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Journal of Lung, Pulmonary & Respiratory Research

Research Article
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Assessment of pulmonary hypertension by cardiac MRI and right sided heart catheter in COPD patients

Abstract

Background: Pulmonary hypertension (PH) is a progressive disorder characterized by abnormally elevated blood pressure of the pulmonary circulation which results, over time, from extensive vascular remodeling and increased pulmonary vascular resistance (PVR). Recent advances in cMRI technology have led to the development of techniques for noninvasive assessment of the morphology of the right side of the heart to be correlated to the hemodynamic parameters collected by RHC which is still the golden standard technique of PH diagnosis.

Aim: To assess the role of Cardiac MRI in severe COPD patients with pulmonary artery pressure more than 35 mmHg as evaluated by Echocardiography and right sided cardiac catheterization.

Patients and methods: The current study was conducted upon 20 patients with moderate or severe chronic obstructive pulmonary disease (COPD) by spirometry according to GOLD 2022 criteria who had been assessed for severe pulmonary hypertension with Pulmonary Artery Pressure more than 35 mmHg by cardiac Magnetic resonance imaging (cMRI) and right sided heart catheter (RHC). They were recruited from the outpatient clinic and department of chest specialized hospital Kobry Elkobba Armed Forces.

Results: Twenty patients included in the study were 90% males, mean age about 64.50 ± 7.94 years old with mean smoking duration 33.89 ±7.03 years and 45% with co-morbidities. Spirometry done for all studied cases included FEV1/FVC, FEV1 and FVC parameters with mean range 43.40 ± 5.17, 38.90 ± 8.60, 79.45 ± 16.59 respectively. The descriptive data of HRCT showed 60% of the patients with emphysema while the rest showed mixed emphysema and ILD. V/Q scan study was positive in 4 patients which represented 20% of the patients whose all included in group B (mPA > 43.5 mmHg). All studied COPD patients who showed severe PHT by a measurement of mPAP > 35 mmHg by RHC with normal PCW pressure underwent cMRI study to assess right ventricular structure and morphology.

Conclusion: Cardiac MRI showed a great rule in the evaluation of the morphological changes associated with the condition of COPDPH in the right side of the heart which should affect its functions. The cardiac MRI is not the best tool in assessment of the right side of the heart in COPD patients due to many causes like the difficulty of holding breaths with COPDPH patients during the maneuver to snap accurate clear shots of the heart, the hypoxia in those patients which makes the maneuver more difficult, the associated co-morbidities may interfere with completing the maneuver like the chronic kidney disease that prohibit the use of gadolinium dye and other co-morbidities like morbid obesity that will not allow the patient to get through the MRI

Keywords: pulmonary hypertension, chronic obstructive pulmonary disease, right sided heart catheterization, cardiacMRI, echocardiography

Volume 10 Issue 1 - 2023

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Received: January 08, 2023 | **Published:** January 19, 2023

Introduction

Chronic Obstructive Pulmonary Disease is a common preventable and treatable disease, the most important character is persistent airflow limitation which is progressive and accompanied with chronic airways inflammatory response to noxious gases or particles. Exacerbations related to the severity of the case in each patient. The chronic limitation of airflow is of COPD character which is due to a combination of parenchymal destruction (emphysema) and small airways disease (obstructive bronchiolitis).[1] Pulmonary arterial hypertension is a progressive disorder characterized by abnormally elevated blood pressure of the pulmonary circulation that results, over time, from extensive vascular remodeling and increased pulmonary vascular resistance.[2] COPD is mainly characterized by limitation of airflow in chronic manner after parenchymal lung destruction and airway narrowing mostly with hypoxia.[3] In addition, the raise in mean pulmonary arterial pressure resistance of the pulmonary vasculature COPD patients is mostly related to the hypoxic severity.[4,5] Remodeling in the pulmonary vessels in COPD patients was reported specially with natives in high-altitude.[6,7] Right heart catheterization (RHC) is essential for a definitive diagnosis.[8] Recent advances in magnetic resonance imaging (MRI) technology have led to the development of techniques for noninvasive assessment of cardiovascular structure and function, including hemodynamic parameters in the pulmonary circulation, which are superior in their identification of right ventricular morphologic changes. These advantages make cardiac MRI an attractive modality for following up and providing prognoses in patients with PAH.[8]

Subjects and methods

The current study conducted upon twenty patients diagnosed as moderate or severe COPD by spirometry (FEV1/ FVC less 70% + FEV1 less than 50%) according to GOLD 2022 criteria with Pulmonary Artery Pressure more than 35 mmHg. The patients were recruited from the outpatient clinic and department of chest specialized hospital Kobry El-kobba Armed Forces.

The eligible enrolled patients had undergone the following workup: Complete history taking, full clinical examination, WHO functional class assessment, spirometry test (using GOLD 2022 severity criteria), Arterial blood gases (ABG room air) and chest radiography (including CXR, HRCT, CTPA and V/Q scan) ECHO heart was done and interpreted by Echo-cardiographers in Cardiology department in Kobry El-kobba Military Complex for all eligible patients. The assessment of pulmonary systolic artery pressure (PASP) carried out by measuring maximal tricuspid regurgitation velocity, and by applying modified equation of Bernoulli the value estimated converted into pressure values to estimate pulmonary artery mean pressure (PAMP).

Right sided heart catheterization was the next step after ECHO assessment that was performed under oxygen supplementation for maintaining arterial oxygen saturation more than 90 %. The measurements that reported hemodynamically like the mean right atrial, pulmonary artery and pulmonary capillary wedge pressures. Mean pressure of the pulmonary artery was calculated by adding the mean diastolic pressure of the pulmonary artery and one third of the pulse pressure.

Basic cardiovascular magnetic resonance (MR) imaging sequences include black blood imaging and bright blood imaging. Black blood imaging is used to depict anatomy, pericardial and mediastinal abnormalities, and extra-luminal aortic disease. Black blood imaging includes ECG-gated true spin-echo or fast spin-echo imaging. Important MR imaging views include the true planar, two-chamber scout, short axis, long axis, four-chamber, and true two-chamber. The true planar view may be in seen in axial, sagittal, or coronal sections.

Statistical analysis

Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 20. Qualitative data were presented as number and percentages while quantitative data were presented as mean, standard deviations and ranges.

Results

Twenty patients included in the study were 90% males, mean age about 64.50 ± 7.94 years old with mean smoking duration 33.89 ± 7.03 years and 45% with co-morbidities. The ABG findings included PH, PaO2, PaCO2, HCO3 and SO2 for patients were 7.40 ± 0.06, 56.30 ± 14.69, 58.65 ± 10.69, 36.87 ± 6.59, 84.70 ± 8.34 respectively. Spirometry done for all studied cases included FEV1/FVC, FEV1 and FVC parameters with mean range 43.40 ± 5.17, 38.90 ± 8.60, 79.45 ± 16.59 respectively.

The descriptive data of HRCT showed 60% of the patients with emphysema while the rest showed mixed emphysema and ILD. V/Q scan study was positive in 4 patients which represented 20% of the patients whose all included in group B (mPA > 43.5 mmHg). According to the median equation, patients were classified into 2 groups according to the mPAP calculated by the RHC:

1) The first group of patients has mPAP between 35 and 43.5 mmHg (Group A), included 10 patients.
2) The second group has mPAP between 43.5 to 101 mmHg (Group B), included 10 patients.

The twenty patients had undergone the proposed diagnostic algorithm to evaluate the right side of the heart where echocardiography was done to assess whether those patients are candidates for RHC (Table 1).

Table 1 Correlation between RHC parameters and mPA among the 2 studied groups

RHC		mPA < 43.5	mPA > 43.5	Independent t-test	
		No = 10	No = 10	t	P-value
RA	Mean± SD	16.30 ±3.09	12.60 ±6.08	-1.71	0.103
	Range	12-21	05-22	6	
RV	Mean± SD	27.40 ±6.9	35.30 ±7.67	2.421	0.026
	Range	10-36	23-48		
PCW	Mean± SD	13.00 ±2.54	13.20 ±3.16	0.156	0.878
	Range	9-16	6-16		
COP	Mean± SD	4.23 ±0.53	3.62 ±0.62	-2.353	0.03
	Range	3.1-4.9	2.9-4.8		
PVR	Mean± SD	884.36 ±527.18	1375.7± 360.46	2.433	0.026
	Range	820-1792	820-1898		

All studied COPD patients who showed severe PHT by a measurement of mPAP > 35 mmHg by RHC with normal PCW pressure underwent cMRI study to assess right ventricular structure and morphology giving the upcoming data; RVEDV, RVESV, RVSV, RA diameter, CO and EF as showed in Tables 2–5.

Table 2 Correlation between cMRI parameters and mPA among the 2 studied groups

MRI		mPA < 43.5	mPA > 43.5	Independent t-test	
		No = 10	No = 10	t	P-value
RVED V	Mean± SD	35.00 ±3.66	26.57 ±4.54	-4	0.002
	Range	29-39	20-32		
RVESV	Mean± SD	42.13 ±4.29	28.00 ±8.41	-4.2	0.001
	Range	33-47	17-39		
RVSV	Mean± SD	4.74 ±0.41	3.96 ±0.74	-2.6	0.023
	Range	3.9-5.2	3.2-5.2		
RADiam	Mean± SD	945.00 ±412.64	1623.57± 345.42	3.42	0.005
	Range	460-1517	945-1932		
CO	Mean± SD	4.48 ±0.42	3.44 ±0.69	-3.5	0.004
	Range	3.9-5	2.3-4.2		
LVEF	Mean± SD	59.38 ±2.88	55.14 ±2.61	-3	0.011
	Range	55-63	51-59		

Table 3 The descriptive data of studied cases as regard Echocardiography

Echo	Mean ± SD	Range
TRV	3.41 ± 0.77	2.5-5.2
mPAP	62.40 ± 23.19	39-126
RVSP	38.25 ± 13.86	25-78
RA	824.25 ± 261.99	414-1320
EF	54.65 ± 4.40	48-64

Table 4 The descriptive data of studied cases as regard Right Heart Catheterization (RHC)

RHC		Total no. 20
RA	Mean ± SD	14.45 ± 5.06
	Range	May-22
RV	Mean ± SD	31.35 ± 8.18
	Range	Oct-48
mPA	Mean ± SD	49.55 ± 18.14
	Range	35-101
	mPA < 43.5	10 (50.0%)
	mPA > 43.5	10 (50.0%)
PCW	Mean ± SD	13.10 ± 2.79
	Range	Jun-16
COP	Mean ± SD	3.93 ± 0.64
	Range	2.9-4.9
PVR	Mean ± SD	1130.03 ± 506.68
	Range	820-1898

Table 5 The descriptive data of studied cases as regard Cardiac MRI

cMRI	Mean ± SD	Range
RVEDV	31.07 ± 5.87	20-39
RVESV	35.53 ± 9.63	17-47
RVSV	4.37 ± 0.69	3.2-5.2
RA Diam	1261.67 ± 508.98	460-1932
CO	3.99 ± 0.76	2.3-5
LVEF	57.40 ± 3.44	51-63

Discussion

The study included 20 patients, 18 males (90%) and 2 females (10%) that showed male sex predominance and this might be directly related to COPD prevalence where it is more common in males than females due to smoking habits. This was in accordance to GOLD 2022 as it showed male predominance of COPD. E.J. Gartman, et al[9] studied 54 COPD patients with pulmonary hypertension with only 18 male patients (33.3 %), There is a difference in data compared to the current study which may be due to the different population studied.

There was a significant correlation according to smoking index and smoking duration among the studied cases, which suggests that cigarette smoking, may play an important role in the vascular changes occurring in the pulmonary circulation in COPD patients. Santos et al.,[10] and MacNee[11] showed structural changes might be caused by the effects of cigarette smoke rather than hypoxemia.

Studying some of the co- morbid conditions revealed that 9 patients (45%) had a co-morbid conditions, 2 patients (20 %) in group (A) while 7 patients (70%) in group (B) had a co- morbid distribution and conditions. There is a significant direct difference correlation between some co-morbid conditions like Morbid obesity, DVT , chronic kidney disease and hyperlipidemia. Chen et al.,[12] study among 109 pulmonary hypertensive patients associated with severe chronic respiratory diseases showed high incidence of multiple co-morbidities like hypertension, diabetes mellitus and arrhythmia.

The (HRCT) findings showed that only 7 patients out of 10 showed emphysema (70%) in group (A) while 5 patients out of 10 showed emphysema and interstitial lung disease (ILD) (50%) in group (B) with direct significant direct difference correlation between both groups in relation to mPA. The present study showed that only 4 patients out of the 20 studied patients had positive ventilation/perfusion scan (V/Q scan) which means there is chronic thromboembolic pulmonary hypertension (CTEPH), all those 4 patients were included in group B. The study made by Hye Jeon Hwang[12] on 52 COPD patients showed 13.1% positive ventilation / perfusion mismatching of the studied group of patients, which was close to the percentage result showed by current study. This was in consistence with M. Toshner et al.,[13] that in included 47 studied patients all had mPA more than 42 mmHg.

This indicates the high susceptibility of CTEPH among COPD patients. Echocardiography (ECHO) was done to demonstrate TRV, sPAP, RA diameter and LVEF respectively as showed in Table 3. E.J. Gartman, et al[9] studied 54 patients with pulmonary hypertension associated with COPD showed sPAP ranged around 43.7 (± 9.2) and LVEF mean range around 63.0 (± 5.1) that was in accordance with the data obtained by the current study. But sPAP was not consistent with A. Girard et al.,[14] that gave the mean number 64 (± 17).

In the current study the comparison of TRV, mPAP and RA diameter showed highly significant direct correlation among the two studied groups, and direct significant correlation with RVSP among both groups, this is due to the difference of the results obtained by those parameters that means with the higher mPAP estimated by RHC the parameters of the echocardiography among the right side will more prominent to suspect the probability of pulmonary hypertension and to evaluate the severity as a primary tool.

There is no significant correlation with the estimation of LVEF with the studied groups; this could be due to the artifacts with obtaining clear views in COPD patients and the difficulty with estimation of ejection fraction.

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Right heart catheterization (RHC) showed finding among mean RA, RV, PA, PCW pressures and mean CO (estimated by L × min) and PVR (that is estimated by dyn·s/ cm5) respectively in Table 4. This was similar to the parameters results showed by A. Girard, et al.,[14] that gave those mean data 9 (± 5) for RA pressure, 48 (± 9) for mPAP, 10 (± 3) for PCW pressure and 4.6 (± 0.98) for CO (that estimated by L × min) but not consistent with PVR that gave 660 (± 109) (estimated in dyn·s/cm^5).

The parameters obtained by RHC like RV pressure showed direct significant correlation in correlation to mPAP and indirect significant correlation among CO and PVR over the two studied groups in correlation to mPAP estimated by RHC. This means that as high as mPAP estimated by RHC, there will be more increase in the change in the other parameters estimated by RHC like RV pressure, CO and PVR wither by the direct or indirect correlation. PCW and RA pressures showed no significant correlations in accordance to mPAP measured by RHC. There were no comparable studies of the RHC parameters in correlation to mPAP measured by RHC to compare the current results. This is mostly as no previous study has divided the severe pulmonary hypertension patients according to mPAP.

Complications associated to RHC had been detected with the current study in percentage to show that 8 patients out of 20 (40%) had complications with the procedure. The common complications involved were hypoxia (10%), arrhythmia (10%), dyspnea (5%), puncture of the carotid artery (10%) and in one case we had an air embolism (5%). MM Hoeper[15] study showed same and other different complications to be associated with RHC with different ranges due to the higher number of studied cases.

The new tool we brought in the current study was cMRI that used to study the morphology the right ventricular changes in the walls and cardiac cycle as a non-invasive tool in COPDPH. Cardiac MRI is a reliable tool which used to evaluate the structure and functions of the right side of the heart in patients with severe pulmonary hypertension.

The current study showed data like RVEDV, RVESV, RVSV, RA diameter, CO and finally LVEF as illustrated in Table 5. All data among those parameters showed either direct significant correlation like RA diameter, or indirect significant difference correlation between the studied groups like in RVEDV, RVESV RVSV. The difference detected among the two groups means the higher sensitivity for this tool in the diagnosis with the increase in mPAP that measured by RHC.

The study of Gao Yan et al.,[17] found that patients with mild to moderate COPD have right ventricular hypertrophy. These patients can only rely on this compensation to maintain their own right heart function; hence, ejection fraction value decreases less. However, right ventricular hypertrophy occurs and progress in patients with severe COPD, and EDV in the right ventricle more decreases. This more reduction in the compensation ability of the right ventricle, which finally causes RVEF to decrease; resulting in right ventricular dysfunction. This suggests the possibility of the combination of COPD and pulmonary heart disease.

This study evaluated the utility of both echocardiography and Right heart catheterization in the estimation of mPAP, that ranged in ECHO 39 - 126 with mean 62.40 (± 23.19) while in RHC ranged in 35 - 101 with mean 49.55 (± 18.14) that highly significant different correlation between the measurements of both modalities as distributed in Figure 1.

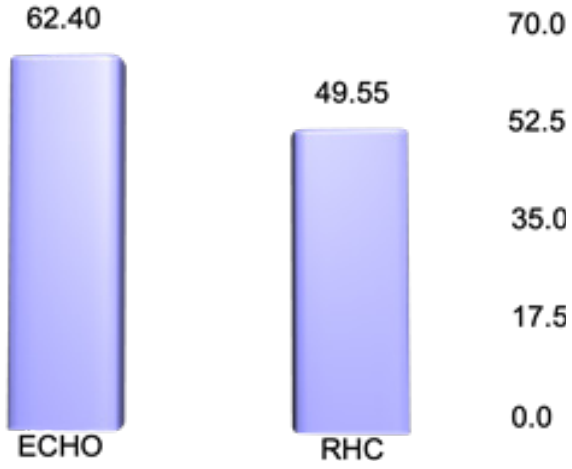

Figure 1 Correlation between mPAP measured by ECHO and RHC.

Fisher, et al.,[16] also studied 65 patients and showed the followed results mPAP by echo12.4 (± 4.7) while gave mean results of mPAP by RHC 9.4 (± 5.0) also with significant correlation between both methods in measurement. This could be due to the unclear views in echocardiography with COPD patients due to changes that happened corresponding to the emphysema.

RA diameter was compared in the current study by echocardiography and cMRI as distributed in Figure 2. This showed highly direct significant difference in the correlation between either modality. This owing to the high accuracy in the measurement and assessment of the right side morphology of the heart by cMRI that showed the higher sensitivity of cMRI over echocardiography as in the prognostic value of the disease.

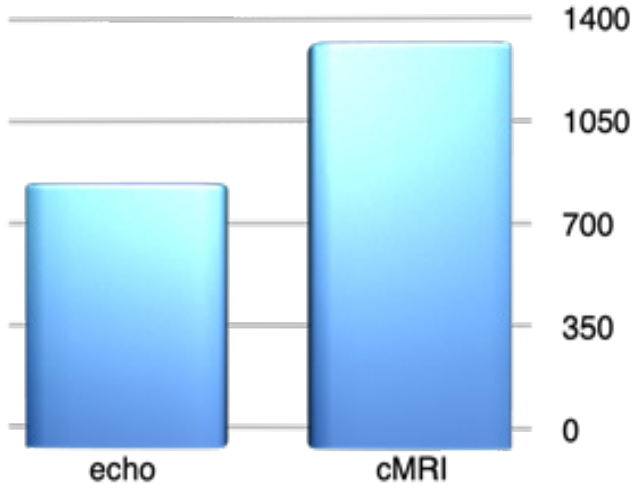

Figure 2 Correlation between RA Diameter measured by ECHO and cMRI.

The study aims at evaluation of the rule of cardiac MRI upon severe COPD patients with severe pulmonary hypertension. From our study, right sided heart catheterization still shows the biggest rule as the gold standard tool in the diagnosis of pulmonary hypertension by accurate estimation of pressures of right side of the heart. However, RHC still an invasive technique with multiple complications. The technique itself needs an expert with skillful technique and repeated experience in high specialized centers.

Echocardiography still not the best tool for diagnosis of PH or assessment of prognosis, but it is considered as good screening tool. This is due to lack of accuracy in measurement of pressure, the unclear views with COPD patients owing to the hyper inflated lungs by emphysema which compress the heart and changed its location and also as the Echo is an operator dependent maneuver that could give different data with different operators.

Cardiac MRI showed a great rule in the evaluation of the morphological changes associated with the condition of COPDPH in the right side of the heart which should affect its functions. The cardiac MRI is not the best tool in assessment of the right side of the heart in COPD patients due to many causes like the difficulty of holding breaths with COPDPH patients during the maneuver to snap accurate clear shots of the heart, the hypoxia in those patients which makes the maneuver more difficult, the associated co-morbidities may interfere with completing the maneuver like the chronic kidney disease that prohibit the use of gadolinium dye and other co-morbidities like morbid obesity that will not allow the patient to get through the MRI machine.

Acknowledgments

None.

Conflict of interest

Author declared there is no conflict of interest.

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