World Journal of Vascular Surgery

Short Communication
Published: 28 Nov, 2018

Percutaneous Transluminal Balloon Angioplasty in Management of the Stenosis and Occlusion of Segmental and Subsegmental Pulmonary Arteries in Patients with Chronic Thromboembolic Pulmonary Hypertension

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Chronic Thromboembolic Pulmonary Hypertension (CTEPH) is a pulmonary-vascular disease caused by a chronic fibro-thrombotic obstruction of the Pulmonary Artery (PA) branches [1-3]. Incomplete resolution of PA thrombosis results in the loss of pulmonary vascular bed, increase of pulmonary vascular resistance and development of pulmonary hypertension with specific changes of the terminal PA wall structure similar to idiopathic pulmonary hypertension [3,4]. Even though surgical management of CTEPH considered "method of choice", some patients may often develop recurrent pulmonary hypertension especially with distal lesion localization [4,5]. In those complicated patients pharmacological treatment and/or Balloon Pulmonary Angioplasty (BPA) may be considered as a new treatment modality [2,6,7].

From June 2015 to October 2018 PBA of 94 PA segments were performed in 50 (18 men and 32 women) with CTEPH. Patient's age varied from 32 years to 80 years (median 53.8+9.4 years) and weight from 65 kg to 95 kg (median 73.9 kg + 9.7 kg). Disease progression period was at median 33.8+25.1 month from initial PA emboli to development of CTEPH. In 27 patients, etiological factor of CTEPH and primary emboli source was lower extremity deep vein thrombosis, in 1-untreated tibial fracture, in 1-endocardial electrode thrombosis and in 21 patient's source of emboli was unidentified. Residual CTEPH after Pulmonary Thromboendarterectomy (PTE) was registered in 3 patients. In those patients, PBA of distally located lesions was performed at different times after surgery (in 1 patient after 14 days and in 2 after 14 and 16 months after surgery). Before PBA, only 13 (26%) patients with CTEPH received PAH-specific therapy. After performing BPA, all patients received PAH-specific therapy.

All patients had specific clinical manifestations of CTEPH, such as shortness of breath at mild exertion, edema and cyanosis. In addition, 15 patients had lower extremities edemas of varying degrees and in 20 patients a decrease of arterial oxygen saturation was noted with an average value 82.4%+3.7% (varied from 81% to 85%) ($p>0.01$). Patient's deviation according to NYHA functional class (FC): in II-9, in III-35 and in IV-6 patients. Alongside with ECG, ECO and chest X- ray, 35 patients has undergone ventilation/perfusion scintigraphy and 10-contrast enhanced pulmonary computer tomography. Only in 12 patients 6 minute walking test (SMWT) was carried out with median result 332 meters + 59.5 meters (from 337 meters to 298 meters) ($p<0.01$). Prior to intervention, all patients were subjected to the right heart catheterization and PA angiography. Cardiac catheterization data showed that pulmonary artery pressure: did not exceed 50 mmHg in 10 (20%) cases; in 17 (34%) it ranged from 50 mmHg to 75 mmHg; in 13 (26%)-from 75 mmHg to 100 mmHg; and in 8 (16%)-more than 100 mmHg. Angiography data provided detailed information about lesion localization and helped to determine target vessels for BPA session. According to the angiography data in 29 patients the lesion was located in the left PA, in 16 patients-in the right, and 5-both lungs. BPA of 39 segments was performed in the lower lobe of the right lung, 2 in the

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Received Date: *12 Nov 2018*
Accepted Date: *26 Nov 2018*
Published Date: *28 Nov 2018*

Citation:
Bockeria LA, Petrosian KV, Sobolev AV, Pursanov MG, Gorbachevskiy SV, Rakhmonov LKh, et al. Percutaneous Transluminal Balloon Angioplasty in Management of the Stenosis and Occlusion of Segmental and Subsegmental Pulmonary Arteries in Patients with Chronic Thromboembolic Pulmonary Hypertension. World J Vasc Surg. 2018; 1(2): 1013.

middle lobe and 4 segments in the upper lobe. In the lower lobe of the left lung BPA of 39 affected segments were performed, and the in the upper lobe-8. It should be noted that 8 patients had large blood clots in at the site of PA trunk bifurcation. Single segment BPA was performed in 33 patients, two segments-in 9, three-in 6, and four-in 2 patients. On average, one patient had 1.8 segments subjected to BPA. Additionally 7 patients required BPA procedure in contra lateral pulmonary vascular pool with an interval of 6 months and 12 months after the initial intervention. For BPA we used intracoronary and peripheral balloons with a diameter from 4 mm to 12 mm. In order to assess the anatomical and morphological features of the lesion and pathophysiological changes in the PA, Optical Coherence Tomography (OCT) was performed in 3 patients and in 1-for intravascular visualization we used intravascular ultrasound. Immediately after BPA, there were no significant changes in central hemodynamic, except for the Systolic Pressure Gradient (SPG) at the site of the lesion, which decreased on average from 26.7 mmHg ± 12.5 mmHg to 9.6 mmHg ± 4.2 mmHg ($p<0.05$). After BPA all patients we noticed that there was no significant decrease in the systolic pressure in the pulmonary artery on average from 71.5 mmHg ± 33.7 mmHg to 60 mmHg ± 26.9 mmHg ($p>0.05$) and an increase in arterial oxygen saturation from an average of 91.7%+3.4% to 93.8%+1.9% ($p>0.05$).

In the short-term postoperative period, the improvement of the overall clinical status of 25 patients was noted and no significant changes in the remaining group. Exercise tolerance increased in all patients, with the majority of patients (n=30) sifting to NYHA II FC. The results of the 6-minute walk test improved from 332.5 meters + 59.5 meters to 373 meters + 56.3 meters ($p<0.05$). We registered no complications associated with the procedure in postoperative period. Long-term results were assessed in 12 patients in average after 7.7 months + 4.0 months after BPA. Subjectively, 46 patients stated an improvement in the overall clinical condition (a decrease in shortness of breath incidence, an increase in physical activity potential). While 30 patients were in NYHA FC II, 14 remained in III FC and 5 shifted in to I FC. Repeated BPA was carried out in 3 patients after 6 months, 8 months and 12 months from the moment of the initial procedure. These patients also noted decrease in shortness of breath incidence, an increase in physical activity potential and showed improved results performing SMWT. In one case, PTE was performed after 7 days since BPA. In another 5 patients a successful PTA was performed in mid-term period after initial BPA (125 days ± 32 days). In these patients, we registered a further decrease of systolic pressure in the PA and right ventricle subnormal value.

Thereby, BPA was safe in 49 patients with CTEPH. In 1 case there was a rupture of the pulmonary artery wall with a fatal outcome and also in 5 patients we registered development of reperfusion syndrome, which in one case required long-term hospital treatment. Survival rates after BPA were 95.7%.

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