Heart, Lung and Circulation (2016) **xx**, 1–4
1443-9506/04/$36.00
http://dx.doi.org/10.1016/j.hlc.2016.10.015

BRIEF COMMUNICATION

Right Ventricular Response During Exercise in Patients with Chronic Obstructive Pulmonary Disease

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Received 20 July 2016; received in revised form 14 October 2016; accepted 19 October 2016; online published-ahead-of-print xxx

Aim Right ventricular (RV) pump function is of essential clinical and prognostic importance in a variety of heart and lung diseases. While the evaluation of RV performance at rest has been implemented in the clinical setting, it is unknown whether this assessment during exercise may provide additional benefit. With this aim, we evaluated the exercise-induced pulmonary arterial systolic pressure (PASP) increase during exercise in patients with severe chronic obstructive pulmonary disease (COPD) as an expression of RV contractile reserve.

Method Cardiopulmonary exercise testing (CPET) with synchronic echocardiography was performed in 81 patients. Patients were classified into two groups according to an exercise-induced PASP increase above 30 mmHg (High PSAP) or below 30 mmHg (Low PSAP) during maximal exercise. Patients were then followed for three years.

Results Sixteen patients (20%) had low PSAP and 65 (80%) showed high PSAP. These were not significant clinical and functional differences. Low PSAP was associated with a significantly lower peak VO2 (mean (SD), 35 (2) % predicted) compared to high PSAP response (peak VO2 45 (3) % predicted), p=0.045. Factors associated with mortality were age and exercise-induced PASP. Seventeen patients died during the three years of follow-up (7 (39%) in the low PSAP group and only 10 (1%) in the high PSAP group, p=0.041).

Conclusion Cardiopulmonary exercise testing with a synchronic echocardiography may be a useful tool for the assessment of RV contractile reserve in severe COPD patients. Exercise-induced PSAP emerges as a possible prognostic factor in these patients.

Keywords COPD exercise right ventricular response

Introduction

There is strong evidence that pathologic changes to the pulmonary vasculature occur at all stages of the chronic obstructive pulmonary disease (COPD) [1], which in structural changes of the right heart are associated with poor outcomes [2]. The current evaluation of right ventricle (RV) performance in COPD patients has been recommended to be obtained at rest [3]. However, it is unknown whether assessment of RV function during exercise may provide additional

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Please cite this article in press as: Rodríguez DA, et al. Right Ventricular Response During Exercise in Patients with Chronic Obstructive Pulmonary Disease. Heart, Lung and Circulation (2016), http://dx.doi.org/10.1016/j.hlc.2016.10.015

and valuable information. Several studies explore this evaluation in left heart diseases but there are no established simple methods to assess RV contractile reserve [4]. Recently, exercise-induced increase in pulmonary arterial systolic pressure, as a possible measure of the RV contractile reserve using exercise stress echocardiography, has appeared as a novel method to assess patients with cardiac and pulmonary diseases [5]. Particularly in COPD patients, an impaired RV response to the exercise could implicate poor prognosis independently of pulmonary function [6]. With this aim, we evaluated the exercise-induced pulmonary arterial systolic pressure (PASP) increase during exercise as an

Table 1 Characteristics of the study population and exercise response.

		Exercise-induced PASP increase	
	All	**≤ 30 mmHg**	**> 30 mmHg**
Demographics			
Patients, n	81	16	65
Male/Female (n)	66/15	14/2	52/13
Age (years)	68(9)	71(7)	67(10)
Body Mass Index (kg/m^2)	26(4)	27(2)	25(4)
Active Smokers (%)	25	20	30
Anaemia (%)	14	13	15
Obesity (%)	20	19	25
Obstructive Sleep Apnoea (%)	8	8	9
Diabetes (%)	11	9	13
NT-proBNP (pg/ml)	604(290)	790(246)	664(380)
Pulmonary Function			
FEV_1/FVC	59(6)	60(3)	61(2)
FEV_1 (L)	1.2(0.6)	1.2(0.4)	1.3(0.8)
FEV_1 (% predicted)	40(17)	38(15)	42(18)
DLco (% predicted)	48(20)	45(21)	52(20)
RV/TLC (%)	55(12)	60(11)	50(13)
mMRC ≥ 2 (%)	66	67	65
PaO_2 (mmHg)	65(11)	66(10)	62(13)
Frequent exacerbation n, (%)	12(14)	2(12)	10(15)
Echocardiography			
Basal			
PASP (mmHg)	31(27)	31(27)	32(27)
TR peak jet velocity (m/s)	2.2(1.6)	2.3(1.5)	2.2(1.8)
TAPSE (mm)	20(5)	20(6)	22(7)
Area RV (mm)	24(7)	23(5)	25(8)
Area LA (mm)	34(8)	32(9)	36(6)
LVEF (%)	63(10)	65(8)	61(13)
Exercise			
PASP max (mmHg)	57(29)*	47(28)*	85(23)*
Δ PASP (mmHg)	26(24)*	16(6)*	53(20)*
VO_2 peak (ml/kg/min)	11.1 (2)	10.1(2)	12.1(2)**
VO_2 peak (%predicted)	40(2)**	35(2)**	45(2)**
V_E peak (% predicted)	80(15)	80(20)	81(15)
HR Basal (bpm)	78(11)	76(12)	79(11)
HR peak (bpm)	118(20)*	115(20)*	130(20)*
Oxygen Pulse (mL/min)/min$-^1$	7	7.1	7.3
$EqCO_2$ at AT, mL/min	38 (9)	39(9)	37(9)
SpO_2 (%) basal	92(3)	91(4)	93(3)
SpO_2 (%) minimum	87(6)	87(6)	87(6)

FVC = forced volume vital capacity; FEV_1 = forced expiratory volume in one second; DL_{CO} = Diffusing capacity of the lung for carbon monoxide; TLC = total lung capacity; RV = Residual Volume; mMRC=modified Medical Research Council; PaO_2 = Arterial Oxygen Pressure; LVEF = Left ventricular ejection fraction; TAPSE = tricuspid annular plane systolic excursion. PASP = Pulmonary Arterial Systolic Pressure; RV = Right Ventricular; LA = Left atrium; VO_2 = oxygen uptake; V_E = Ventilation; HR = Heart Rate; $EqCO_2$ = equivalent of carbon dioxide at anaerobic threshold; SpO_2 = Oxygen saturation. p-value. * $p < 0.001$, ** $p < 0.05$

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