Srce i krvni sudovi 2020; 39(4): 123-127

Review article

Balloon angioplasty for chronic thromboembolic pulmonary hypertension

Slobodan Obradovic[1,2], Boris Dzudovic[3], Zoran Jović[1,2], Nemanja Djenic[2,3], Jovan Matijasevic[4,5], Uros Batranovic[4], Srdjan Gavrilovic[4]

[1]Clinic of Cardiology, Military Medical Academy, Belgrade, [2]Medical Faculty, University of Defense, Belgrade, Serbia [3]Clinic of Emergency Internal Medicine, Military Medical Academy, Belgrade, [4]Clinic of Pulmonology, Institute of Pulmonary Diseases Sremska Kamenica, [5]School of Medicine Novi Sad, University of Novi Sad, Serbia

Abstract Chronic thromboembolic pulmonary hypertension is a rare but progressive and severe disease which lead to respiratory and heart failure. Patients with proximal thromboembolic disease should be treated with pulmonary endarterectomy and patients with distal disease can be treated with drugs and balloon angioplasty. Balloon pulmonary angioplasty is a safe procedure which often have to be repeated several times in one patient to result with significant functional, hemodynamic and right ventricular function improvement. We summarized indication, technique and the outcome of this procedure in chronic thromboembolic pulmonary hypertension patients.

Kew words chronic thromboembolic pulmonary hypertension, balloon angioplasty

Introduction

Chronic thromboembolic pulmonary disease (CTEPD) with or without pulmonary hypertension (CTEPH) is relatively rare but devastating disease. After the first attack of pulmonary embolism (PE) it will be diagnosed with prospective follow-up in about 1-4% of patients after more than 3-12 months (1,2). In the real world, CTEPD and CTEPH would be recognized usually a 6-24 months after PE. Patients with exertional dyspnea or fatigue on mild effort after PE are candidates for this late PE complications (4). Current European Society of Cardiology (ESC) guidelines for PE management from 2019 (4) for the first time suggest the active approach to the diagnosis of CTEPD(H) and recommend transthoracic echocardiography, BNP and 6-minute walking test (6MWT) for patients who had complaints of dyspnea or fatigue on effort 3 or more months after acute PE (figure 1). If a right ventricle dysfunction is discovered with or without elevated BNP or decrease 6MWT patient should undergo to perfusion lung scintigraphy and multi-slice detector computed tomography to established the diagnosis of CTEPD. After that, a patient should be admitted to the specialized center who will performed right heart catheterization and confirmed, or not, pulmonary hypertension. The cut-off value for a mean pulmonary artery pressure for the diagnosis of pulmonary hypertension is 20 mmHg.

A CTEPH is a chronic, progressive and usually diffuse disease. A five-year survival for a patient with mPAP above the 30 mmHg is only 30% without treatment (5). However, the treatment options were significantly improved in the recent years. Pulmonary endarterectomy is reserved for patients with proximal organized thrombotic masses in the main, lobar and proximal segmental pulmonary arteries. In the centers specialized to this sophisticated surgery perioperative mortality is nowadays less than 5% (6). Pulmonary endarterectomy is performed in deep hypothermia in bloodless surgical field (6). Approximately half of the operated patients have no pulmonary hypertension after surgery and may considered cured. However, a half of them still have significant PH and need further treatment with drugs and/or balloon angioplasty. Indications for pulmonary endarterectomy and pulmonary artery balloon angioplasty are presented in table 1.

Table 1. Indication for PEA and BAPA in patients with CTEPD(H)[3,7]

	PEA	BAPA
Functional status	NYHA II-IV	NYHA II-IV
Hemodynamics	mPAP>30 mmHg	mPAP>20 mmHg
Pulmonary vascular resistance	>3.75 Wood units	>3,75 Wood units
Localization of thrombi	Main PA, left and right PA, lobar PA and proximal segmental PA	Segmental and subsegmental PA
Comorbidities	If severe, surgery might be contraindicated	BAPA might be successful for lobar arteries but unlikely for main PAs
Patient's consent		PH after PEA
Other indications		

Correpsonding author: Slobodan Obradović, MD, PhD, Clinic of cardiology, Military Medical Academy, Belgrade, E-mail: sloba.d.obradovic@gmail.com

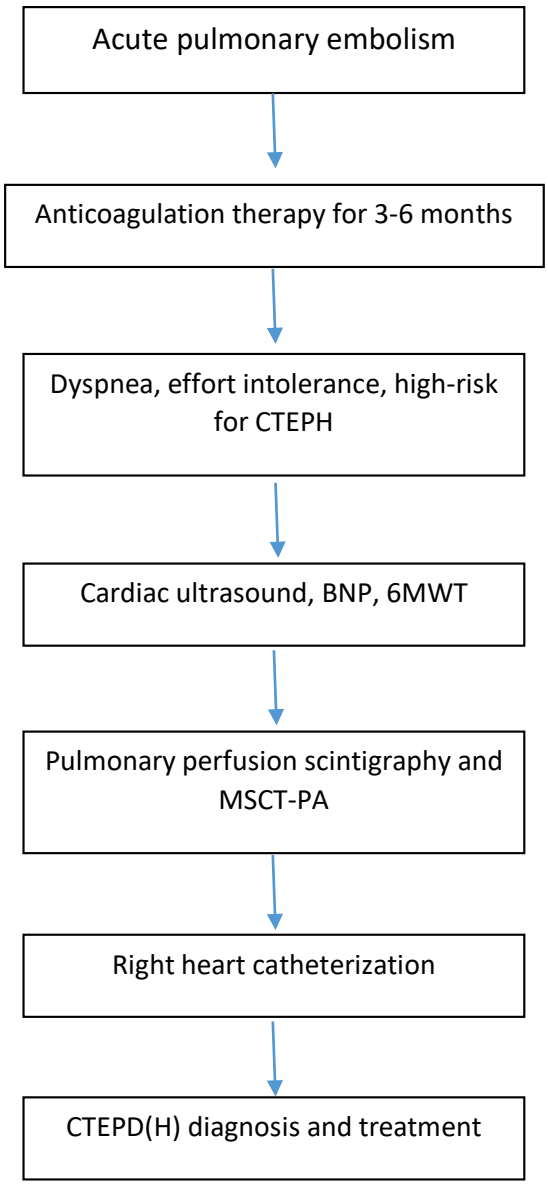

Figure 1. Proposed algorithm for the diagnosis of CTEPD(H) by ESC from 2019

Technical issues about balloon pulmonary angioplasty

Lesions in pulmonary arteries may be defined as classical stenosis, web like lesions, organized thrombus masses and total occlusions[7,8]. The first series of CTEPH patients treated with BPA was published in Circulation 2001 by Feinstain et al[9]. Balloon angioplasty on various lesions are very efficacious in the improvement of blood flow even in the case we are not angiographically sure that we decrease the degree of obstruction. Peripheral flow and venous flow are better tools for the estimation of BAPA success than the appearance of lesion after intervention. There are some important steps which have to be followed for the successful BAPA treatment. It is wise to treat lesions in one pulmonary lobus in one intervention. Patients with very high systolic right ventricle blood pressure or mean pulmonary artery pressure or with high BNP levels should not receive more than 200-250 ml of contrast per intervention and 2-3 segmental or subsegmental arteries should be treated, and not more. The reason for this that patients with signs of severe RV dysfunction and high PA blood pressure are prone to pulmonary edema and the early sings of that are dry cough during the intervention when the intervention should be interrupted. A 5000-8000 j of unfractionated heparin is given before the procedure. Long 65-80 cm 7F sheath should be used for the support and better manipulation of guiding catheter. The tip of sheath should be positioned in the lobar artery for the adequate support. It is important to keep straight, as possible, a sheath through the heart. Long guidewires serve for the introducing guiding catheter at the place for BAPA because exchange of them are very common need. Different guiding catheter can be used, but the most useful is right Judkins 6F catheter but all kind of catheters can be useful. Till now we did not use guidewires dedicated to chronic total coronary occlusions. Runthrough, BMW, Sion, Sion Blue, Filder XT are the most often used guidewires. Support with balloons were very common. On the smallest sings of extravascular contrast, a procedure should be interrupted. During the 42 procedures on 120 pulmonary arteries, in only one patient we had severe pulmonary edema with hemoptysis. The main predictive variable for periprocedural edema and intra-pulmonary bleeding is high pulmonary hypertension with systolic pulmonary pressure more than 80 mmHg. If we wanted to make balloon angioplasty on arteries with diameters more than 5-10 mm, we used two balloons and kissing technique because if we used balloons with diameters more than 5 mm it is possible that we cannot pull-back large balloon into a catheter. We also successfully performed kissing balloons on bifurcation lesions.

Pulmonary balloon angioplasty in patients with CTEPH can improve functional status, right ventricle performance, 6MWT, decrease mPAP, PVR and BNP. Very probably BPA can decrease mortality and hospitalization due to RV heart failure.[10-17]

Our experience on balloon pulmonary angioplasty

The first balloon pulmonary angioplasty in a patient with chronic pulmonary embolism was done in 2003 by Sinisa Rusovic and Slobodan Obradovic[18]. It was women with extensive recurrent PE after irradiation of portio vaginalis uteri carcinoma and iliac venous thrombosis. Balloon angioplasty was performed in several segmental pulmonary arteries with significant improvement of circulation and patient functional class. The second patient was male in the subacute PE after trichinellosis. Both cases were published in the monography PE through the case reports from 2011, by Sinisa Rusovic, Branko Gligic and Slobodan Obradovic. From the 2015-now we performed 40 pulmonary angioplasties on 18 patients. In each patient at least one pulmonary artery was dilated during one session. The program of BAPA in CTEPH patients was also developed in the Clinic of Pulmonary Diseases in Sremska Kamenica under the leadership of Jovan Matijasevic and 10 procedures were successfully

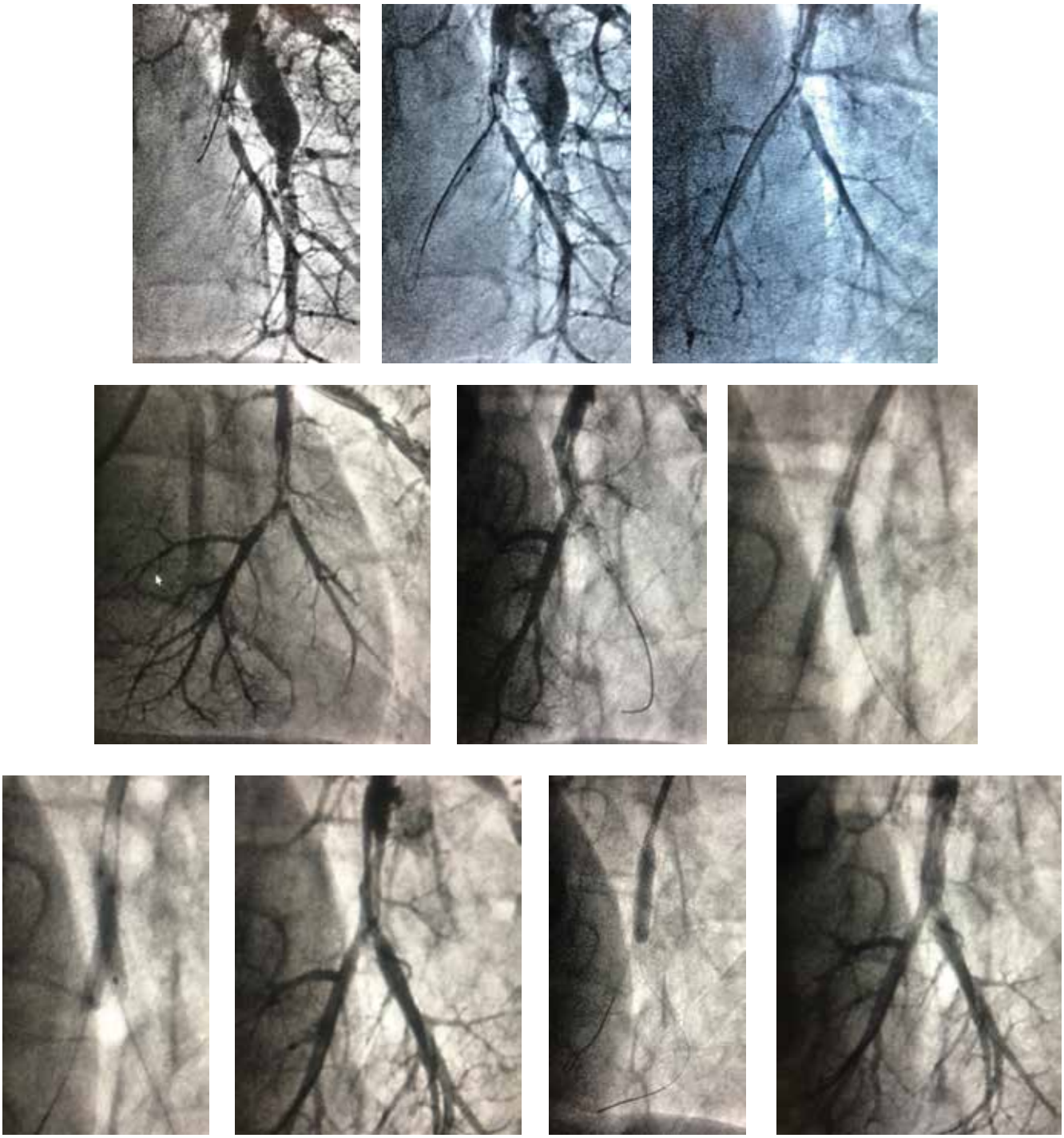

Figure 1A-J. Balloon angioplasty on chronic total occlusion on bifurcation lesion of segmental left-lower lobe pulmonary postero-basal sub-segmental artery

performed together with doctor Slobodan Obradovic.
The patient who is admitted for the first time for the procedure need to have perfusion lung scintigraphy, expert cardiac ultrasound with the good estimation of right ventricle function, BNP or NT-proBNP blood levels, 6-minute walking test and basic laboratory parameters. At each hospitalization 1-3 procedures were performed with 2-3 days between because of estimation on renal function after 48 hours from each procedure is needed. All kind of lesions is target, and good visualization on each pulmonary segments, especially those with impaired perfusion on scintigraphy is necessary to estimate the feasibility of procedure. Patients with high mean pulmonary pressure > 40 mmHg are prone to reperfusion injury and procedure need to be limited to 1-2 PA and use of no more than 200 ml of contrast. Exacerbation of dry cough during procedure is a sign that lung injury began to be manifested and it is time to stop the procedure. Small pulmonary hemorrhage is also signs when the procedure should be stopped. We had one refractory lung edema after procedure and two patients had less severe local reperfusion edema after the procedure.
On the pictures 1 and 2, we presented one reconstruction of bifurcation occlusion and one BAPA on sub-segmental branch occlusion in a young man with severe CTEPH.
In two patients BAPA interventions in our institution were bridge toward the pulmonary endarterectomy

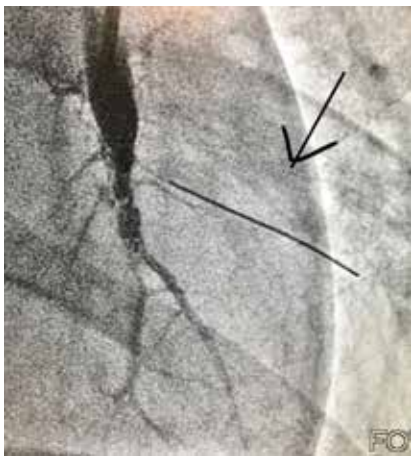
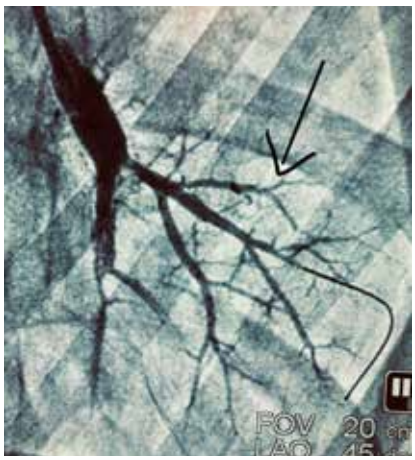

Figure 2A and B. Balloon angioplasty on chronic total occlusion on sub-segmental left-lower lobe apical segment

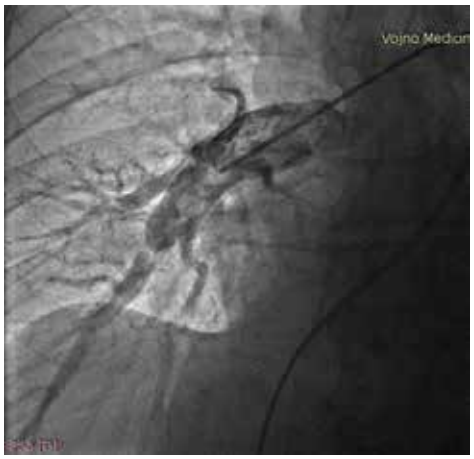
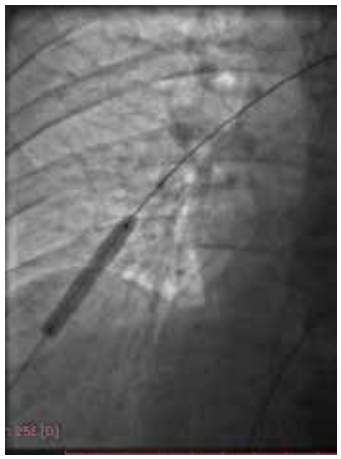
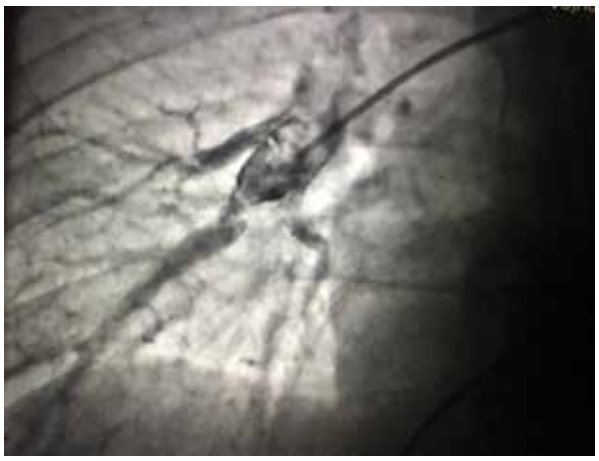


Figure 3A-D. Balloon angioplasty on right lower lobar pulmonary artery and endarterectomy material from the same patient after pulmonary endarterectomy in Kerckoff-Klinik

which was done in the Kerckoff-Klinik in Bad Nauheim, Germany. The BAPA in one of them and material after endarterectomy is presented on picture 3.

All patients with CTEPH need oral anticoagulant therapy and till now it is unknown whether novel oral anticoagulants are better than standard vitamin K antagonists in this indication. Riociguat is the only drug which have class one recommendation for the PH in patients with CTEPH, however, many patients are better on sildenafil or ERAs[19-22].

Conclusion

Balloon angioplasty on pulmonary arteries is one treatment option for patients with CTEPH and obstructive lesions on segmental and sub-segmental pulmonary arteries in combination with anticoagulants and drugs for pulmonary hypertension. We can expect significant improvement in pulmonary artery pressure, decrease of BNP, better results on 6-minute walking test and better functional performance after several successful procedures.

References

1. Pengo V, Lensing AW, Prins MH, et al. Incidence of chronic thromboembolic pulmonary hypertension after pulmonary embolism. N Engl J Med 2004;350:2257-64.
2. Becattini C, Agnelli G, Pesavento R, et al. Incidence of chronic thromboembolic pulmonary hypertension after a first episode of pulmonary embolism. Chest 2006;130:172-5.
3. Papamatheakis DG, Poch DS, Fernandes TM, et al. Chronic thromboembolic pulmonary hypertension. JACC 2020;76: 2155-69.
4. Konstatinides SV, Meyer G, Becattini C, et al. 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS). Eur Heart J 2020;41(4):543-603.
5. Riedel M, Stanek V, Widimsky J, Prerovsky I. Longterm follow-up of patients with pulmonary thromboembolism. Late prognosis and evolution of hemodynamic and respiratory data. Chest 1982; 81: 151-8.
6. Jenkins D, Madani M, Fadel E, et al. Pulmonary endarterectomy in the management of chronic thromboembolic pulmonary hypertension. Eur Respir Rev 2017;26:160111.
7. Jin Q, Zhao Z-H, Luo Q, et al. Balloon pulmonary angioplasty for chronic thromboembolic pulmonary hypertension: State of the art. World J Clin Cases 2020 July 6; 8(13): 2679-802.
8. Lang I, Meyer BC, Ogo T, et al. Balloon pulmonary angioplasty in chronic thromboembolic pulmonary hypertension. Eur Resp Rev 2017;26:160119.
9. Feinstein JA, Goldhaber SZ, Fernandes SM, et al. Balloon pulmonary angioplasty for treatment of chronic thromboembolic pulmonary hypertension. Circulation 2001;103:10–3.
10. Fukui S, Ogo T, Goto Y, et al. Exercise intolerance and ventilatory inefficiency improve early after balloon pulmonary angioplasty in patients with inoperable chronic thromboembolic pulmonary hypertension. Int J Cardiol 2015;180: 66–8.
11. Fukui S, Ogo T, Morita Y, et al. Right ventricular reverse remodelling after balloon pulmonary angioplasty. Eur Respir J 2014; 43:1394–402.
12. Inami T, Kataoka M, Yanagisawa R, et al. Longterm outcomes after percutaneous transluminal pulmonary angioplasty for chronic thromboembolic pulmonary hypertension. Circulation 2016; 134:2030–2.
13. Ogawa A, Satoh T, Fukuda T, et al. Balloon pulmonary angioplasty for chronic thromboembolic pulmonary hypertension: results of a multicenter registry. Circ Cardiovasc Qual Outcomes 2017;10:004029.
14. Mizoguchi H, Ogawa A, Munemasa M, et al. Refined balloon pulmonary angioplasty for inoperable patients with chronic thromboembolic pulmonary hypertension. Circ Cardiovasc Interv 2012;5:748–55.
15. Kataoka M, Inami T, Hayashida K, et al. Percutaneous transluminal pulmonary angioplasty for the treatment of chronic thromboembolic pulmonary hypertension. Circ Cardiovasc Interv 2012;5:756–62.
16. Sugimura K, Fukumoto Y, Satoh K, et al. Percutaneous transluminal pulmonary angioplasty markedly improves pulmonary hemodynamics and long-term prognosis in patients with chronic thromboembolic pulmonary hypertension. Circ J 2012;76:485–8.
17. Mahmud E, Behnamfar O, Ang L, Patel MP. Balloon pulmonary angioplasty for chronic thromboembolic pulmonary hypertension. Interv Cardiol Clin 2018;7:103–17.
18. Obradovic S, Rusovic S, Gligić B. Plućna tromboembolija kroz prikaze zlučajeva. Izdavač Gajić 2011, Beograd.
19. Ghofrani HA, D'Armini AM, Grimminger F, et al. Riociguat for the treatment of chronic thromboembolic pulmonary hypertension. N Engl J Med 2013; 369: 319–29.
20. Jais X, D'Armini AM, Jansa P, et al. Bosentan for treatment of inoperable chronic thromboembolic pulmonary hypertension: BENEFiT (Bosentan Effects in iNopErable Forms of chronIc Thromboembolic pulmonary hypertension), a randomized, placebo-controlled trial. J Am Coll Cardiol 2008; 52:2127–34.
21. Ghofrani HA, Simonneau G, D'Armini AM, et al. Macitentan for the treatment of inoperable chronic thromboembolic pulmonary hypertension (MERIT-1): results from the multicentre, phase 2, randomised, double-blind, placebo-controlled study. Lancet Respir Med 2017; 5: 785–94.

Sažetak

Balon angioplastika kod hronične tromboembolijske plućne hipertenzije

Slobodan Obradović[1,2], Boris Džudović[3], Zoran Jović[1,2], Nemanja Đenić[2,3], Jovan Matijaševič[4,5], Uroš Batranović[4], Srđan Gavrilović[4]

[1]Klinika za kardiologiju, Vojnomedicinska akademija, Beograd, [2]Medicinski fakultet, Univerzitet odbrane, Beograd, [3]Klinika za urgentnu internu medicine, Vojnomedicinska akademija, Beograd, [4]Klinika za pulmologiju, Institut za plućne bolesti Sremska Kamenica, [5]Medicinski fakultet Novi Sad, Univerzitet u Novom Sadu

Hronična tromboembolijska plućna hipertenzija je retko, ali progresivno i teško oboljenje koje vodi u respiratornu i srčanu insuficijenciju. Pacijenti sa proksimalnom tromboembolijskom bolešću pluća bi trebalo da se leče plućnom endarterektomijom, a pacijenti sa distalnom bolešću, lekovima i balon angioplastikom. Balon plućna angioplastika je bezbedna procedura koja se više puta mora ponavljati kod pacijenata i onda će rezultirati značajnim funkcionalnim, hemodinamskim poboljšanjem, kao i boljom funkcijom desne srčane komore. U radu su sumirane indikacija, tehnika i ishod ove procedure kod bolesnika sa hroničnom tromboembolijskom bolešću pluća.

Ključne reči: hronična tromboembolijska plućna hipertenzija, balon angiolastika