, spirometry, flow-volume curve, body plethysmography and gas exchange. It is imperative for each laboratory to establish or select normal values for the pulmonary function parameters of the population it serves because a number of variables such as ethnic origin, age, sex, height and body surface area can affect the pulmonary function parameters. The PFTs do not, however, provide specific diagnoses. A previous study by Khadadah et al. [6] examined the predictive value of a provisional clinical diagnosis of pulmonary disorders using PFT, and concluded that other diagnostic aids in addition to PFT will be required for a more accurate final diagnosis.

The aim of this study was to describe the current use of the PFT laboratory by defining the types of patients referred, the most frequent diagnoses before the PFT, major symptoms patients present for evaluation, the degree of matching between the referral diagnoses and the final diagnoses after the test, and elucidation of the factors that control this matching.

Subjects and Methods

The study was carried out at the Al-Amiri Hospital, Kuwait, a secondary medical center with 547 beds covering a population of 248,000 people. During the year 1999, all patients referred to the PFT laboratory were screened using a questionnaire administered by a respiratory technician. The questionnaire contained both demographic data and data about the referral point, referring physician, symptoms on referral, smoking habits, area of residency, ethnic origin, as well as the diagnosis before the PFT as shown on the referring documents.

Patients sitting in an upright position were subjected to a full PFT of both spirometry and body plethysmography using Master Lab of Eric Jaeger (version 4.34 software). The tests were conducted by the same technician to minimize inter-test variability. The results were interpreted by the physician in charge of the PFT laboratory in compliance with ATS guidelines [5, 7] for categorization of diseases and for criteria of reversibility among the different obstructive disorders.

The spirometry was done both before and after bronchodilator treatment to assess reversibility. The lung volumes and the gas exchange were measured and taken into consideration to differentiate between different disease categories. The data were collected, analyzed and reported using the ATS recommendations of 1994 for diagnostic accuracy as well as reproducibility [5, 7, 23]. The normal predicted values used for this laboratory were the international reference values provided by the manufacturer (Master Lab Eric Jaeger, version 4.34 software). This laboratory serves a multinational population in the central part of Kuwait city, and takes into consideration that Asian values are 10–15% lower than those of Caucasians [1, 8].

Table 1. Demographic profile of the patients

Profile	Male	Female	All
Patients	262	202	464
Age, years			
Range	6–87	5–88	5–88
Median	47	50	49
Nationalities, %			
Kuwaiti	58.5	78.5	67.1
Other Arab	19.2	11.5	15.9
Non-Arab	22.3	10.0	17.0
Smoking habits, %			
Current smokers	50.4	13.7	34.5
Ex-smokers	5.0	5.5	5.2
Current and ex-smokers			
<20 years	3.8	0.0	2.6
20–39 years	52.4	8.0	35.8
>40 years	75.2	24.4	50.7

The referring physician made the diagnosis before the PFT, based on medical history, symptoms and signs as well as some diagnostic tools other than PFT results. The pulmonologist in charge of the laboratory made the diagnosis after the test based on interpretation of PFT. The patients' symptoms were considered acute or chronic if they were less or greater than 6 weeks in duration, respectively. Test results that were inconsistent with the ATS recommendations were excluded from the diagnostic accuracy testing.

Statistical Methods

SPSS Windows (version 9) was used for data analysis. Statistical quartiles and percentages were used to describe the findings. The relation between two categorical variables like chronicity of symptoms and diagnoses before the test was tested by χ^2 test. A value of $p \leq 0.05$ was taken as significant.

Results

Of the 464 patients referred to the laboratory over the study period, 262 were male (56.5%) and 202 female (43.5%); age ranged from 5 to 88 years and a quartile range varying from 33 to 61 years with a median age of 49 years. Kuwaitis and non-Kuwaiti Arabs comprised 67 and 16% of the study group, respectively. Current smokers were 34.5% of the patients, and 5.2% were ex-smokers. Of smokers, 50.4% were male and 13.7% female; corresponding percentages for ex-smokers were 5.0 and 5.5 (table 1), respectively.

The two principal diagnoses for referral were asthma in 31.8% and chronic obstructive pulmonary disease (COPD) in 9%. However, in almost one third of the cas-

Table 2. Diagnoses on referral

Diagnoses	Patients	
	n	%
Asthma	147	31.7
COPD	42	9.1
Pulmonary fibrosis	9	1.9
Pre-operative assessment	8	1.7
Sarcoidosis	7	1.5
RLD	5	1.0
Pneumonia	4	0.9
Pre-transplant assessment (liver, kidney, lung)	3	0.6
Chest wall disease	1	0.2
Pulmonary embolism	1	0.2
Chest infection	1	0.2
Connective tissue disease	1	0.2
Others	83	17.9
Unspecified/unknown	152	32.8
Total	464	100

In subsequent tables, the category RLD includes all referral diagnoses of pulmonary fibrosis, sarcoidosis, RLD, chest wall disease and connective tissue disease. Others = Other diagnoses than the ones mentioned, e.g. upper-airway obstruction or mixed etiology.

es, the diagnosis was either unspecified or unknown (table 2).

The distribution of the referral symptoms and duration are shown in table 3.

The major symptoms for referral were dyspnea (40.9%), cough (36.4) and chest pain (12.5%); other symptoms such as expectoration were only 2.6%. Dyspnea as a major symptom was slightly more common in female (43.1%; 87/202) than male patients (39.3%; 103/262), but the difference was not significant ($p > 0.05$). It was uniformly present in all age groups (more than 40%) except in the group <20 years (31.6%). The smoking pattern was comparable with those with cough, as 31.6% (55/174) were current smokers, and 6.3% (11/174) were ex-smokers. This finding was not significantly different for patients without such symptoms (36.5 and 4.4% for current and ex-smokers, respectively).

For patients with cough as the referral symptom, 33.3% (51/153) were smokers and 5.9% (9/153) ex-smokers, while the corresponding values for patients without cough were 35.2 and 4.8%, respectively. The smoking status was unknown in 16 patients with cough. No significant gender difference was observed among them (34.4% males and 39.1% females). However, smoking was more common in the group ≥ 40 years (40.3%) than below (28.6%).

Table 3. Presence of symptoms before referral

Symptoms	Patients	
	n	%
<i>Cough</i>		
Not present	295	63.6
Present	169	36.4
<6 weeks	78	16.8
≥ 6 weeks	91	19.6 (53.8)
<i>Dyspnea</i>		
Not present	274	59.1
Present	190	40.9
<6 weeks	50	10.8
≥ 6 weeks	140	30.2 (73.7)
<i>Chest pain</i>		
Not present	406	87.5
Present	58	12.5
<6 weeks	19	4.1
≥ 6 weeks	39	8.4 (67.2)
Statistical significance (p value)	<0.001	<0.01

Cough vs. dyspnea: $p = 0.0001$; cough vs. chest pain: $p = 0.104$; dyspnea vs. chest pain: $p = 0.4289$.

Chronicity was highest for dyspnea and lowest for cough.

Values in parentheses are the percentages of chronic cases (in relation to its referral) with the respective symptoms for ≥ 6 weeks compared to all with the same symptom. $p < 0.01$.

Chest pain was higher among female (16.8%; 34/202) than male patients (9.2%; 24/262; $p < 0.01$). Again the smoking pattern was comparable to those of cough and dyspnea, but smoking was not associated with chest pain. Details of other symptoms were not analyzed. They were too infrequent (12 out of a total of 464 patients).

Duration of Symptoms before Referral to PFT

For respiratory diseases, any symptom lasting more than 6 weeks was considered beyond the usual course of a common mild respiratory complaint that is usually precipitated by exposure to cold or flu-like illness; hence symptoms lasting longer than 6 weeks were regarded as chronic. The chronicity was highest for dyspnea (73.7%; 140/190) and lowest for cough (53.8%; 91/169), the difference being significant ($p < 0.01$; table 3).

Role of Chronicity of Symptoms in Determining the Diagnosis before the Test

The chronicity of symptoms showed some association with the diagnosis before the test in the patients with

Table 4. Duration of dyspnea, cough and chest pain among the different diagnostic categories before PFT

Diagnosis before PFT	Symptom duration					
	0		<6 weeks		≥ 6 weeks	
	n	%	n	%	n	%
<i>Dyspnea</i>						
Asthma	78	53.1	19	12.9	50	34.0
COPD	15	35.7	5	11.9	22	52.4
RLD	10	43.5	4	17.4	9	39.1
<i>Cough</i>						
Asthma	89	60.5	27	18.4	31	21.1
COPD	16	38.1	9	21.4	17	40.5
RLD	12	52.2	4	17.4	7	30.4
<i>Chest pain</i>						
Asthma	129	87.8	5	3.4	13	8.8
COPD	33	78.6	4	9.5	5	11.9
RLD	18	78.3	2	8.7	3	13.0

The percentages of all individuals with the three diagnoses before PFT are given. Only data for patients for whom the specific diagnoses and symptom duration were known were assessed. Patients with missing data were not included in the analysis. $p = 0.05$, chronic dyspnea with COPD vs. no COPD, and chronic cough with RLD and COPD vs. asthma and others. No statistical significance was found for the symptom of chest pain ($p = 0.73$).

Table 5. Combination of symptoms in patients with different diagnoses before PFT

Diagnoses before PFT	Combination of symptoms			
	0		2+	
	n	%	n	%
Asthma	69	46.9	152	35.4
COPD	11	26.2	123	54.8
RLD	7	30.4	110	43.5
Others	95	56.2	144	26.0
Total	182	47.8	129	33.9

Percentages of all individuals with the respective diagnosis before the test are given.

COPD for dyspnea ($p = 0.05$), and COPD and restrictive lung disease (RLD) for cough ($p < 0.05$). Chest pain, however, did not show any significant difference in the distribution of chronicity in relation to a diagnosis before the test ($p > 0.5$; table 4).

Fig. 1. Percentage of patients assessed according to referral points.

Impact of the Combination of Symptoms in Determining the Diagnosis before the Test

COPD was more often accompanied by two or more symptoms (54.8%; 23/42) compared to the absence of any symptoms (26.2%). However, in the case of asthma and RLD, no such evidence was indicated; the respective symptom and non-symptom values being 35.4 and 46.9% for asthma and 43.5 vs. 30.4% for RLD (table 5), respectively.

Referral Point

The majority of cases were from the medical Outpatient Department (OPD; 67%), followed by medical inpatients (18.1%) and pediatric OPD (10.4%). Far fewer patients were recruited from surgical OPD (0.8%), surgical inpatients (2.7%) and polyclinics (0.5%; fig. 1). Asthma was the most prevalent diagnosis (69.4%) among referrals from medical departments, followed by COPD (19.6 %) and RLD (11%).

Referring Person

Nearly two thirds (63%) of referrals were done by consultants, followed by senior registrars (20%) and the remaining 16% registrars and assistant registrars (fig. 2). More than two fifth of the cases (44%) referred by the consultants were those thought to have asthma and needing confirmation, followed by about one third (37.6%) of

Fig. 2. Percentage of cases assessed according to different physician ranks.

non-specific cases with a combination of symptoms the nature of which needed to be verified. The same pattern was seen among cases referred by the senior registrars and others.

Relationship between the Rank of the Referring Person and Matching between Diagnoses before and after PFT

Of the 147 labeled asthmatics, 108 had a specific pathological diagnosis including asthma, and the remaining 39 subjects were found to be either normal or the test results were non-conclusive and therefore not included in the analysis for concordance. The same holds true for COPD (24 out of 42) and RLD (10 out of 23). The overall diagnostic accuracy for all physician ranks was 55%, but that of consultants was higher (60.4%) than that of senior registrars to assistant registrars (51.9%; table 6).

Discussion

This study involved mostly adults (40–64 years old) because children less than 6 years of age are generally unable to reliably perform spirometric studies that need both cooperation and understanding of the spirometry maneuver. This also holds true for the body plethysmograph which can induce an apprehensive reaction in a

Table 6. Overall concordance rate and concordance rates for consultants and non-consultants before and after the PFT

Before PFT	After PFT				
	Asthma	COPD	RLD	Others	Total
<i>Overall</i>					
Asthma	42	42	11	13	108
COPD	3	20	1	–	24
RLD	–	1	9	–	10
Others	21	42	26	25	114
Total	66	105	47	38	256
<i>Consultants</i>					
Asthma	16	16	2	5	39
COPD	–	7	–	–	7
RLD	–	1	6	–	7
Others	6	9	7	10	32
Total	22	33	15	15	85
<i>Non-consultants</i>					
Asthma	26	26	9	8	69
COPD	3	13	1	–	17
RLD	–	–	3	–	3
Others	15	33	19	15	82
Total	44	72	32	23	171

Concordance rates were 55% (overall, $\kappa = 29.7\%$, $p < 0.001$), 60.4% (consultants, $\kappa = 40.6\%$, $p < 0.001$) and 51.9% (non-consultants, $\kappa = 22.8\%$, $p < 0.001$), calculated only for cases where both test results are available for matching among the three categories of asthma, COPD, RLD and apart from normal diagnoses after PFT. Others = All other pathological diagnoses.

child as it involves being kept in a closed box to estimate restrictive patterns if any. Chronic RLD, however, is rather rare in children compared to obstructive lung disease [1, 9, 10]. The age group of this study was compatible with the age group of patients who usually attend medical OPD or are admitted to medical inpatient wards.

Major symptoms for referral to PFT were dyspnea, cough and chest pain, with chronic dyspnea being the most common chronic symptom. Generally, dyspnea, categorized into cardiac, pulmonary, mixed cardiopulmonary and non-cardiac non-pulmonary types, can be effectively managed in most cases by the family doctor in the primary care clinic. Usually, a careful history and thorough physical examination can readily identify the cause. An initial test with chest X-ray, electrocardiogram and screening spirometry can provide valuable information. In some cases it can be non-conclusive and a com-

plete PFT, arterial blood gas analysis, echocardiography and exercise tolerance test are needed. These are usually done as second-line investigations [11].

In this study, diagnosis before the test was shown to be associated with chronic dyspnea in COPD, chronic cough with COPD and RLD but not with chronic chest pain. Combination of any two symptoms (dyspnea, cough or chest pain) aided in the diagnosis of COPD but not of asthma and RLD. It is possible that other factors, e.g. findings of physical examination prior to referral, may be helpful in the diagnosis before the test.

The percentage of surgical patients (3.5%) referred to the PFT laboratory was lower than expected because such cases are normally referred for pre-operative cardiac assessment. However, clinically significant postoperative pulmonary complications are as common as cardiac complications. So cases, especially smokers suspected on clinical grounds of having pulmonary dysfunction, should be referred for full PFT and arterial blood gas analysis to avoid potential postoperative complications [12–14], which has been shown that generally would decline after 8 weeks of pre-operative cessation [12].

Referral points were mainly medical service units treating predominantly patients with pulmonary diseases. The relatively high frequency of asthma diagnoses before the test, from the medical side, could reflect the uncertainty in diagnosing asthma. It is commonly agreed that the most useful laboratory method to evaluate air flow obstruction, which enables definition of the physiological pattern of air flow limitation, is PFT [15] using forced expiratory maneuver. It helps in the differentiation from the restrictive pattern. In asthma, diagnosis is based on appropriate clinical history and evidence of reversible air flow obstruction or hyperreactive airways. Recent data have confirmed the marked difficulty in diagnosing asthma on purely clinical grounds, and that disease severity is often grossly underestimated by both the patient and the physician in the absence of spirometry or peak expiratory flow rate measurements [15]. Consequently, it is always a combination of the clinical picture, and the objective evidence of the existence of a disease that helps in establishing the most probable diagnosis.

The overall diagnostic accuracy for all ranks of physicians in our study was 55%, being lower than in previous reports [9, 16]. Probably to preserve the precision of the diagnostic accuracy, only cases that had specific pathological diagnoses both before and after the test were evaluated. Equally important, when the rank of the referring physician was related to the matching rate between both diagnoses, the diagnostic accuracy for the consultants in-

creased to 60.4%. COPD was less frequently estimated in diagnoses (9.0%) before the test in comparison to asthma (31.8%; table 1). Taking diagnosis after PFT as the gold standard, the diagnosis of COPD before PFT showed a lower sensitivity (32%; 20/63) compared to that for asthma (93.0%; 42/45). The Third National Health and National Examination Study (NHANES III) [9] shows that COPD remained underdiagnosed as in this study, and recommended the use of spirometry in the primary care setting to identify asymptomatic diseases.

Generally, the physician may not be able to reliably identify whether the patient has an obstructive or restrictive pattern simply from history taking and physical examination [14]. This has been shown in other studies [6, 16–18]. When physicians were asked to predict the result of the PFT, they correctly predicted the obstructive pattern 85% of the time, whereas for restrictive or normal patterns, the predictive rate was only 56% [16].

The accuracy of a referring diagnosis can be improved if additional tools like a respiratory-symptom-related questionnaire, e.g. the International Union Against Tuberculosis and Lung Diseases questionnaire, is added [19–22] at the medical interview, as a part of assessment before referral. Also, utilization of simple spirometry at the primary care level to identify disease category prior to referral to the PFT laboratory will increase the diagnostic yield and identify more subclinical COPD cases, especially among smokers, as demonstrated by the NHANES III study [9]. Radiological images other than plain chest radiographs, e.g. high-resolution CT scans, can be requested where applicable (e.g. if RLD or emphysema is suspected) before the PFT, to improve the concordance rate of the diagnoses before and after the test. However, this might not be practical due to the costs as well as limited availability in some medical centers. Furthermore, it is the PFT result that might direct the physician to order such radiological imaging to clarify a patient's symptomatology.

Based on literature search, this study appears to be unprecedented, and therefore we could not compare our results with others, especially regarding the diagnostic concordance rate among different ranks of physicians.

Conclusion

Our results show that the PFT laboratory is necessary in general hospitals. The use of such objective testing should be encouraged to identify different pulmonary disease categories, and to determine their severity, progress

and response to treatment. A further study with a larger number of patients is warranted where other tools such as a respiratory-symptom-related questionnaire and simple spirometry will be used in addition to the clinical data to categorize the patients' diagnoses before referral to the PFT laboratory.

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