ARCHIVES OF THE TURKISH SOCIETY OF CARDIOLOGY

Official journal of the TURKISH SOCIETY OF CARDIOLOGY

Percutaneous Treatment of Left Main Coronary Artery Compression in a Pulmonary Artery Hypertension Patient Associated with Atrial Septal Defect

Atriyal Septal Defektle İlişkili Pulmoner Arteriyal Hipertansiyon Hastasında Sol Ana Koroner Arter Basısının Perkutan Tedavisi

CASE REPORT
OLGU SUNUMU

ABSTRACT

Pulmonary arterial hypertension is still a fatal disease persisting with poor prognosis, despite all the advances in treatment (new agents and new combination strategies) in recent years. Patients present with different symptoms which are not specific to the disease (dyspnea, angina, palpitation, and syncope). Angina may occur secondary to myocardial ischemia due to increased right ventricular afterload (oxygen supply and demand mismatch) or external compression on the left main coronary artery. Left main coronary artery compression is associated with post-exercise sudden cardiac death in pulmonary arterial hypertension patients. It should be kept in mind in the differential diagnosis of angina in patients with pulmonary arterial hypertension and should be treated immediately. Here, we report a pulmonary arterial hypertension patient associated with secundum-type atrial septal defect presented with *ostial* left main coronary artery compression caused by an enlarged pulmonary artery and treated with intravascular ultrasound-guided percutaneous coronary intervention.

Keywords: Atrial septal defect, pulmonary arterial hypertension, LMCA compression, intravascular ultrasound, adult congenital heart disease, percutaneous coronary intervention.

ÖZET

Son yıllarda tedavideki tüm gelişmelere (yeni ajanlar ve yeni kombinasyon stratejileri) rağmen, pulmoner arteriyel hipertansiyon kötü seyirli ölümcül bir hastalık olmaya devam etmektedir. Hastalar, hastalığa özgü olmayan çeşitli semptomlarla (nefes darlığı, anjina, çarpıntı ve senkop) sağlık kuruluşlarına başvurmaktadırlar. Anjina, artmış sağ ventrikül art yüküne ikincil miyokardiyal iskemi (oksijen arz ve talep uyumsuzluğu) veya sol ana koroner artere dışarıdan bası nedeniyle oluşabilir. Sol ana koroner arter basısı, pulmoner arteriyel hipertansiyon hastalarında, egzersiz sonrası ani kardiyak ölümle ilişkilidir. Pulmoner arteriyel hipertansiyon hastalarında anjina ayırıcı tanısında akılda tutulmalı ve acilen tedavi edilmelidir. Burada, genişlemiş bir pulmoner arterin neden olduğu ostial sol ana koroner artere bası ile başvuran ve intravasküler ultrason eşliğinde perkütan koroner girişim ile tedavi edilen sekundum tipi atriyal septal defekt ile ilişkili pulmoner arteriyel hipertansiyon hastasını sunuyoruz.

Anahtar Kelimeler: Atriyal septal defekt, pulmoner arteriyal hipertansiyon, LMCA basısı, intravasküler ultrason, erişkin doğumsal kalp hastalığı, perkutan koroner girişim

Pulmonary arterial hypertension (PAH) is still a devastating disease having serious morbidity and mortality in spite of all advances in treatment.[1] Disease may manifest with a broad spectrum of symptoms (dyspnea, exercise intolerance, fatigue, palpitation, and chest pain) all nonspecific to the disease.[1]

Although chest pain is mostly caused by the oxygen supply–demand mismatch due to right ventricular (RV) hypertrophy induced by increased afterload, external compression of the left main coronary artery (LMCA) by enlarged pulmonary artery (PA) can also induce angina.[2] Because LMCA compression can be fatal, it should be always

Muhammed Furkan Deniz
Ümit Yaşar Sinan
Ahmet Yıldız
Emir Barış Özgür Ökçün
Mehmet Serdar Küçükoğlu

Istanbul University-Cerrahpasa Institute of Cardiology, Department of Cardiology, Istanbul, Türkiye

Corresponding author:
Ümit Yaşar Sinan
✉ drumityasar@hotmail.com

Received: October 5, 2022
Accepted: November 20, 2023

Cite this article as: Deniz MF, Sinan ÜY, Yıldız A, Ökçün EBÖ, Küçükoğlu MS. Percutaneous treatment of left main coronary artery compression in a pulmonary artery hypertension patient associated with atrial septal defect. *Turk Kardiyol Dern Ars.* 2023;51(3):221-225.

DOI:10.5543/tkda.2022.26096

considered in the differential diagnosis in PAH patients admitted with angina.

Here, we discuss a PAH patient who presented with angina due to LMCA compression and was treated with intravascular ultrasound (IVUS)-guided percutaneous coronary intervention (PCI).

Case Report

A 70-year-old female patient with hypertension was admitted with complaints of fatigue, dyspnea, and long-lasting angina. On physical examination, pulmonic component of second heart sound (P2) was loud. There was a 3/6 holosystolic murmur at the right parasternal area and coarse crackles in both lungs. The patient had hypoxia (SaO_2: 90%) in room air. Electrocardiogram showed sinus rhythm with right bundle branch block, right axis, and p pulmonale. The patient was on valsartan, metoprolol, and furosemide for several years because of systemic hypertension. In laboratory examination, there was nothing remarkable except increased natriuretic peptide levels (NT-ProBNP: 1332 pg/mL).

Transthoracic echocardiography (TTE) revealed normal left ventricular (LV) systolic function, enlarged right heart chambers and PA (RV: 35 mm, right atrium (RA): 46 mm, and PA diameter: 45 mm), severe tricuspid regurgitation (peak systolic tricuspid regurgitation jet: 4.2 m/s), and borderline impaired RV function (tricuspid annular plane systolic excursion: 17 mm, tricuspid Sa: 11.5 cm/s). In color flow Doppler, there was suspicion of left to right shunt, and the pulmonary flow to systemic flow ratio (Qp/Qs) was calculated as 1.2. The estimated systolic pulmonary artery pressure (sPAP: 90 mmHg) was increased. Transesophageal echocardiography (TEE) confirmed a 27 × 22 mm secundum-type atrial septal defect (ASD) causing left to right shunt (Figure 1 and Video 1). Because the patient had angina and high probability of PH in TTE, we decided to perform coronary angiography (CAG) together with right heart catheterization.

The hemodynamic evaluation showed that the mean PAP was 55 mmHg, pulmonary vascular resistance (PVR) was 5.2 Wood

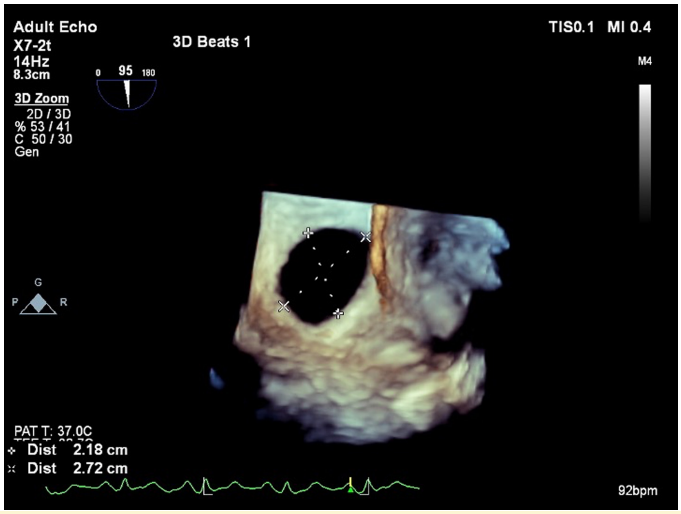

Figure 1. 3D TEE image is showing a 27 × 22 mm secundum-type ASD. ASD, atrial septal defect; TEE, transesophageal echocardiography.

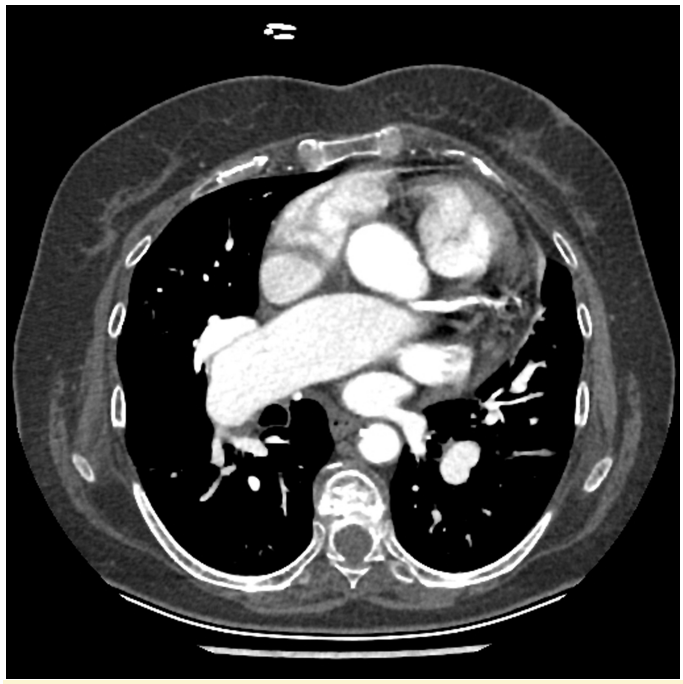

Figure 2. Enlarged PA and < 60° LMCA take-off angle on CT images. CT, computed tomography; LMCA, left main coronary artery; PA, pulmonary artery.

Unit, right atrial pressure was 10 mmHg, left atrial pressure was 10 mmHg, cardiac output (Qs) was 7.5 Lt/min, pulmonary output (Qp) was 8.3 Lt/min, Qp/Qs was 1.1, cardiac index (CI) was 4.4 Lt/min/m^2. We realized a 90% stenosis of LMCA ostium in left cranial image which was not prominent in caudal images and in CAG (Video 2). There was nothing remarkable in other coronary territories.

Contrast-enhanced thorax computed tomography (CT) was planned for further evaluation of LMCA *ostial* stenosis which was thought to be due to external compression of the enlarged PA on LMCA. Thorax CT showed enlarged PA (46 mm) causing external compression on the LMCA ostium. Also, the take-off angle was recorded as 60° on CT images (Figure 2).

Because the patient had angina related to severe *ostial* LMCA stenosis, PCI was planned. During the procedure, the LMCA ostium was evaluated with IVUS which proved the nature of stenosis was not associated with atherosclerosis. Intravascular ultrasound clearly confirmed external severe compression of LMCA ostium which changed dynamically during systole and diastole (Video 3). Therefore, a 4 × 8 mm Resolute ONYX (Medtronic, Calif, USA) stent was implanted on the LMCA ostium. Post-dilatation was performed with a 4.5 mm balloon. After the post-dilatation procedure, IVUS images showed that the stent struts were apositioned and full patency was achieved (Video 3). Also on CAG, cranial images showed that the external compression had disappeared after stenting (Video 4).

The patient also had precapillary PH according to hemodynamic evaluation and was classified as PAH associated with congenital heart disease (ASD) according to the sixth World Symposium on PH.[3] The 6-minute walking distance was

178 m, World Health Organization (WHO) functional capacity was III. The patient was predominantly in the intermediate risk category according to the 2015 ESC/ERS PAH risk assessment table.[1] Initial combination therapy with macitentan and sildenafil was initiated. In addition to the combination therapy, the patient was discharged with valsartan 80 mg, metoprolol 50 mg, acetylsalicylic acid 81 mg, clopidogrel 75 mg, furosemide 40 mg, and spironolactone 25 mg. Informed consent was obtained from the patient.

Discussion

Pulmonary arterial hypertension is a disease characterized by plexiform lesions due to vascular remodeling induced by various stimuli in the pulmonary vascular bed.[1,4] The reported incidence is approximately 1% in adults, and over the age of 65, this rate rises to 10%.[5] Increased PVR due to pulmonary vasculopathy triggers RV dysfunction which is the leading cause of mortality in PAH patients, by increasing afterload.[4,6] Pulmonary arterial hypertension patients with RV dysfunction has a poor prognosis.[4,6]

In clinical practice, PAH patients may admit with a broad spectrum of symptoms (dyspnea, exercise intolerance, fatigue, and chest pain).[1,7] Chest pain was reported with a frequency of 7%-29% in various registries.[2,8] The main mechanism of chest pain is the oxygen supply–demand imbalance of the myocardium due to increased afterload causing RV hypertrophy.[1,4] However, external compression of LMCA by enlarged PA can also cause angina in these patients.[1,2] Increased PA diameter (>40 mm) and PA/aortic diameter (>1.5) is the strongest predictor of LMCA compression. Galie et al[2] reported approximately 6% LMCA compression in PH patients and this study revealed that the main PA diameter was larger than 40 mm and was the strongest predictor of LMCA compression. Therefore, patients presented with angina and PA diameter larger than 40 mm LMCA compression should be further examined with CT or CAG for LMCA compression. Computed tomography can give detailed information about the relationship between PA and aorta. Pulmonary artery hypertension patients with angina were classified according to the pulmonary artery-LMCA distance, take-off angle, and angulation by Galie et al.[2] Left main coronary artery compression was confirmed by CAG in patients with a short pulmonary artery-LMCA distance, a take-off angle of <60˚, and a stenosis of >50% in CT.[2] Kaymaz et al[9] showed relation between younger age, D-shaped septum, higher PA systolic, diastolic, and mean pressures and pulmonary vascular resistance, larger PA diameter, smaller aortic diameter and pulmonary arterial hypertension associated with patent-ductus arteriosus, atrial or ventricular septal defects and LMCA extrinsic compression in a study comprised 269 out of 498 patients with

Table 1. Imaging and hemodynamic data of PAH patients with LMCA compression reported in the literature

First author, year, Patients (*n*)	LMCA compression range (%)	PA size (mm) (mean, SD)	mPAP (mmHg) (mean, SD)	PA/Aorta ratio (mean, SD)	PVR (Wood units) (mean, SD)
Mesquita [9] 2004, LMCo: *n* = 7	Between 50-90%	55 (13)	50 (11)	2 (0.6)	Not reported
Akbal [10] 2018, LMCo: *n* = 22	≥ 50%	46 (8)	73 (19)	1.6 (0.3)	13 (10)
Galie [7] 2017 LMCo: *n* = 48	All ≥ 50%	54 (17)	64 (21)	1.9 (0.6)	13 (9)
Lee [4] 2017, LMCo: *n* = 20	≥ 50%	56 (12)	70 (19)	2.0 (0.7)	9 (3)
Nuche Beren- guer [23] 2019, LMCo: *n* = 20	Not reported	53 (11)	63 (27)	Not reported	Not reported
Case reports cohort LMCo: *n* = 89	Mean 76% (18)[a]	56 (19)	56 (16)[b]	1.8 (0.5)[c]	12 (6)[d]

LMCA, left main coronary artery; LMCo, left main coronary artery compression; PA, pulmonary artery; PVR, pulmonary vascular resistance; mPAP, mean pulmonary artery pressure; SD, standard deviation.
[a]Reported in 57 patients; [b]Reported/calculated in 75 patients; [c]Reported in 32 patients; [d]Reported in 25 patients.

confirmed PH who underwent CAG because of various clinical scenario (PA aneurysm on TTE, angina or incidental LMCA compression on CT). The LMCA compression ratio was 8.2% (22 of 269 patients).[9] In a recent systemic review and meta-analysis, PA diameter, PA/aorta ratio, and Congenital Heart Disease (CHD) were found to be associated with LMCA compression.[10] Table 1 summarizes the imaging and hemodynamic data of PAH patients with LMCA compression reported in the literature.[10]

Because LMCA compression is a dynamic process, it becomes apparent in systole and may regress or disappear completely due to aortic pressure exceeding PA pressure in diastole. Contrarily, compression might be more prominent during exercise due to increased PAP. Ischemia triggered by LMCA compression can lead to complications such as myocardial ischemia, heart failure, arrhythmia, and sudden cardiac death (SCD). Sudden death can be observed in approximately 26% of these patients and might be the initial clinical scenario. So, LMCA compression secondary to PA enlargement is described as an emergency that should be treated quickly.[11,12] There is no consensus on how LMCA compression in PAH patients should be treated. Preferred treatment is coronary stenting, associated with low mid-term mortality.[10] Percutaneous coronary intervention was performed for the first time in a patient with PAH and extrinsic LMCA compression in 2001, and it was reported that the patient's symptoms were relieved after the procedure.[13] Coronary artery bypass grafting (CABG), one of the treatment options applied in LMCA stenosis derived by atherosclerotic lesions, is still controversial in PAH patients. In patients who will undergo cardiac surgery for another reason, it is reasonable to perform CABG in the same session. But it is not applicable in isolated LMCA stenosis in PAH patients. In addition, surgery is not the first option in patients with PAH since perioperative anesthesia has a high risk. In different studies, postoperative mortality rates in non-cardiac surgical interventions varied between 1% and 18%.[14] So PCI is applicable in these patients if there is no indication for surgery. The durability of stents implanted to treat LMCA compression is scarce. Different studies on PCI have been published since 2001 and showed that implanting a bare metal stent or drug-eluting stent (DES) has a similar impact on the outcome. Galie et al[2] reported positive long-term follow-up results of PCI in 45 PH patients with LMCA stenosis due to extrinsic compression. Drug-eluting stent was implanted in the majority of patients and no major complications were observed during the postprocedure period. There was no cardiovascular death, MI, cerebrovascular event (CVE), and stent thrombosis during the 22-month follow-up.[2]

Our patient was treated with a DES after LMCA compression was clearly shown on CAG. Smaller than 60˚ take-off angle and severe *ostial* stenosis on CT were also supportive for PCI. Stent was implanted by IVUS-guided PCI. Compression was clearly demonstrated on pre-procedural IVUS images and it changed dynamically during diastole and systole. While IVUS proved LMCA stenosis was not of an atherosclerotic nature, stent apposition and release of compression were also confirmed. Intravascular imaging is an effective way to reveal the dynamic nature of compression and exclude atherosclerosis in those cases. Also, it allows to show relief of compression after the PCI procedure and to measure maximal stent expansion. We preferred Resolute ONYX DES (Medtronic, Calif, USA) to treat LMCA stenosis because this third-generation DES has high flexibility, increased radial force, and a low risk of restenosis.[15]

Conclusion

In conclusion, extrinsic LMCA compression should always be considered in PAH patients with angina. Percutaneous coronary intervention eliminates the symptom of angina, reduces the risk of SCD, and affects survival positively. Using IVUS during the procedure gives information on the underlying pathophysiological mechanism of LMCA compression and makes the PCI safe. During PCI, third-generation DES with high flexibility and radial strength should be preferred.

Conflict of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

Acknowledgment: None.

Funding Statement: None.

Video 1: Color Doppler imaging showing left to right shunting.

Video 2: Left cranial image on coronary angiography showing 90% stenosis of LMCA ostium. LMCA, left main coronary artery.

Video 3: IVUS images showing well-positioned stent struts and full patency on coronary blood flow. IVUS, intravascular ultrasound.

Video 4: Images showing that LMCA compression has disappeared on CAG. LMCA, Left main coronary artery; CAG, coronary angiography.

References

1. Galiè N, Humbert M, Vachiery JL, et al. ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension. *Eur Respir J*. 2015;46(4):903-975. [CrossRef]
2. Galiè N, Saia F, Palazzini M, et al. Left main coronary artery compression in patients with pulmonary arterial hypertension and angina. *J Am Coll Cardiol*. 2017;69(23):2808-2817. [CrossRef]
3. Simonneau G, Montani D, Celermajer DS, et al. Haemodynamic definitions and updated clinical classification of pulmonary hypertension. *Eur Respir J*. 2019;53(1):1801913. [CrossRef]
4. Humbert M, Guignabert C, Bonnet S, et al. Pathology and pathobiology of pulmonary hypertension: state of the art and research perspectives. *Eur Respir J*. 2019;53(1):1801887. [CrossRef]
5. Hoeper MM, Humbert M, Souza R, et al. A global view of pulmonary hypertension. *Lancet Respir Med*. 2016;4(4):306-322. [CrossRef]
6. Mandras SA, Mehta HS, Vaidya A. Pulmonary hypertension: A brief guide for clinicians. *Mayo Clin Proc*. 2020;95(9):1978-1988. [CrossRef]
7. Galiè N, McLaughlin VV, Rubin LJ, Simonneau G. An overview of the 6th World Symposium on Pulmonary hypertension. *Eur Respir J*. 2019;53(1):1802148. [CrossRef]
8. Brown LM, Chen H, Halpern S, et al. Delay in recognition of pulmonary arterial hypertension: factors identified from the REVEAL Registry. *Chest*. 2011;140(1):19-26. [CrossRef]
9. Akbal OY, Kaymaz C, Tanboga IH, et al. Extrinsic compression of left main coronary artery by aneurysmal pulmonary artery in severe pulmonary hypertension: its correlates, clinical impact, and management strategies. *Eur Heart J Cardiovasc Imaging*. 2018;19(11):1302-1308. [CrossRef]
10. Badea R, Dorobantu DM, Sharabiani MTA, Predescu LM, Coman IM, Ginghina C. Left main coronary artery compression by dilated pulmonary artery in pulmonary arterial hypertension: a systematic review and meta-analysis. *Clin Res Cardiol*. 2022;111(7):816-826. [CrossRef]
11. Demerouti EA, Manginas AN, Athanassopoulos GD, Karatasakis GT. Complications leading to sudden cardiac death in pulmonary arterial hypertension. *Respir Care*. 2013;58(7):1246-1254. [CrossRef]

12. Delcroix M, Naeije R. Optimizing the management of pulmonary arterial hypertension patients: emergency treatments. *Eur Respir Rev*. 2010;19(117):204-211. [CrossRef]
13. Rich S, McLaughlin VV, O'neill W. Stenting to reverse left ventricular ischemia due to left main coronary artery compression in primary pulmonary hypertension. *Chest*. 2001;120(4):1412-1415. [CrossRef]
14. Pilkington SA, Taboada D, Martinez G. Pulmonary hypertension and its management in patients undergoing non-cardiac surgery. *Anaesthesia*. 2015;70(1):56-70. [CrossRef]
15. Saia F, Dall'Ara G, Marzocchi A, et al. Left main coronary artery extrinsic compression in patients with pulmonary arterial hypertension: Technical Insights and Long-Term Clinical Outcomes After Stenting. *JACC Cardiovasc Interv*. 2019;12(3):319-321. [CrossRef]