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Short communication

Manometry Optimized Positive Expiratory Pressure (MOPEP) in Excessive Dynamic Airway Collapse (EDAC)

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ABSTRACT

Background: Positive expiratory pressure(PEP) breathing modalities are commonly prescribed in obstructive lung diseases, however practical methods of airway pressures(AP) quantification for therapeutic efficacy are lacking. Excessive dynamic airway collapse(EDAC) is characterized by expiratory central airway collapse leading to dyspnea and poor quality of life(QoL), with limited therapeutic options.
Purpose: To measure AP and exertional dyspnea in EDAC patients during normal breathing and with use of pursed-lip breathing(PLB), nasal PEP device(nPEP), and oral-PEP valve(oPEP) during rest and exercise using an Esophageal Manometer.
Methods: EDAC patients exercised on a bicycle ergometer sequentially using normal breathing, PLB, nPEP, and oPEP for five-minute intervals. AP's were measured by continuous topographic upper airway manometry. Pre- and post-exercise BORG dyspnea scores were recorded and QoL measured with the St. George's respiratory questionnaire(SGRQ-C). The most effective and patient-preferred PEP modality was prescribed for daily activities and SGRQ-C repeated after one week.
Results: Three women with symptomatic EDAC participated. Expiratory laryngopharyngeal AP's during exercise with normal breathing, PLB, nPEP and oPEP in patient-1 were 1.7, 14, 4.5, and 7.3 mmHg, in patient-2; 2.3, 8, 8.3, and 12 mmHg, and in patient-3; 1, 15, unobtainable, and 9 mmHg, respectively. Maximal reduction in BORG scores occurred with PLB in patient 1 and with oPEP in patients 2 and 3. After 1 week mean SGRQ-C scores declined by 17-points.
Conclusions: Upper airway manometry directly measures laryngopharyngeal pressures during rest and exercise and can be used to select and optimize PEP breathing techniques to improve respiratory symptoms in EDAC patients.

1. Background

Excessive dynamic airway collapse (EDAC) is an uncommon and underdiagnosed obstructive lung disease characterized by excessive inward bulging of the posterior tracheao-bronchial membrane impeding expiratory airflow and causing functional limitations [1,2]. EDAC is an independent factor for exertional dyspnea, reduced quality of life (QoL), and increased respiratory exacerbations in patients with or without underlying lung disease [3]. Continuous positive airway pressure (CPAP) is the only mode of non-invasive therapy available to improve symptoms by working as a pneumatic stent [4,5]. However its use in daily activities is not pragmatic and the overall nocturnal adherence is poor [6]. Efficacy of other positive expiratory pressure (PEP) breathing techniques in EDAC is not known. A method of measuring the effective pressure generated by different therapies during daily activities is also lacking.

Using a novel application of esophageal manometer for measuring upper airway pressures, we evaluated the efficacy of pursed-lip breathing (PLB), nasal PEP-device (nPEP), and oral PEP-

Abbreviations: EDAC, excessive dynamic airway collapse; CPAP, continuous positive airway pressure; PLB, pursed-lip breathing; oPEP, oral positive-expiratory pressure device; nPEP, nasal positive-expiratory pressure device.

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Table 1
Baseline characteristics.

	Patient 1	Patient 2	Patient 3
Age (years)	38	48	53
BMI (kg/m^2)	37.4	35	42
Comorbid conditions	GERD, fibromyalgia, anxiety	GERD, asthma, depression	COPD
Smoking exposure	None	None	25 pack years
Use of bronchodilators	Yes	Yes	Yes
Use of SABA < 4 h	No	No	No
Pulmonary Function Test			
FEV_1 liters (% predicted)	2.64 (81%)	2.11 (81%)	1.18 (37%)
FVC liters (% predicted)	3.24 (84%)	2.52 (79%)	1.8 (45%)
FEV_1/FVC (%)	78	83	66
TLC liters (% predicted)	4.53 (86%)	3.71 (73%)	6.55 (115)
RV liters (% predicted)	1.22 (71%)	1.29 (69%)	4.46 (218%)
DLCO ml/mmHg/min (% predicted)	24 (89%)	18.79 (89%)	12.6 (42%)
6- minute walk test			
Distance (feet)	1170	1165	660
Baseline SpO_2	95%	96%	95% (on 2LPM)
Nadir SpO_2	94%	91%	91% (on 2LPM)
Pre- exercise BORG score	2	0	3
Post- exercise BORG score	6	4	6
St. George Respiratory Questionnaire			
Symptoms score	91.59	46.06	86.1
Activity score	75.78	84.54	100
Impact score	88.25	38	78.4
Total score	85.01	53.7	86.4
Dynamic Bronchoscopy			
Severity % collapse (length)	Trachea: 60% (4 cm) RMB: 80% (1 cm) LMB: 99% (3.8 cm)	Trachea: 50% (4 cm) RMB: 75% (1.5 cm) LMB: 60% (4 cm)	Trachea: 90% (4 cm) RMB: 95% (1.5 cm) LMB: 95% (4 cm)
CPAP pressure required to prevent main airway collapse on exhalation	8.9 mm Hg (12 cm H_2O)	8.9 mm Hg (12 cm H_2O)	N/A

BMI; body mass index, GERD; gastro-esophageal reflux disease, COPD; chronic obstructive pulmonary disease, SABA; short-acting beta agonist, FEV_1; forced expiratory volume in 1 s, FVC; forced vital capacity, TLC; total lung capacity, RV; residual volume, DLCO; diffusion capacity of carbon monoxide, SpO2: oxygen saturation, RMB; right main-stem bronchus, LMB; left main-stem bronchus, CPAP; continuous positive airway pressure, LLL; left lower lobe.

Table 2
Exercise testing with different breathing modalities.

	Normal breathing		Pursed-lip breathing		Nasal PEP device (Theravent®)		Oral PEP valve	
	Rest	End exercise[a]	Rest	End exercise[a]	Rest	End exercise[a]	Rest	End exercise[a]
Patient 1								
Respiratory rate/min	24	34	24	20	22	24	22	30
Heart rate/min	118	146	122	144	118	129	121	148
SpO_2	95	95	96	96	97	94	94	94
Expiratory LPP[b] (mm Hg)	1.5	1.7	8	14	4	4.5	5	7.3
I:E ratio (sec)		0.8: 0.8		1: 2		1: 1.4		1: 1
Inspiratory UES pressure[b]	54	136	80	88	67	105	48	92
Expiratory UES pressure[b]	32	64	33	59	47	47	40	42
Borg score	3	7	3	6	3	7	3	6.5
Comfort score[c]		2		7		3		6
Preference score[d]		3		8		2		7
Patient 2								
Respiratory rate/min	23	31	18	17.5	16	15	14	12
Heart rate/min	96	128	110	138	99	139	100	135
SpO_2	97	97	98	95	97	97	96	97
Expiratory LPP[b] (mm Hg)	1.3	2.3	4.6	8	6.4	8.3	10	12
I:E ratio (sec)		0.7: 1.2		1.5: 1.5		1: 3		4: 1
Inspiratory UES pressure[b]	34	116	39	75	70	99	78	120
Expiratory UES pressure[b]	39	27	18	20	38	27	55	41
Borg score	1	9	2	8	2	4	1	3
Comfort score[c]		1		5		9		7
Preference score[d]		2		7		10		5
Patient 3								
Respiratory rate/min	26	42	20	28	16	–	18	26
Heart rate/min	109	127	111	123	113	–	110	135
SpO_2 (on 2LPM)	98	93	98	92	96	–	98	91
Expiratory LPP[b] (mm Hg)	0.2	1	13	15	4.2	–	8.5	9
I:E ratio (sec)		0.6:0.6		1:1		–		1:1.2
Inspiratory UES pressure[b]	31	101	62	106	–	–	71	138
Expiratory UES pressure[b]	31	83	29	56	–	–	54	65
Borg score	3	9	3	10	3	–	3	4
Comfort score[c]		7		1		–		10
Preference score[d]		7		1		–		10

Conversion: 1 mm Hg = 1.35 cm H_2O.
PEP; positive expiratory pressure, SpO2: oxygen saturation, LPP; laryngo-pharyngeal pressure, I:E; inspiratory to expiratory time ratio, UES; upper esophageal sphincter.
[a] Values obtained by average of three representative breaths in each of the last 2 min of exercise.
[b] Pressure in mm of Hg.
[c] Rating from 0 to 10 where 0 is least comfortable and 10 is most comfortable.
[d] Rating from 0 to 10 where 0 is least preferred and 10 is most preferred for daily use.