# Pulmonary Thromboendarterectomy in Chronic Thromboembolic Pulmonary Hypertension: A Report of 15 Cases

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## Abstract

***Backgrounds-*** Chronic thromboembolic pulmonary hypertension (CTEPH) is a serious and under-diagnosed disorder with significant morbidity and mortality. It is thought to result from single or recurrent pulmonary thromboemboli arising from the sites of venous thrombosis, often from the lower limbs. Surgical correction of anatomical obstructions (endarterectomy of pulmonary artery) is the treatment of choice in these patients, and the patients' outcomes are good. The mortality rate in some centers is about 5%, but in others it is up to 30%.

***Methods-*** We started pulmonary endarterectomy in Shaheed Rajaie Heart Center (RHC) in Iran four years ago. Pulmonary thromboendarterectomy is performed under hypothermia and total circulatory arrest with cardiopulmonary bypass. All patients are evaluated in our hospital for known risk factors of deep vein thrombosis and pulmonary emboli. Right heart catheterization and measurement of pulmonary artery pressure and vascular resistance are performed in some of the patients and left heart catheterization in those who are over 45 years of age. CT angiography of the pulmonary artery with multi-slice CT scan is done in all patients before and after endarterectomy. Patient selection for successful endarterectomy is based on CT angiography and perfusion lung scan with consideration of pulmonary vascular resistance in some cases.

***Results-*** During a 4-year period, 15 patients (5 female and 10 male) underwent this type of surgery in RHC. Their mean age was 35.87 (min. 18, max. 55) years old. The mean pulmonary artery systolic pressure by echocardiography was 87.60 mmHg (min. 55mmHg, max. 140 mmHg, SD 23.26 mmHg) and the mean pulmonary artery pressure was 46.43mmHg (min. 23 mmHg, max. 60 mmHg, SD 11.70 mmHg). Mean surgery time was 5.33 hours (min. 4hrs, max. 14 hrs, SD. 2.46 hrs), mean bypass time was 138 minutes (min. 84, max. 220, SD=43.28 minutes), mean intubation time was 49.88 hours (min. 7 hrs, max. 216 hrs, SD 61.66 hrs), and intensive care unit stay time was 5.43 days (min. 3, max. 9, SD=1.98). Two fatalities occurred due to bleeding and shock. The mortality rate was 20%. IVC filters were placed in a minority of the patients who had clear-cut evidence of lower extremity deep vein thrombus as a cause of pulmonary thromboembolic events.

***Conclusions-*** Pulmonary endarterectomy is the treatment of choice in CTEPH with an acceptable mortality rate and a good prognosis. It is possible to perform this procedure without recourse to more sophisticated evaluations with an acceptable mortality rate in patients who have segmental lobar or main pulmonary artery organized clot ***(Iranian Heart Journal 2010; 11 (2):44-48).***

**Key words:** pulmonary thromboendarterectomy ■ pulmonary hypertension, chronic

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Chronic thromboembolic pulmonary hypertension (CTEPH) is a serious and under-diagnosed disorder with significant morbidity and mortality.[1] It is thought to result from single or recurrent pulmonary thromboemboli arising from the sites of venous thrombosis.[1,2,3] For reasons that are still unclear, the lysis of blood clots does not occur in up to 3.8% of survivors of acute pulmonary thromboemboli, which then evolves into the organization of the clot inside the pulmonary artery.[2,3,4] Increased pulmonary vascular resistance (PVR) and pulmonary arterial pressure (PAH) due to the obstruction of the pulmonary artery results in right heart strain and remodeling.[2-5] In contrast to venous thromboembolism (VTE), classic risk factors have not been found, with the exception of anticardiolipin antibodies (ACLA) and lupus anticoagulant (LAC) in 10–20% of patients[4-8] and plasma factor VIII (FVIII) in 25% of patients.[5] There are reports that have documented an association of splenectomy,[6-8] ventriculoatrial (VA) shunt for the treatment of hydrocephalus, and chronic inflammatory conditions[6-8] with CTEPH. Surgical correction of anatomical obstruction, i.e. pulmonary endarterectomy (PEA), is the treatment of choice in these patients, and the outcome is good.[9-14] The mortality rate in some centers is about 5%, but in others it is up to 20 percent.[1,2,13.14] The aim of the present study was to report the present status of PEA in our center and probably in Iran and to present the availability of this life-saving surgery to other coworkers in Iran and other countries.

## Methods

We began pulmonary endarterectomy at our center four years ago. Surgery in most of the patients is done by one surgeon who is more experienced in this field. Pulmonary thromboendarterectomy is performed under hypothermia and total circulatory arrest and cardiopulmonary bypass with classic methods. All patients are evaluated in hospital for known risk factors of deep vein thrombosis and pulmonary emboli. Right side catheterization and measurements of pulmonary artery pressure and pulmonary vascular resistance are done in some patients. There is a limitation for doing classic angiography in all patients because of fear of injection in patients with very high pulmonary artery pressure and poor imaging with the present angiography facilities and techniques, and lack of experience in this field. However, CT angiography of the pulmonary artery with multi-slice CT scan is done in all patients before and after endarterectomy. Eligibility of patients for successful endarterectomy is determined by CT angiography and perfusion lung scan with consideration of the pulmonary vascular resistance in some patients. The main criteria for inclusion in the present study were: 1) major involvement of main, bronchial, and segmental artery; 2) patients being symptomatic with PTE; 3) acceptable cardiopulmonary status for operation based on present criteria; 4) pulmonary vascular resistance less than 1300 dynes/ s/ cm; and 5) good correlation between PAH and pulmonary artery obstruction and no other explanation for PAH. The bronchial artery diameter was not considered in decision making for endarterectomy. No change in final decision was made in some patients who underwent classic angiography. Duplex study of the iliac and femoral veins was done in all of the patients, and IVC filters were deployed in certain patients before operation. Cardiac evaluation was performed with electrocardiography as well as transthoracic and transesophageal echocardiographic examinations in all the patients and coronary angiography in clinically suspicious cases. None of the patients had pulmonary-specific treatment before operation. All the patients gave informed consent for the operation, and all of them were aware that this operation was available in other countries. All the recorded data were transferred to SPSS software for descriptive analysis (Table I).

## Results

During a 4-year period, 15 patients (5 female and 10 male) underwent this type of surgery in RHC. Their mean age was 35.87 (min. 18, max. 55) years old. The mean pulmonary artery systolic pressure by echocardiography was 87.60 mmHg (min. 55mmHg, max. 140 mmHg, SD 23.26 mmHg) and the mean pulmonary artery pressure was 46.43mmHg (min. 23 mmHg, max. 60 mmHg, SD 11.70 mmHg). Mean surgery time was 5.33 hours (min. 4hrs, max. 14 hrs, SD. 2.46 hrs), mean bypass time was 138 minutes (min. 84, max. 220, SD=43.28 minutes), mean intubation time was 49.88 hours (min. 7 hrs, max. 216 hrs, SD 61.66 hrs), and intensive care unit stay time was 5.43 days (min. 3, max. 9, SD=1.98). Two fatalities occurred due to bleeding and shock. The mortality rate was 20%. IVC filters were placed in a minority of the patients who had clear-cut evidence of lower extremity deep vein thrombus as a cause of pulmonary thromboembolic events.
patients are reported in Table I.

**Table I. Data of 15 patients with CTEPH**

| Patient no. | Sex | Age | FC 1 | FC2 | sPAP1 | sPAP2 | CT Score | Coagulation defectrs | MPAP | Pump time (mins) | Days in ICU | Surgery time (hrs) | Intubation time (hrs) | Follow up (months) | Status at present |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | M | 37 | 3 | 1 | 65 | ? | ? | No | .? | 134 | 4 | 4.5 | 9 | 16 | Alive |
| 2 | F | 31 | 4 | - | 75 | 54 | 21 | No | ? | 220 | 5 | 5.0 | 120 | - | Dead |
| 3 | M | 36 | 4 | ? | 70 | 46 | 15 | No | 46 | 100 | 7 | 5.0 | 20 | 1 | Alive |
| 4 | M | 18 | 4 | 3 | 140 | 60 | 23 | No | 60 | 185 | 7 | 5.5 | 19 | 42 | Alive |
| 5 | F | 41 | 33 | 1 | 90 | 23 | 20 | Yes | 23 | 150 | 4 | 4.0 | 41 | 48 | Alive |
| 6 | M | 54 | 3 | - | 65 | ? | ? | No | .? | 144 | 6 | 5.0 | 36 | - | Dead |
| 7 | F | 28 | 4 | 1 | 85 | 43 | 20 | Yes | 43 | 95 | 7 | 4.0 | 16 | 5 | Alive |
| 8 | M | 18 | 4 | 1 | 95 | 50 | 23 | No | 50 | 166 | 3 | 5.5 | 7 | 32 | Alive |
| 9 | M | 41 | 4 | ? | 69 | ? | ? | No | .? | 135 | 8 | 4.0 | 45 | ? | Alive |
| 10 | F | 48 | 4 | ? | 85 | ? | ? | No | 54 | 94 | 9 | 4.0 | 216 | ? | Alive |
| 11 | M | 35 | 3 | 3 | 105 | 49 | 18 | No | 49 | ? | .? | ?. | ?. | 40 | Alive |
| 12 | M | 34 | 3 | ? | 120 | ? | ? | No | .? | 132 | 6 | 4.5 | 19 | ? | ? |
| 13 | F | 55 | 4 | 1 | 55 | ? | 28 | No | .? | 84 | 3 | 5.0 | 18 | 4 | Alive |
| 14 | M | 38 | 3 | ? | 110 | ? | 17 | No | .? | 96 | 4 | 4.5 | 13 | ? | ? |
| 15 | F | 24 | 3 | 2 | 85 | 35 | 21 | No | .? | 205 | 3 | 5.5 | 72 | 28 | Alive |

FC1= NYHA function class before operation, FC2= NYHA function class after operation, sPAP1= systolic pulmonary artery pressure before operation, sPAP2= systolic pulmonary artery pressure after operation, MPAP= mean pulmonary artery pressure

## Discussion

At present, pulmonary endarterectomy (PEA) is the treatment method of choice for CTEPH, with acceptable mortality (less than 10%) and good long-term results.[1,3,13,14] It is highly recommended that this operation be done in specialized centers with experienced surgical and medical teams.[1]

We had problems in the first and third patients, but thereafter there was no problem with surgery, and all of the patients had good pre-operative, intraoperative, and postoperative course.

The demographic data of our patients are not different in comparison with those in most reports from other countries, except for age.[1,3,12,13,14] We were wary of operating older aged patients because of lower experience. Well-experienced centers perform this operation routinely with low mortality (5%) and in patients as old as 80 years of age.[1,3,8]

The mortality rate of our patients was 20%. We believe that the higher mortality rate in our patients was due to patient selection and

surgical technique at the beginning of the study. The last 10 patients had a very good course due to more precise evaluation and selection of patients and also rapid progression of surgical experience in our surgical team. Fatality in the first and third patients was due to bleeding and shock, because of unsuccessful operation and RV failure in the ICU and persistence of PAH. All of the patients thereafter had a good course intraoperatively and postoperatively in hospital and were discharged in good condition. All the patients who underwent complete PEA had normal function class and pulmonary pressure on follow-up examinations.

One patient had incomplete PEA, and PAH had not decreased after the operation. Despite the persistence of high pressure however, he had improvement of function class with medical therapy including sildenafil and standard therapy with digoxin, diuretics, and warfarin. Another patient, who had undergone surgery in London, returned to our center for follow-up. Postoperative CT angiography showed persistence of obstruction in the left pulmonary artery, with no change in PAH on echocardiography. He was given sildenafil and warfarin and followed up.

One Arab patient from Iraq was referred to us because of PAH. He had PAH with a mixture of organized cloth (CTEPH) and hydatid cyst in the pulmonary artery. He was treated surgically and discharged from the hospital. He did not come back to our center for follow-up.

Patients with thromboembolic disease proximal to the segmental arteries (type 1 or type 2 disease) have been shown to have the most favorable hemodynamic outcomes from PEA, whereas patients with disease limited to the segmental pulmonary arteries have a higher surgical risk and a poorer prognosis.[1] We did operation in type 1 and 2 of CTEPH, based on CT angiography and perfusion lung scan. Major segmental defects on perfusion scan and presence of organized clot at the corresponding branches in axial CT sections are considered good candidates for operation. Operation in these patients had a better outcome.

We had two (20%) cases with antiphospholipid syndrome and positive LAC and ACLA, similar to other reports.[6,7,8] Also there were two patients with a history of splenectomy in the past. No patient had factor V Leiden, protein C, or protein S deficiency. Two patients had lower than normal platelet counts. We do not know of any relation between low platelet count and tendency to develop CTEPH.

## Conclusion

At present, pulmonary endarterectomy is the treatment method of choice for CTEPH with acceptable mortality (less than 10%) and good long-term results.[1,2,9-14] It is highly recommended that this operation be undertaken at specialized centers with well-experienced surgical and medical teams.[1,12]

We can perform PEA in CTEPH cases with acceptable mortality. We will be obliged to all colleagues in Iran if they refer their patients with CTEPH to our tertiary center for PEA evaluations.

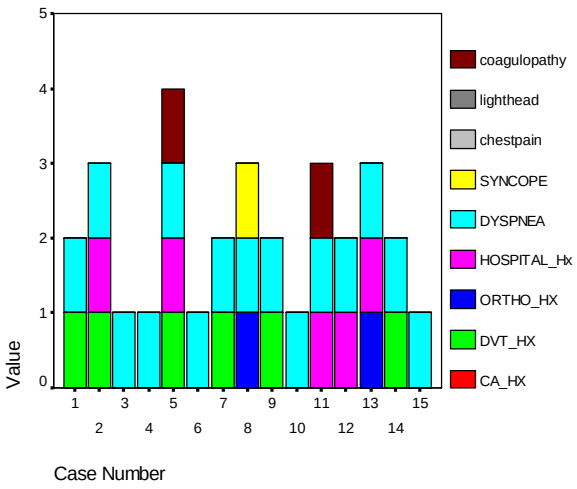


**Fig. 1.** Some clinical and paraclinical data of 15 patients who underwent pulmonary endarterectomy HOSPITAL_HX = history of hospitalization before evaluation for PEA, ORTHO_HX = history of orthopnea, DVT_HX = history of deep veins thrombosis, CA_HX = history of known cancer

## Conflict of Interest

No conflicts of interest have been claimed by the authors.

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