

Open Pulmonary Thromboembolectomy in Patients with Major Pulmonary Thromboembolism

Sak Lee, Suk-Won Song, Gijong Yi, Young-Nam Youn, Kyung-Jong Yoo, and Byung-Chul Chang

Department of Thoracic and Cardiovascular Surgery, Yonsei University College of Medicine, Seoul, Korea.

Purpose: We retrospectively analyzed open pulmonary thromboembolectomy in patients with acute and chronic pulmonary thromboembolism. **Materials and Methods:** Between August 1990 and May 2005, 12 consecutive patients with acute and chronic pulmonary thromboembolism underwent open pulmonary thromboembolectomy at Yonsei Cardiovascular Center. Their mean age was 47.5 years, and 7 of the patients were female. Among 12 patients, 5 had acute onset, and 7 had chronic disease, and 9 patients were associated with deep venous thrombosis. Extent of pulmonary embolism was massive in 3 patients with hemodynamic instability, and submassive in 8 patients. Preoperative echocardiogram revealed elevated right ventricular pressure in all patients, and 7 patients were in NYHA functional class III or IV. Pulmonary thromboembolectomy was performed in all patients under total circulatory arrest. **Results:** There were 2 hospital deaths (16.7%). Among the patients who survived, mean right ventricular pressure was decreased significantly from 64.3 mmHg to 34.0 mmHg with improvement of NYHA functional class. **Conclusion:** Open pulmonary thromboembolectomy is thought to be an immediate and definitive treatment for massive pulmonary embolism with optimal results. Even though operative mortality is still high, early diagnosis and immediate surgical intervention in highly selective patients may improve the clinical outcome.

Key Words: Pulmonary thromboembolism, thromboembolectomy

INTRODUCTION

Pulmonary thromboembolism is an increasing

disease entity with still advanced mortality and high recurrence rates. In most of patients, conservative anticoagulation therapy is effective; however, massive pulmonary embolism with cardiovascular collapse, indicating significant obstruction of major pulmonary vasculature, has a very poor prognosis, and sufficiently treat these patients has been a challenge. In this study, we evaluated the clinical outcome of 12 consecutive patients with massive or submassive pulmonary thromboembolism who were surgically treated.

MATERIALS AND METHODS

From August 1990 to May 2005, 12 patients underwent pulmonary thromboembolectomy at Yonsei Cardiovascular Center. Hospital records of all patients who underwent open pulmonary thromboembolectomy were retrospectively reviewed. There were 5 men, and 7 women, and their mean age at the time of operation was 47.5 years (range: 30 - 65 years). Among 12 patients, 5 had acute onset, and 7 had chronic disease, and 9 patients were associated with prior or concurrent deep venous thrombosis of lower extremity. Other associated disease included anti-phospholipid antibody syndrome in 3 patients, sticky platelet syndrome in 1 patient, and protein C deficiency in 1 patient (Table 1). Three patients had massive pulmonary embolism, and 9 had submassive pulmonary embolism. Massive pulmonary embolism was diagnosed in patients with shock or hypotension (defined as systolic blood pressure less than 90mmHg or a decrease of more than 40 mmHg over 15 minutes if not caused by new-onset arrhythmia, hypovolemia, or sepsis), and submas-

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Reprint address: requests to Dr. Byung-Chul Chang, Department of Thoracic and Cardiovascular Surgery, Yonsei University College of Medicine, 250 Seongsanno, Seodaemun-gu, Seoul 120-752, Korea. Tel: 82-2-2228-8483, Fax: 82-2-313-2992, E-mail: bcchang@yuhs.ac

Table 1. Clinical Variables and Outcome of Patients

No.	Age (yrs)	Sex	Symptoms	Risk factors	Extent of disease	Operative findings	Mortality
1	54	F	Dyspnea, cough	DVT, sticky plt Sd	Submassive	Bilateral PA	No
2	56	M	Chest pain	DVT	Submassive	Bilateral PA	No
3	43	F	Dyspnea	DVT, ptn C def	Submassive	Main, bilateral PA	No
4	46	M	Dyspnea	DVT, anti-PL Ab	Submassive	Main, bilateral PA	No
5	30	F	Dyspnea, dizziness	DVT	Submassive	Main, bilateral PA	No
6	48	F	Dyspnea, syncope	DVT	Massive	Main, left PA	No
7	61	F	Dyspnea, facial edema	Anti-PL Ab	Submassive	Multiple lobar PA	No
8	33	M	Dyspnea	DVT	Massive	RA, bilateral PA	No
9	45	F	Syncope, hypoxia	DVT, anti-PL Ab	Massive	Main, bilateral PA	Yes
10	65	M	Dyspnea	DVT	Submassive	Bilateral PA	Yes
11	46	F	Chest pain		Submassive	Main, bilateral PA	No
12	43	M	Dyspnea		Submassive	Multiple lobar PA	No

F, female; M, male; DVT, deep venous thrombosis; Sticky plt Sd, sticky platelet syndrome; Anti-PL Ab, anti-phospholipid antibody syndrome; PA, pulmonary artery; RA, right atrium.

sive pulmonary embolism was identified by the echocardiographic finding of right ventricular dysfunction without hemodynamic instability.^{1,2} All patients had 1 or more symptoms suggestive of pulmonary embolism such as dyspnea, pleuritic chest pain, syncope, dizziness, cough, and hypoxia. Two patients required intubation prior to surgery. The indication of surgery was acute hemodynamic or respiratory compromise or chronic symptomatic patients with a major pulmonary embolism, and pulmonary hypertension. The diagnosis and extent of the disease was made by chest computed tomogram (CT), and transthoracic echocardiogram (TTE) was also performed in all patients to evaluate right and left ventricular function, right ventricular pressure, and association of other intracardiac disease. One patient with acute massive pulmonary thromboembolism preoperatively suffered from cardiac arrest, requiring cardiopulmonary resuscitation. All but 2 patients had perioperative placement of an inferior vena caval (IVC) filter. In all survivors, anticoagulation by means of warfarin sodium was started on postoperative day 1 to maintain international normalized ratio (INR) of 1.5 - 2.0. Postoperative anticoagulation was main-

tained after surgery for 6 months to 1 year, and changed to low dose aspirin afterwards.

Surgical technique

Through a classical median sternotomy approach, vertical pericardiotomy was performed, and conventional cardiopulmonary bypass was initiated after systemic heparinization. The arterial cannula was placed in the ascending aorta and bicaval venous cannula was placed through the right atrium. The procedure was performed with aortic cross-clamping, cold blood cardioplegia, and deep hypothermia with intermittent periods of circulatory arrest. A transverse arteriotomy was made in the pulmonary trunk to the left main pulmonary artery, and another incision was sequentially made in the right main pulmonary artery, and the fresh and organized thrombi were gently extracted as distal as possible. The lungs were manually compressed to mobilize the peripheral clots. Rewarming the patients, the pulmonary arteries were repaired. Weaning from the cardiopulmonary bypass was successfully performed in all patients.

RESULTS

All patients had large central emboli in the right and/or left pulmonary artery. All patients had moderate or severe right ventricular dysfunction, identified by intraoperative trans-esophageal echocardiogram (TEE). Mean cardiopulmonary bypass and aortic clamp time were 239.8 ± 43.8 minutes (range, 189 - 291 minutes), and 131.8 ± 40.8 minutes (range, 88 - 174 minutes), respectively. Mean total circulatory arrest time was 47.4 ± 27.8 minutes (range, 16 - 88 minutes) with lowering mean body temperature to $19.9 \pm 2.8^\circ\text{C}$ (range, $17 - 25^\circ\text{C}$). Mean duration of ventilator care and ICU stay were 1.7 ± 0.9 days (range, 1 - 3 days), and 4 ± 2.6 days (range, 2 - 9 days), respectively. Three of the 12 patients underwent concomitant cardiac surgical procedures: one had a repair of foramen ovale, another patient had an excision of right atrial thrombi, and the other patient had a tricuspid annuloplasty. Seven of the 12 patients required postoperative inotropic support by means of dobutamine, or milrinone for mean of 5 ± 4.9 days (range, 1 - 15 days). Mean hospital stay was 15.7 ± 5.6 days (range, 9 - 25 days).

There were two hospital deaths (16.7%) on postoperative day 5, and 15, respectively. One of the patients had massive pulmonary embolism with unstable hemodynamics which required preoperative ventilator care as well as inotropic support, and underwent urgent operation. The patient's preoperative central venous pressure patient was 28 mmHg and, even though cardiopulmonary bypass weaning was successfully performed, reperfusion pulmonary edema developed on immediate postoperative period and eventually died. The other patient had elective operation for submassive pulmonary embolism, and postoperative course was relatively uneventful. However, sudden massive endobronchial bleeding occurred during weaning from mechanical ventilator and died.

For all survivors, postoperative echocardiogram was performed before discharge. Postoperative mean right ventricular pressure was decreased significantly from 64.3 ± 19.2 mmHg (range, 45 - 104 mmHg) to 34.0 ± 11.3 mmHg (range, 25 - 54 mmHg) ($p = 0.002$). Mean NYHA functional class also significantly improved from 3.1 ± 0.9 (range,

2 - 4) to 1.4 ± 0.5 (range, 1 - 2) ($p = 0.0001$). Localized reperfusion injury was documented on chest X-ray, taken during postoperative period, in three patients that was resolved before discharge.

Follow-up was completed in all survivors ($n = 10$) for mean duration of 40.4 ± 9.0 months (range, 24.9 - 58.0 months), and there was no recurrence of pulmonary thromboembolism during follow up period.

DISCUSSION

Despite the current emphasis on deep venous thrombosis prophylaxis, the prevalence of pulmonary embolism in hospitalized patients is around 1%.³ Severe pulmonary embolism is associated with a high mortality rate, due to acute right heart failure, and hypoxia despite advances in diagnosis and therapy.⁴⁻⁶ Open pulmonary embolectomy, previously thought to be a treatment of last resort, has recently been encouraged for patients with severe pulmonary embolism.⁷⁻⁹ Thrombolytic therapy and catheter-based transvenous thromboembolctomy have been proven effective in patients with acute massive pulmonary embolism.¹⁰⁻¹⁴ However, these treatment modalities are also associated with an increased risk of hemorrhage, recurrent pulmonary embolism, and failure to completely resolve the intraluminal thrombus, eventually resulting in pulmonary hypertension.^{9,10,15,16} Therefore, pulmonary embolectomy is suggested for selected highly compromised patients who are unable to receive thrombolytic therapy or whose critical status does not allow sufficient time to infuse thrombolytic agents.¹⁷

The most frequent indication for pulmonary embolectomy is hemodynamic instability despite heparin therapy and resuscitative efforts, which is reported as high as 74%.¹⁷ Other indications include cardiac arrest, contraindications to or failure of thrombolytic therapy.^{17,18} On the other hands, the only absolute contraindication to thromboendarterectomy is the presence of severe underlying lung disease, either obstructive or restrictive. Advanced age, severe right ventricular failure, and the presence of collateral disease influence the risk assessment, however, they are not absolute contraindication.¹⁹ In this study, patients with acute pulmo-

nary embolism underwent urgent or emergent embolectomy due to hemodynamic instability, and patients with chronic pulmonary embolism underwent elective embolectomy mainly due to severe symptoms of congestive heart failure or pulmonary hypertension. Despite poor preoperative condition in these patients, we were able to perform successful open pulmonary embolectomy in all patients using conventional cardiopulmonary bypass. Use of femoral artery and venous bypass by the means of percutaneous cardiopulmonary support (PCPS) has also been reported as an alternative to conventional cannulation in unstable patients,²⁰ which was not required in our patients.

The placement of IVC filter in patients who undergo pulmonary embolectomy is well supported by several studies.²¹⁻²³ Decousus et al.²¹ demonstrated in their randomized study of 400 patients with DVT that, placement of an IVC filter was associated with 1% rate of pulmonary embolism, whereas patients without IVC filter placement had 5% pulmonary embolism rate within the first 12 days, and Rosenberger et al.²² also reported that recurrent pulmonary embolism can occur early after pulmonary embolectomy even in the presence of coagulopathy, and therefore, concurrent IVC filter placement should be considered during or immediately after pulmonary embolectomy to prevent recurrent pulmonary embolism. Our institute has a policy to place IVC filter on a routine basis in patients with deep venous thrombosis, as well as patients who are scheduled for pulmonary thromboembolectomy. In this study, we failed to insert IVC filter in 2 patients: 1 patient refused the procedure, who survived without a recurrence, and the other patient underwent urgent operation and died postoperative day 5, and there was no time for IVC filter placement.

A mortality of 16.7% after open pulmonary thromboembolectomy is still high, but close to that observed in previous reports (11 - 35%).²⁴⁻²⁷ To improve the outcome, early diagnosis through reasonable clinical suspicion of pulmonary thromboembolism, rapid treatment, and careful patient selection all should precede.

In conclusion, open pulmonary thromboembolectomy is thought to be an immediate and definitive treatment for massive pulmonary embolism with optimal results. Even though the operative

mortality is still high, early diagnosis and immediate surgical intervention in highly selective patients may improve the clinical outcome.

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