A Case of Right Ventricular Dysfunction with Right Ventricular Failure Secondary to Obesity Hypoventilation Syndrome

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
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None declared

Patient:	**Male, 53**
Final Diagnosis:	**Right ventricular dysfunction secondary to obesity hypoventilation syndrome**
Symptoms:	**Shortness of breath**
Medication:	**—**
Clinical Procedure:	**Echocardiogram (TTE)**
Specialty:	**Cardiology**

Objective: Challenging differential diagnosis

Background: Obesity hypoventilation syndrome (OHS) is characterized by a body mass index (BMI) ≥ 30 kg/m^2, daytime hypercapnia, an arterial carbon dioxide tension ≥ 45 mmHg, and obstructive sleep apnea (OSA). OHS can lead to pulmonary hypertension. It has not been clearly demonstrated that OHS with pulmonary hypertension can lead to right ventricular dysfunction and right heart failure. A case is presented of right ventricular dysfunction and right ventricular failure secondary to OHS.

Case Report: A 53-year-old man, who was morbidly obese with a BMI of 75 kg/m^2, presented with shortness of breath (SOB) and hypercapnia. He had never smoked but had a history of severe OSA and hypertension. On examination, the patient was obese with normal lung auscultation and mild pitting edema of the lower extremities. A spiral computed tomography (CT) angiogram showed no evidence of pulmonary embolism or interstitial lung disease. Pulmonary function testing showed no obstructive airway disease and a normal diffusion capacity. Two-dimensional transthoracic echocardiogram (TTE) showed normal left ventricular function and a dilated right ventricle (RV) with a flattened septal wall, moderate tricuspid regurgitation, and an estimated right ventricular systolic pressure of 55–60 mmHg. The patient was discharged on continuous positive airway pressure (CPAP) and oxygen at night, and as needed during the day.

Conclusions: This report has shown that OHS without underlying causes of alveolar hypoventilation can result in isolated right ventricular dysfunction and right ventricular failure.

MeSH Keywords: **Heart Failure • Hypertension, Pulmonary • Obesity Hypoventilation Syndrome**

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Background

Population data from the US between 2011 and 2014 showed that 37% of adults were obese, with a body mass index (BMI) of >30 kg/m^2 [1]. Up to 30% of severely obese hospitalized patients with a BMI ≥35 kg/m^2 have been reported to have hypoventilation syndrome (OHS) [2]. It is important to recognize this condition, as patients with OHS with a BMI ≥35 kg/m^2 who are hospitalized are reported to have a one-year survival of only 80% [2]. Obesity hypoventilation syndrome (OHS) is characterized by a body mass index (BMI) ≥30 kg/m^2, daytime hypercapnia, an arterial carbon dioxide tension ≥45 mmHg, and obstructive sleep apnea (OSA) [3]. OHS can lead to pulmonary hypertension and right ventricular failure, but right ventricular hypertrophy can be associated with preserved cardiac function [3].

Due to the obesity epidemic in the US, OHS is now likely to be the second most common cause of chronic hypercapnia seen clinically, with the most common cause being chronic obstructive pulmonary disease (COPD), with interstitial lung disease being less common. Advanced neuromuscular diseases, such as muscular dystrophy and amyotrophic lateral sclerosis can result in hypercapnia resulting in the need for ventilatory support. Patients who suffer from a cerebrovascular accident (CVA) may also develop chronic hypercapnia and need ventilatory support. All these patients with advanced neuromuscular disease will need a percutaneous endoscopic gastrostomy (PEG) and tracheostomy before placement in a long-term care facility.

Isolated right ventricular dysfunction with or without right ventricular failure can occur with COPD, chronic thromboembolic pulmonary hypertension, acute pulmonary embolism, and chronic lung disease other than COPD that results in hypoxemia. However, it remains unclear whether or not OHS alone can cause isolated right ventricular dysfunction and right ventricular failure. This report is of a case of OHS and isolated right ventricular dysfunction with right ventricular failure.

Case Report

A 53-year-old man, who was morbidly obese with a BMI of 75 kg/m^2, presented with shortness of breath (SOB) and hypercapnia. He had never smoked but had a history of hypertension and severe obstructive sleep apnea with an apnea-hypopnea index (AHI) >30 per hour. There was no known family history of cardiac disease, and the patient did not have a history of syncope.

On examination, his blood pressure was 132/83 mmHg, and he had a regular pulse of 98 bpm, a respiratory rate of 20 breaths/minute, a temperature of 98.7°F, with oxygen saturation (SaO$_2$) of 88% on room air. His heart sounds were normal

Table 1. Pulmonary function tests.

	Measured value	Predicted value
FEV1	1.83 liters	61%
FVC	2.19 liters	58%
FEV1/FVC	83	
TLC	5.84 liters	101%
DLCO	25 ml/min/mmHg	89%

FEV$_1$ – forced expiratory volume in one second; FVC – forced vital capacity; TLC – total lung capacity; DLCO – diffusing capacity of the lungs for carbon monoxide.
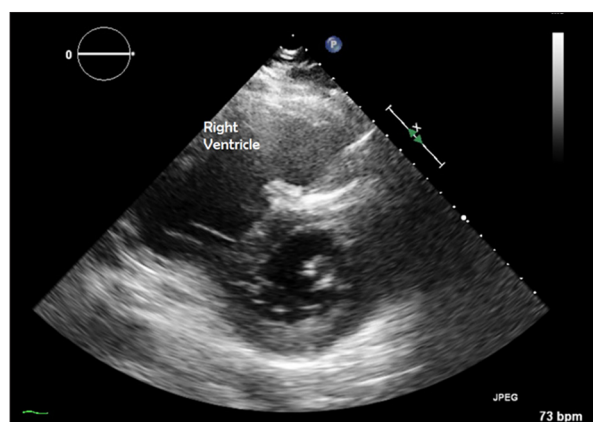

Figure 1. Two-dimensional transthoracic echocardiogram (TTE) parasternal short-axis view of the heart. A large right ventricle is shown with a 'D sign,' or flattened interventricular septum (diameter 1.3 cm) due to right ventricular pressure overload. A low normal left ventricular ejection fraction of 50% was present.

without murmurs. Lung auscultation showed reduced but clear breath sounds, and mild lower limb edema was present.

Blood gases showed a pH of 7.31, PaO$_2$ of 57 mmHg, a PaCO$_2$ of 61 mmHg, and a SaO$_2$ of 86% on room air. Serum bicarbonate was 30 mmol/L, brain natriuretic peptide (BNP) 160 pg/ml, troponin 0.030 ng/ml, and thyroid function tests were normal. An electrocardiogram (ECG) showed normal sinus rhythm with a rate of 95 beats/min, a normal electrical axis with good R wave progression in the precordial leads. No epsilon waves were seen in the precordial leads.

Pulmonary function tests showed no obstruction or restriction with a normal diffusing capacity of the lungs for carbon monoxide (DLCO) and normal total lung capacity (TLC), as shown in Table 1. The patient had a reduced forced expiratory volume in one second (FEV$_1$) and forced vital capacity (FVC) with a normal FEV$_1$/FVC ratio, which are commonly seen with obesity hypoventilation syndrome (OHS) (Table 1) [4,5].
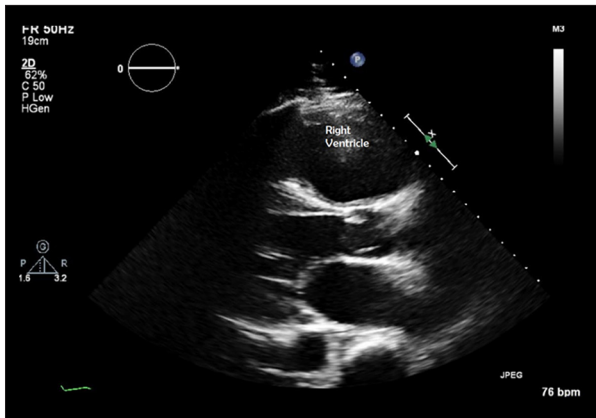
Figure 2. Two-dimensional transthoracic echocardiogram (TTE) parasternal long-axis view of the heart. An enlarged and dilated right ventricle is shown secondary to right ventricular pressure overload. The left atrium is slightly enlarged.

Table 2. Echocardiography findings.

	Measurement	Normal range for men
Aortic root	3.1 cm	2.1–3.5 cm
Left atrium (LA)	4.1 cm	3.0–4.0 cm
LVID in diastole	5.6 cm	4.2–5.9 cm
LVID in systole	4.4 cm	2.1–4.0 cm
IVS in diastole	1.3 cm	0.6–1.0 cm
LVPW in diastole	1.5 cm	0.6–1.0 cm
Right ventricular measurements		
RVD in diastole	7.8 cm	–
TR max velocity	303 cm/sec	–
TR max pressure gradient	37 mmHg	–

LVID – left ventricle inner dimension; LVPW – left ventricle posterior wall; IVS – interventricular septum; RVD – right ventricle dimension; TR – tricuspid regurgitation. No pericardial effusion or valvular abnormalities. No pulmonic stenosis. The findings were in keeping with left ventricular hypertrophy with a normal left ventricular ejection fraction (LVEF), severe right ventricle (RV) dilation and dysfunction, left and right atrial enlargement, and moderate pulmonary hypertension.

Chest computed tomography (CT) showed normal lung parenchyma without pulmonary embolism. Two-dimensional transthoracic echocardiogram (TTE) showed normal left ventricular function and a dilated right ventricle (RV) with a flattened septal wall (1.3 cm in diameter), moderate tricuspid regurgitation, an estimated right ventricular systolic pressure of 55–60 mmHg, right and left atrial dilatation, mild concentric left ventricular hypertrophy, and a left ventricular ejection fraction of 50% (Figure 1). The right ventricle was severely dilated and dysfunctional (Figure 2). There was moderate tricuspid regurgitation (max. velocity 303 cm/sec) with an estimated right ventricular systolic pressure (RVSP) of 55–60 mmHg (Table 2). Pulse-wave tissue Doppler imaging (TDI) of the anterior and posterior mitral annulus showed abnormal left ventricle relaxation. The patient was discharged on continuous positive airway pressure (CPAP) and oxygen at night, and as needed during the day.

Discussion

The gold standard diagnostic procedure for the identification of pulmonary hypertension is right heart catheterization, with pulmonary hypertension defined as a mean pulmonary artery pressure (PAP) ≥20 mmHg [6]. Four studies have used right heart catheterization to demonstrate the presence of pulmonary hypertension in patients with obesity hypoventilation syndrome (OHS) [7–10]. Sugerman et al. identified pulmonary hypertension in 23/26 patients with OHS [7]. However, only nine patients (34.6%) had pulmonary hypertension without left heart dysfunction. Kessler et al. studied 34 patients with OHS, 29 had right heart catheterization, 17 patients (59%) had pulmonary hypertension, but only 19/181 (10.5%) with obstructive sleep apnea (OSA) alone had pulmonary hypertension [8]. There was no difference in cardiac output determined by thermodilution between patients with OHS and those with isolated OSA [8]. Kauppert et al. performed right heart catheterization in 21 patients with OHS and found pulmonary hypertension in 17/21 (81%) patients [9]. However, three patients had postcapillary pulmonary hypertension, and 14/21 (66.7%) had pulmonary hypertension not related to left heart failure [9]. Held et al. identified 12 patients with OHS, but three patients also had chronic obstructive pulmonary disease (COPD) that complicated the clinical presentation [10]. Therefore, nine patients with OHS had pulmonary hypertension (defined as a mean PAP ≥25 mmHg) by right heart catheterization [10]. All patients had normal left ventricular function, although the average data from 17 patients who underwent right heart catheterization were presented, and patients with OHS and pulmonary hypertension were not analyzed in isolation [10]. These four previously published clinical studies support that pulmonary hypertension secondary to OHS occurs in some patients without left heart failure, COPD, interstitial lung disease, or other causes [7–10].

Although right heart catheterization is the best way to determine the presence of pulmonary hypertension, transthoracic echocardiography (TTE) provides an estimate of the presence or absence of pulmonary hypertension [6,11]. A large study

by Almeneessier et al. investigated 77 patients with OHS who were screened for the presence of pulmonary hypertension with TTE [3]. In this previous study, pulmonary hypertension was defined as a pulmonary artery systolic pressure (PASP) >40 mmHg [3]. Fifty-three (68.8%) out of 77 patients had pulmonary hypertension, and none had prior treatment with noninvasive ventilation [3]. In this previously published study, the body mass index (BMI) was 43.2±10.4 kg/m² and the average age was 60.5±11.7 years [3]. The study showed that pulmonary hypertension is common in patients with OHS who have not been treated with noninvasive ventilation when initially screened by TTE [3]. These previous studies using TTE in screening for pulmonary hypertension in OHS are consistent with the right heart catheterization data and show that pulmonary hypertension can occur in the absence of left ventricular failure.

The use of the apical four-chamber view in TTE to diagnose pulmonary hypertension measures tricuspid regurgitant jet velocity (TRV) and reflects the difference in pressure between the right atrium (RA) and the right ventricle (RV) [6]. Assuming that there is no pulmonary stenosis, the right ventricular systolic pressure (RVSP) is assumed to be equivalent to the pulmonary artery systolic pressure (PASP) and can be calculated from the Bernoulli equation using an estimated right atrial pressure determined from an inferior vena cava echocardiogram (Table 3) [6]. The Bernoulli equation is as follows:
RVSP=4(TRV)²+estimated RA pressure
RVSP=PASP in the absence of pulmonary stenosis

A PASP >40 mmHg is consistent with a mean PAP >25 mmHg. A mean PAP of ≥25 mmHg is currently defined as pulmonary hypertension [6]. However, a PASP >40 mmHg is a conservative value, and an even lower PASP may be consistent with pulmonary hypertension but may risk overdiagnosis (false positives) and is used less often. However, right heart catheterization measures the mean PAP directly and is the gold standard for diagnosing pulmonary hypertension.

The case in the present report had pulmonary hypertension with normal left ventricular function, and a brain natriuretic peptide (BNP) of 160 pg/ml. The patient had never smoked. The spiral computed tomography (CT) angiogram showed no evidence of pulmonary embolic disease or interstitial lung disease, and pulmonary function tests showed no obstructive or restrictive lung disease. However, the patient did have moderate pulmonary hypertension on TTE, with right ventricular dysfunction and right ventricular dilation. Right ventricular dysfunction and ventricular failure manifested clinically as bilateral leg edema. We believe this to be a rare case of OHS with resultant pulmonary hypertension that resulted in right ventricular dysfunction and mild right ventricular failure.

An underlying mechanism for pulmonary hypertension secondary to OHS is chronic nocturnal and diurnal hypoxemia, hypercapnia, and acidosis that leads to chronic vascular constriction and vascular remodeling [12,13]. Also, patients with OHS have increased upper airway resistance and reduced respiratory compliance [4]. In some patients, these factors may result in a significant effort to breathe, resulting in hypercapnia and hypoxemia that also promote recurrent pulmonary arterial vasoconstriction, vascular remodeling, and pulmonary arterial hypertension [4]. Previous studies have shown that OSA results in right ventricular dysfunction [14–16]. The Framingham study evaluated sleep-disordered breathing in patients with a BMI of 32±5 kg/m² compared with those without sleep-disordered breathing [14]. The study found a small but significant increase in right ventricular wall thickness [14]. However, right atrial and right ventricular dimensions and right ventricular systolic function were no different than in the controls, and there was no clinical right ventricular failure [14].

Dorsunoglu et al. used a complex myocardial performance index (MPI) and compared subjects with mild or moderate OSA compared with normal controls [15]. All subjects, patients and normal controls, had normal left ventricular systolic function as determined by measurement of the ejection fraction [15]. Those patients with moderate OSA had an increased left and right MPI compared with the normal controls and compared with mild OSA [15]. No patients had clinical symptoms of ventricular failure or clinical heart failure [15]. The right ventricular diastolic diameter in all subjects was normal and varied from 9 mm to 30 mm [15]. This finding was in contrast to the finding in the patient in this report who had a markedly enlarged right ventricular diastolic diameter of 78 mm (Table 2). Romero-Correl et al. also used the same MPI index and compared normal patients with patients with mild OSA and moderate to severe OSA [16]. The patients with moderate to severe OSA when compared with controls had an increased right and left MPI index, consistent with right and left cardiac dysfunction, despite normal left ventricular systolic function measured by the ejection fraction [16]. The patients did not have clinical symptoms of heart failure [16]. An additional finding was an increased left atrial volume index consistent with diastolic dysfunction that was present in the OSA patients and not present in normal controls [16]. The patient in the present case report also had diastolic dysfunction, which was probably secondary to his systemic hypertension. These latter three studies showed that subclinical right ventricular dysfunction could occur without clinical heart failure in patients with OSA [14–16]. However, the patient in the present case report also had OHS and would be expected to have more severe and prolonged pulmonary hypertension, which would be more likely to result in right ventricular failure over time.

A previously published study evaluated the echocardiography findings in 47 patients with OHS without obstructive airways

disease on pulmonary function testing [17]. Left ventricular function were evaluated in at least 39 patients, with right ventricular function evaluated in 25 patients [17]. Left and right ventricular dysfunction was found in some patients [17]. However, it was unclear whether there were patients with right ventricular dysfunction who did not have left ventricular dysfunction [17]. Also, pulmonary embolic disease and interstitial lung disease could not be completely excluded by spiral CT angiography and non-contrast-enhanced CT, respectively [17]. Therefore, in this previous study, there was no clear cut evidence to support the presence of right ventricular dysfunction due to OHS and pulmonary hypertension [17].

Conclusions

This case report has shown that obesity hypoventilation syndrome (OHS) with pulmonary hypertension, without obstructive lung disease, can result in right ventricular dysfunction and right ventricular failure. This condition should be diagnosed and managed clinically, as the mortality for OHS is high. Effective treatment includes weight loss, treatment at night with continuous positive airway pressure (CPAP) or noninvasive bilevel positive airway pressure (BiPAP) ventilation, as needed, and diuretics if the patient progresses to right heart failure.

Acknowledgments

Conflict of interest

References:

1. Rosenthal RJ, Morton J, Brethauer S et al: Obesity in America. Surg Obes Relat Dis, 2017; 10: 1643–50

2. Nowbar S, Burkart KM, Gonzales R et al: Obesity-associated hypoventilation in hospitalized patients: Prevalence, effects, and outcome. Am J Med, 2004; 116: 1–7

3. Almeneessier A, Nashwan SZ, Al-Shamiri MQ et al: The prevalence of pulmonary hypertension with obesity hypoventilation syndrome: A prospective observational study. J Thorac Dis, 2017; 9: 779–88

4. Mokhlesi B, Tulaimat A: Recent advances in obesity hypoventilation syndrome. Chest, 2007; 132: 1322–36

5. Marik PE, Desai H: Characteristics of patients with the "Malignant Obesity Hypoventilation Syndrome" admitted to an ICU. J Intensive Care Med, 2013; 28: 124–30

6. Howard LS, Grapsa J, Dawson D et al: Echocardiographic assessment of pulmonary hypertension: standard operating procedure. Eur Respir Rev, 2012; 21: 239–48

7. Sugerman HJ, Baron PL, Fairman RP et al: Hemodynamic dysfunction in obesity hypoventilation syndrome and the effects of treatment with surgically induced weight loss. Ann Surg, 1988; 207: 604–13

8. Kessler R, Chaouat A, Schinkewitch P et al: The obesity-hypoventilation syndrome revisited: a prospective study of 34 consecutive cases. Chest, 2001; 120: 369–76

9. Kauppert CA, Dvorak I, Kollert F et al: Pulmonary hypertension in obesity-hypoventilation syndrome. Respir Med, 2013; 107: 2061–70

10. Held M, Walthelm J, Baron S et al: Functional impact of pulmonary hypertension due to hypoventilation and changes under noninvasive ventilation. Eur Respir J, 2014; 43: 156–65

11. Fisher MR, Forfia PR, Chamera E et al: Accuracy of Doppler echocardiography in the hemodynamic assessment of pulmonary hypertension. Am J Respir Crit Care Med, 2009; 179: 615–21

12. Galie N, Humbert M, Vachiery JL et al: 2015 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension: The Joint Task Force for the Diagnosis and Treatment of Pulmonary Hypertension of the European Society of Cardiology (ESC) and the European Respiratory Society (ERS): Endorsed by: Association for European Paediatric and Congenital Cardiology (AEPC), International Society for Heart and Lung Transplantation (ISHLT). Eur Heart J, 2016; 37(1): 67–119

13. Fridman SE, Andrus BW: Obesity and pulmonary hypertension: A review of pathophysiologic mechanisms. J Obes, 2012; 2012: 505274

14. Guidry UC, Mendes LA, Evans JC et al: Echocardiographic features of the right heart in sleep-disordered breathing: The Framingham Heart Study. Am J Respir Crit Care Med, 2001; 164: 933–38

15. Dursunoglu N, Dursunoglu D, Kilic M: Impact of obstructive sleep apnea on right ventricular global function: Sleep apnea and myocardial performance index. Respiration, 2005; 72: 278–84

16. Romero-Corral A, Somers VK, Pellikka PA: Decreased right and left ventricular performance in obstructive sleep apnea. Chest, 2007; 132: 1863–70

17. Alawami M, Mustafa A, Whyte K et al: Echocardiographic and electrocardiographic findings in patients with obesity hypoventilation syndrome. Intern Med J, 2015; 45: 68–73