Variability In The Interpretation Of Pulmonary Function Tests

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Abstract

Pulmonary function tests (PFTs) interpretations can vary among pulmonologists although several guidelines are available to facilitate interpretation of the raw data. We designed a study to determine the degree of agreement in the interpretation of PFTs. This study was a survey by mail. Five PFTs with a variety of obstructive and restrictive defects were mailed with an interpretation form and a demographic questionnaire to 208 Board Certified pulmonologists. Ninety-five physicians responded to the survey, 85% had more than 5 years experience, 57% physicians practiced in a university or an academically affiliated hospital and 41% taught PFT interpretation. There was about 90% agreement in PFT interpretation in case of severe obstruction and restriction. The degree of agreement among pulmonologists was much lower in cases of milder and mixed disorders. Except for a severe obstructive and restrictive defect, we conclude that there is significant variability in PFT interpretation by experienced pulmonologists.

ABBREVIATION

ACCP: American College of Chest Physicians;ATS: American Thoracic Society;BC: Board certified;DLCO: Diffusion capacity for carbon monoxide;PFTs: Pulmonary Function Tests.

INTRODUCTION

Pulmonary function tests (PFTs) guide physicians in making diagnostic and therapeutic decisions. Several guidelines are available to facilitate interpretation of the raw data; yet, interpretations vary among pulmonologists.₁, ₈, ₉, ₁₂A great deal of disagreement is present in the narrative interpretation of the same raw data.₉, ₁₂The reasons for these differences are not entirely clear, but may include training bias, differences in the knowledge of pulmonary physiology or training, the use of different guidelines or normal ranges. We designed a study to determine the degree of agreement in the interpretation of pulmonary function tests by pulmonologists.

We conducted a survey by mail of PFT interpretations by board certified pulmonologists in the state of Illinois. Five PFTs with a variety of obstructive and restrictive defects were mailed with an interpretation form and a demographic questionnaire to 208 pulmonologists. The intent of the PFT interpretation was to determine the homogeneity of responses, and not the frequency of a "correct" answer.

METHODS

This study was a survey by mail of board-certified pulmonologists who belonged to the Illinois chapter of the American College of Chest Physicians (ACCP) asking for formal PFT interpretation. The survey questionnaires included an interpretation form and a demographic questionnaire, which were mailed to 208 pulmonologists. The demographic information included type of hospital, years in practice, time spent in pulmonary medicine, the number of PFT's interpreted in a month and whether respondents taught PFT interpretation. The PFT interpretation questionnaires were designed to assess variation in the interpretation of pulmonary function test data. The questionnaires included a form for assessment of lung volumes, airflow rates, pulmonary diffusion capacity for carbon monoxide (DLCO), bronchodilator responses and overall interpretation of PFT as normal, obstructed, restricted or mixed. The interpretation responses were analyzed by comparing the interpretation from each pulmonologist to other interpretations for the same pulmonary function test. A second survey was mailed 8 weeks later to those who had failed to respond. The distribution for each variable was determined by a percentage in each category.

RESULTS

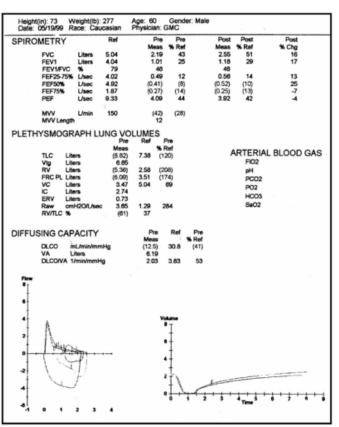
A total of ninety-five physicians responded to either of the two mailings. Seventy three percent were between ages 36 and 50, 85% had been practicing for more than 5 years. Forty-three percent practiced in a community hospital, 39% in an academically affiliated hospital and 18% in a university. Fifty-five percent were in practice for more than 10 years and 58% interpreted more than 30 PFTs a month. Fifty-one percent taught PFT interpretation. Fifty percent used current American Thoracic Society (ATS) criteria. The figures 1 to 5 summarize the results of the study presented as each PFT with an individual table representing the response to the interpretations of these PFT's by pulmonologists. Our data shows percentage of agreement among pulmonologists in various PFT parameters such as forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), FEV1/FVC ratio, maximum voluntary ventilation (MVV), total lung capacity (TLC), functional residual capacity (FRC), residual volume (RV), DLCO, response to bronchodilator; and the final interpretation of the PFT as normal, obstruction, restriction or mixed. PFT 1 showed >90% agreement in most of the parameters except for TLC and bronchodilator response. PFT 2 showed >90% agreement in FVC, FEV1, TLC, MVV, RV and in the bronchodilator response, however, significant variability was observed the assessment of FEV1/FVC ratio, FRC, DLCO and in the final interpretation of this PFT. PFT 3 showed ≥90% agreement in most of the parameters except for FEV1/FVC ratio and DLCO. PFT 4 showed >90% agreement in most of the parameters except for FEV1/FVC ratio, TLC, FRC and in the interpretation of PFT. PFT 4 showed >90% agreement in most of the parameters except for the bronchodilator response and in the interpretation of PFT. There was >90% agreement in the final interpretation of PFT in case of severe obstruction and restriction as shown in Figure 1 and 3, however, marked variability was observed in the interpretation of PFTs shown in Figure 2, 4 and 5. These findings suggest that, with the exception of severe obstructive and restrictive defect, significant variability may occur in the interpretation of PFTs by the pulmonologists.

Figures 1 to 5: The figures 1 to 5 show individual PFTs 1 to 5 with their respectively interpretation results tabulated as percentage of agreement among the pulmonologists in various PFT parameters such as forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), FEV1/FVC ratio, maximum voluntary ventilation (MVV), total lung capacity (TLC), functional residual capacity (FRC), residual volume (RV), DLCO, response to bronchodilator; and the

interpretation of the PFT as normal, obstruction, restriction or mixed.

Figure 1

Figure 1a, b: PFT 1 shows >90% agreement in most of the parameters except for TLC and bronchodilator response.



PFT 1	Normal (%)	Increase (%)	Decrease (%)	
FVC	0	0	100	
FEV1	0	0	100	
FEV1/FVC	0	0	100	
MVV	5	0	95	
TLC	22	77	1	
FRC	0	100	0	
RV	1	99	0	
DLCO 0		0	100	
Broncho	dilator	Yes	No	
Respo	nse	86	14	

Interpretation

Normal	0 %
Obstruction	99 %
Restriction	0 %
Mixed	1 %

Figure 3

Figure 2a, b: PFT 2 shows >90% agreement in FVC, FEV1, TLC, MVV and bronchodilator response, however, significant variability was observed the assessment of FEV1/FVC ratio, FRC, DLCO and in the final interpretation of this PFT.

Dete:	05/13/98	Race:	Hispanic	Phy	sician:				echnician: po	-
SPIRO	METRY		Pre		Pre		Post	Post	Post	
			Meas		% Ref		2.92	% Ref 70	% Chg 11	
	FVC	Liter		4.20	63 58		2.92	62	9	
	FEV1	C %	1.94 73	3.45	- 20		73	02	•	
	FEV1/FV FEF25-7			3.66	41		1.53	42	2	
	FEF25%	Use			45		3.87	50	12	
	FEF50%	L/se		4.40	(37)		1.87	43	14	
	FEF75%	L/se		1.73	32		0.48	28	-12	
	FIV1/FIV		64				75			
	PEF	Une		8.39	64		6.09	73	13	
	MVV	L/m		148	(29)					
PLETH	YSMOO	RAP	LUNG	VOLU	MES					
				Pre I	Ref	Pre		ost Post		
				eas		Ref	м	eas % Rei	% Chg	
		Liters			L15	(74)				
		Liters		3.04 1.91 1	.93	99				
	RV	Liters			32					
		Liters			20	63				
		Liters		0.37						
		Liters		2.07						
		cmH2O/	Usec :		.50	141				
		L/sec/cn			508	54				
	sGaw	1/cmH2	0 sec 0.	090 0.1	183	49	-			
DIFFU	SING C	PACI	TY		Pre	Ref	Pre % Ref			
	DLCO		n/mmHg		(24.8)	35.5	(70)			
	VA	Liters			4.00		(1.0)			
	DLCON		mmHa		(8.20)	4.13	(150)			
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PFT 2	Normal (%)	Increase (%)	Decrease (%)	
FVC	0	1	99	
FEV1	0	1	99	
FEV1/FVC	49	8	43	
MVV 1		0	99	
TLC	1	0 3 4	99	
FRC	34		63 2	
RV	95			
DLCO	17	73	10	
Bronchodilator Response		Yes	No	
		5	95	
nterpretatio	n			

Normal	0 %
Obstruction	1 %
Restriction	52 %
Mixed	47 %

Figure 5

Figure 3a, b: PFT 3 shows ≥90% agreement in most of the parameters except for FEV1/FVC ratio and DLCO.

Height(in): 63 Weight(ib): 204 Date: 11/23/96 Race: C	Age: 73 Gender: Male Physician: 11W	Room: 84 Technicia	
SPIROMETRY Pre History FVC Ullers 1.72 FEV1 Ullers 1.32	Raf Pre Pre % Raf % Raf 2.55 67 67 1.99 66 66	Post Post Mass % Ruf 1.67 65 1.31 65	Post % Chg -3 -1
FEV1/FVC % 77 FEF25-75% Usec 1.08 FEF50% Usec 1.82 FEF75% Usec 0.24	79 2.10 52 52 2.73 67 67 0.80 30 30	79 1.24 59 1.86 68 0.26 33	14 2 9
PEF Live 6.21 MVV Umin 52 MVV Length 12	6.49 98 98 100 52 52	5.59 85	-10
	VOLUMES Pre Ref Pre mes % Ref 97) 4.79 (62)		L BLOOD GAS
Vig Liters 2 RV Liters (1 FRC PL Liters 1 VC Liters 1 IC Liters 1 ERV Liters 0	06 259 211 (59) 67 257 70 72 255 67 14 42 54 217 71 42 42	FI02 % pH PC02 m P02 m H005 r Sa02 %	nmtig milig maq/L
DIFFUSING CAPACITY DLCO mUniwhmitig VA Uiers DLCOVA Uniwhmitig,	Pro Raf Pro Means % Raf 18.1 19.7 92 2.96 (6.08) 3.47 (174)		•
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PFT 3	Normal (%)	Increase (%)	Decrease (%)
FVC	0	0	100
FEV1	1	0 99	
FEV1/FVC	85	2	13
MVV	5	1	94
TLC	0	0	100
FRC	2	2 0	
RV	2	0	98
DLCO	18	82	0
Bronch	odilator	Yes	No
Resp	onse	0	100
Interpretat	tion		
Nor	mal		0 %
Obstru	uction		0 %
Restri	ction		90 %
Mix	ed		10 %

Figure 7

Figure 4a, b:PFT 4 shows >90% agreement in most of the parameters except for FEV1/FVC ratio, TLC, FRC and in the interpretation of PFT.

Height Date:	(in): 68 05/11/99	Weight(lb) Race: Ca	143 ucasian	Age: 55 Physician:	Gender: Mai GMC	e		
CDIDO	METRY		Ref	Pre	Pre	Post	Post	Post
SFIRU	MEINI			Meas	% Ref	Meas	% Ref	% Chg
	FVC	Liters	4.18	4.51	108	4.56	109	1
	FEV1	Liters	3.38	3.29		3.38	100	2
	FEV1/FVC		. 81	73		74		
	FEF25-75		3.50	2.40		2.60	74	8
	FEF50%	L/sec	4.28	3.49		3.53	82	1
	FEF75%	L/sec	1.62	0.81	50	0.84	52	3
	PEF	L/sec	. 8.31	7.94	96	7.77	93	-2
	MVV MVV Long	L/min th	140	144				
PLETH		ters	Pre Meas (7.68)	Ref %	Pre Ref (23)	,	ARTERIA	L BLOOD GAS
		lers lers	4.18	2.15 (1	47)		pH	•
	FRCPLU		4.39		118		PCO2	manila
		ters	4.51		108		PO2 m	
		lers						
	ERV L	lers	1.23				HCO3	
	Raw cr	nH2O/Use	c 0.49	1.19	41		Se02 1	
DIFFU		mL/min/mr		Pre Mens 20.5 6.52 3.14	Ref. Pre % Ref 21.2 96 3.93 80			
Now						·	,	
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PFT 4	Normal (%)	Increase (%)	Decrease (%)
FVC	99	1	0
FEV1	100	0	0
FEV1/FVC	46	0	54
MVV	100	0	0
TLC	19	81	0
FRC	77	22	1
RV	8	92	0
DLCO	97	0	3

Bronchodilator	Yes	No
Response	0	100

Interpretation

Normal	47 %
Obstruction	53 %
Restriction	0 %
Mixed	0 %

Figure 9

Figure 5a, b: PFT 4 shows >90% agreement in most of the parameters except for the bronchodilator response and in the final interpretation of PFT.

	(in): 72 V 06/14/99 F	Veight(1b) Race: Bla	242 ck	Age: 58 Physician	Gend PULMO	ar. Male NARY				
SPIRO	METRY		Ref	Pa			Post Meas	Post % Ref	Post % Chg	
	FVC	Liters	4.94	2.9			3.02	61	1	
	FEV1	Liters	3.98	2.0			2.21	58	10	
	FEV1/FVC	%	80	6			73		10	
	FEF25-75%		3.97	1.10			1.68	42	42	
	FEF50%	Usec	4.85	(1.40			(2.02)	(42)	44	
	FEF75%	L/sec	1.86	(0.38			0.54	29	44	
	PEF	L/sec	9.16	8.0			7.52	82	-6	
	MVV MVV Lengt	L/min	150	(73						
PLETH	YSMOGR	APH L								
			Pre	Ref	Pro					
	TLC Lis	ers	(5.36)	7.17	(75)				L BLOOD GAS	s
	Vtg Lit	ers	4.55		<i>v</i> - <i>y</i>			FIO2 %		
	RV LIB	ers.	2.20	2.48	89			pH		
	FRC PL Lin		2.87	3.58	80			PCO2	mmHa	
	VC LIB		3.17	4.94	64			PO2 m		
	IC LIN	ers	2.50							
	ERV LIB	ens	0.68					HCO3		
		H2OL/se	c 1.66	1.25	132			SaO2 9	6	
	RV/TLC %		41	37						
DIFFUS	SING CAP	ACITY		Pre	Ref	Pre				
				Meas		% Ref				
		nUmin/mr	nHg	22.3	28.8	77				
		iters		5.16						
	DLCOWA 1	/min/mmi	łg	4.31	3.94	110				
Flow										
*T										
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PFT 5	Normal (%)	Increase (%)	Decrease (%)
FVC	0	0	100
FEV1	0	0	100
FEV1/FVC	3	0	97
MVV	4	0	96
TLC	7	0	93
FRC	92	0	8
RV	96	1	3
DLCO	94	0	6
Bronchodilator		Yes	No
Response		28	72

Interpretation

Normal	0 %	
Obstruction	20 %	
Restriction	0 %	
Mixed	80 %	

DISCUSSION

Pulmonary function testing plays an essential role in making diagnostic and therapeutic decisions.1, 8 The clinical value of lung function tests is maximized when good quality tests are interpreted with appropriate reference values and appropriate interpretive schemes.₁, ₅ Over the years considerable measures have been taken to reduce the technical and biologic variation in the pulmonary function testing. Standardizing requirements for instrument performance and protocols for testing have significantly reduced intrainstrument and inter-instrument variability.11, 16Also increased accountability for the effects of diurnal, circadian, and seasonal changes in the measurements has reduced intrasubject or biologic variability in pulmonary function testing.₁, 7, 11, 12 However, a great deal of disagreement exists in the narrative interpretation of PFT data. There are several guidelines available to facilitate the interpretation of the raw data, such as American Thoracic Society, Intermountain Thoracic Society, European Thoracic Society, Computerassisted interpretation and others.1,2,3,4, 14Many clinicians also use their personal and training experience as well as the textbook information to assist PFT interpretation. However,

despite the interpretation guidelines, significant variability has been observed in the interpretations of these tests among physicians._{1,2,3,4,5,6} In this study, we demonstrate that, amongst experienced pulmonologists, with the exception of severe obstructive or restrictive defect, significant variability exists in the interpretation of lung function tests. Our group included experienced pulmonologists, 85% of them have been in practice for more than 5 years and 58% reported reading more than 30 PFTs a month. We had an equal distribution of pulmonologists practicing in a university or university affiliated hospital or in private practice settings; and 50% of them taught PFT interpretations. However, only 50% used present ATS criteria, and despite use of these criteria showed considerable variability in their PFT interpretation. Reasons for the differences in PFT interpretation are not entirely clear, but may include training bias, differences in knowledge of pulmonary physiology, the use of different guidelines or normal ranges, or addition of subjective analysis. In conclusion, we demonstrate that, except for severe obstruction and restriction there is significant variability in PFT interpretation by experienced pulmonologists. This variability may have important diagnostic and therapeutic implications for patient care and suggest that training and standardization is necessary.

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