Pulmonary embolectomy: review of a 15-year experience and role in the age of thrombolytic therapy

Abstract  Objective. Surgical intervention for fulminant pulmonary embolism is nowadays most commonly restricted to patients with failure of or contraindication to thrombolytic therapy. Such a second choice indication may alter operative risks or late outcome, and this was investigated in a retrospective study.

Material and methods. Thirty-six patients (17 male, mean age: 50.6 ± 15.5 years) with fulminant pulmonary embolism of either the pulmonary trunk or one of the pulmonary arteries and at least one contralateral segment underwent pulmonary embolectomy on cardiopulmonary bypass during a 15-year period (1979–1989: 31 patients, group I; 1990–1994: 5 patients, group II).

Group II included only patients who did not meet the criteria for acute thrombolysis. All patients were in strongly compromised circulatory conditions (29/36 high dose catecholamines, 20/36 mechanical ventilation, 14/36 pre-operative cardiopulmonary resuscitation).

Results. The perioperative mortality rate was 26% in group I (8/31 patients, 7 with pre-operative cardiac arrest) and 20% in group II (1/5 patients not related to failure of previous thrombolytic therapy). Severe but non-fatal complications occurred in six patients who fully recovered following treatment. Follow-up was completed to 93% (25/27 patients) and comprised a total of 248 patient-years (mean: 119 months). Twenty-three out of 25 patients (92%) were in functional class I or II (NYHA). No recurrent pulmonary embolism or late clinical symptoms related to embolectomy were observed. One patient died 8 years postoperatively (late mortality: 0.4% patient-year). There was no difference between group I and group II regarding perioperative mortality, complications and late results.

Conclusions. Late results after pulmonary embolectomy are excellent in respect to functional class and late mortality. Early mortality is closely associated with preoperative cardiac arrest. Previous thrombolysis does not alter the perioperative risks, occurrence of complications or late outcome after surgical intervention.

Key words  Pulmonary embolism • Thrombolysis • Surgery • Pulmonary embolectomy

Introduction

Fulminant pulmonary embolism is associated with a high mortality rate, due to acute right ventricular failure and hypoxia, and requires emergency therapy [1, 10]. Relief of the right ventricle together with restoration of a sufficient oxygen saturation is clearly recognized to be the main therapeutic objective. An increasing time interval between the first onset of symptoms and the beginning of therapeutic
intervention is known to influence whether the outcome for the patient is fatal, thus thrombolysis is widely accepted as the front-line treatment of this disease at present [22]. However, surgical intervention for fulminant pulmonary embolism, successfully applied in these patients in the past, remains necessary at least for patients with failure of or contraindication to thrombolytic therapy [17]. Such a second choice indication may alter the operative risks or late results. To determine whether the early or late outcome has changed with this different therapeutic strategy, we reviewed all the patients who had been operated for pulmonary embolism at our institution in a retrospective study and compared the results before and after the introduction of thrombolysis as the first choice treatment.

Material and methods

Patient characteristics

During a 15-year period between January 1979 and December 1994, 36 patients with fulminant pulmonary embolism of either the pulmonary trunk or one of the pulmonary arteries and at least one contralateral segment underwent pulmonary embolectomy on cardiopulmonary bypass. The average patient age was 50.6±15.5 (range 16–75) years and the number of men (17) and women (19) was nearly the same. Of 32 (88.9%) patients who stayed in hospital at the time of pulmonary embolism, 26 (72.2%) had undergone prior surgery (general surgical procedure in 7, gynecologic procedure in 5, multiple injuries and orthopedic procedure in 14) and 6 (16.7%) patients suffered from different primary diseases (internal 4, neurologic 2). Among the four (11.1%) outpatients, three were initially admitted to a near-by hospital and one patient was admitted directly to our institution.

All patients had the symptoms and clinical signs of severe pulmonary embolism including dyspnea, cyanosis, tachycardia, chest pain and hemodynamic compromise. Twenty-nine (80.6%) patients were in prolonged cardiogenic shock, necessitating high dose catecholamines. Twenty (55.6%) patients required mechanical ventilation. In 14 (38.9%) cardiac failure or cardiac arrest developed and they required intermittent (6) or continuous (8) external and internal cardiac massage prior to operation. The baseline patients data are given in Table 1.

Table 1 Baseline data from 36 patients with fulminant pulmonary embolism operated from 1979 to 1994

<table>
<thead>
<tr>
<th>Age</th>
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<td>Sex</td>
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<td>Male</td>
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<td>Etiology</td>
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<td>Previous surgery</td>
<td>26</td>
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<td>Different diseases</td>
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<tr>
<td>Cardiogenic shock</td>
<td>29</td>
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<td>Mechanical ventilation</td>
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<td>Cardiac arrest</td>
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The diagnosis of fulminant pulmonary embolism was verified directly by pulmonary angiography in 23 (63.9%) and by ventilation perfusion scan in 2 (5.6%) patients. Additional transthoracic echocardiography was used in four (11.1%) patients most recently. In 11 (30.6%) patients the diagnosis and the ultimate decision for urgent surgical intervention were based only on indirect findings (hemodynamic situation, arterial blood gases, Swan-Ganz catheterization, history of previous operation or acute deep venous thrombosis) without further confirmation of the embolism by imaging techniques. Massive pulmonary embolism was confirmed consistently at the time of surgical exploration.

Primary surgical intervention in all patients with fulminant pulmonary embolism was the therapy of first choice at our institution between January 1979 and December 1989. Group I included 31 (86.1%) patients who were operated during this time. Since 1990 primary thrombolysis has been prescribed for all patients without contraindication to thrombolytic therapy, so pulmonary embolectomy was performed only in patients with contraindication to thrombolysis (Table 2) or after the failure of thrombolysis. During this time interval only five (13.9%) patients were operated on, who did not meet the criteria for thrombolysis or after the failure of thrombolysis, forming group II. In two of them embolism occurred 1 and 3 days, respectively, after major abdominal surgery, so thrombolysis was contraindicated with respect to the bleeding risk. Another two patients experienced fulminant pulmonary embolism following minor orthopedic procedures and underwent primary thrombolysis. Because their hemodynamic situation deteriorated, despite thrombolytic therapy, they ultimately became candidates for surgical intervention. The fifth patient of group II had been lysed successfully for pulmonary embolism following conservative treatment of a lower leg fracture, but developed intracranial bleeding requiring neurosurgery. Two weeks later he experienced recurrent fulminant embolism and underwent pulmonary embolectomy after all.

Surgical technique

Pulmonary embolectomy was performed using extracorporeal circulation in all cases. In eight (22.2%) patients requiring continuous cardiopulmonary resuscitation, external chest compression was followed by manual cardiac massage after sternotomy and pericardiectomy. In two (5.6%) patients partial bypass through the femoral vessels was instituted before the initiation of total cardiopulmonary bypass with cannulation of the main pulmonary vessels and ascending aorta. In three (8.3%) patients embolectomy was performed on inflow occlusion and fibrillating heart, all others (33) had cardiopulmonary arrest (Brettschneider solution, 15 ml/kg body weight, 4°C) with cross-clamped aorta on moderate hypothermia (28°C). The pulmonary trunk was incised longitudinally and thrombi were removed with the Fogarty-maneuver or direct suction. Both pleural cavities were opened and the peripheral pulmonary vascular bed was cleared by gentle manual compression of the lungs. The right atrium and ven-
tricle were explored, and the venae cave were flushed for residual clots. At the end of the procedure an intravenous caval filter was inserted via the atrial incision into the inferior vena cava in 32 patients. Mitral valve replacement was performed in one patient, and coronary artery bypass grafting in another patient with ischemic heart disease. In both patients the pulmonary embolism occurred following cardiac catheterization.

Data analysis and statistics

Perioperative data were taken from patient records and a formal follow-up of all living patients was carried out by outpatient visits or by telephone interviews with the patient, the patient’s physician or both. Follow-up was completed to 93% (25/27 patients) and comprised a total of 248 patient-years (mean: 119±52.6 months). The patients were divided into two groups: group I included 31 (86.1%) patients who were operated on between January 1979 and December 1989 (primary surgical intervention) and group II included five (13.9%) patients who have been operated on since 1990 (primary thrombolysis). Both groups were compared with respect to perioperative mortality rate, frequency of severe complications, and functional class (NYHA) at long-term follow-up.

The data were expressed as means ± 1 SD when appropriate. Statistics were performed with the Fisher exact-test as the number of patients in group II is considerably smaller than in group I. Actuarial survival rates of both groups were computed following the Kaplan-Meier method [19].

Results

Early results

The overall perioperative mortality rate was 25% (9/36), with no statistically significant difference between the two groups. Eight of 31 patients (26%) in group I died, seven of them with preoperative cardiac arrest. One patient in group II (20%) died due to cardiac failure supposed to be non-related to previous thrombolytic therapy. Early mortality in the patient population as a whole was significantly higher after preoperative cardiac arrest (8/14; 57.1%). Out of 22 patients without preoperative cardiac arrest and consecutive resuscitation, only one (4.5%) patient, a 75-year-old woman, died of multi-organ failure 3 days after pulmonary embolectomy (P = 0.009; Fisher exact-test). Right heart failure was the main cause of perioperative mortality (group I: n = 3; group II: n = 1), one patient could not be weaned off bypass and died intraoperatively. Cerebral hypoxia (2) and multi-organ failure (2) were also causes of death. Cerebral bleeding occurred in one patient (group I); there was no bleeding complication in group II (Table 3).

Severe but non-fatal complications occurred in 6/27 (22%) patients. These were pneumonia with sepsis, acute renal failure, cerebral hypoxia, cardiac low output syndrome with insertion of an intra-aortic balloon pump and gastrointestinal bleeding in group I (5/23 patients; 22%). In group II 1/4 (25%) patients experienced severe complications (acute renal failure). All of these patients recovered fully following treatment during their hospital stay. None of the patients showed residual effects of the complication in the follow-up (Table 3).

Long-term results

Follow-up was completed in 25/27 survivors and one late death was discovered. This patient, with coronary artery bypass grafting in the same session (group I), died 8 years postoperatively (late mortality: 0.4%/patient-year) of ischemic cardiac disease. Actuarial survival (Kaplan-Meier) showed no difference between the two groups (Fig. 1). Analysis of functional capacity (NYHA) showed 15 (60%) patients in functional class I, 8 (32%) patients in class II, one (4%) patient in class III, and one (4%) patient in class IV. Both patients (75 and 83 years old) exceeding functional class II were in group I and had a follow-up period of 14 years (Fig. 2). Neither in group I nor in group II were any late clinical symptoms related to pulmonary embolectomy or recurrent pulmonary embolism observed.
Fulminant pulmonary embolism is a disease with a high morbidity and mortality which does not spare even very young patients [5, 7, 9, 14, 26, 29]. In cases with obstruction of more than 50% of the pulmonary arterial tree, causing an increase in pulmonary artery pressure with consecutive right ventricular failure, the mortality rate reaches 50%. In cases of massive embolism with systemic hypertension requiring vasoactive drug therapy and cyanosis needing respiratory support, the mortality rate rises to 70%. Survival is unlikely in almost 100% of the patients, if clinical deterioration continues. Vigorous treatment in patients suffering from this disease is mandatory, because the interval from onset of symptoms to death is usually very short (30 min: 50%; 1 h: 70%; 6 h: more than 85%) [8, 13].

Surgical intervention was the only option in the past. In 1908 Trendelenburg [33] described pulmonary embolectomy with outflow occlusion. The use of inflow occlusion, described by Lewis [21], represents another alternative technique which does not require cardiopulmonary bypass. Cooley [4] first described successful pulmonary embolectomy performed on cardiopulmonary bypass in 1961. However, this approach is limited to a few, highly specialized surgical centers. A review of 651 cases of pulmonary embolectomy was performed by Del Campo in 1985 [6] and revealed a mortality rate of 40% for those carried out with, and 51% for those performed without, cardiopulmonary bypass. Although recently published material from 1986 to 1994 demonstrates a better outcome for the surgical approach of pulmonary embolism, with an average overall mortality rate of 26% (16–46%) [2, 3, 15, 20, 22, 24, 27, 31], these results justified the increasing use of thrombolytic agents for the treatment of pulmonary embolism.

Since the early 1970s, thrombolysis with urokinase and streptokinase has been introduced in the treatment of pulmonary embolism, and the mortality rate and recurrence of embolic episodes have decreased by 25% [25, 32, 34]. After the introduction of recombinant tissue-type plasminogen activator (rt-PA) as a thrombolytic agent, a more aggressive approach to pulmonary embolism was tested [11, 12, 23, 35]. Clinical experience shows that the resolution of the embolic material and the reduction of the thrombotic masses in the pulmonary trunk in patients in unstable circulatory conditions is frequently associated with a dramatic hemodynamic stabilization. Although data from a meta-analysis did not show even a slight trend towards improved survival with thrombolytic therapy, it still seems justified based on findings in hemodynamically unstable patients [18, 27]. Moreover, the short time interval between the necessity and institution of a therapy which is available everywhere has led to a broad acceptance of thrombolysis as the front line therapy in massive pulmonary embolism.

The results of the presented series treated with pulmonary embolectomy show comparable and, in some aspects, even better results in group I, if compared to the current surgical literature. In this group, operated between 1979 and 1989, the overall mortality rate was 26% and perioperative complications (22%) were non-fatal. The main predictive factor of outcome was pre-operative cardiac arrest and consecutive resuscitation prior to operation. In this group of 14 patients the mortality rate was 57.1% vs 4.5% in the group of 22 patients without preoperative cardiac arrest. It can be assumed that these patients would benefit most if therapeutic interventions were initiated directly after the onset of pulmonary embolism. Consequently, in the following years primary thrombolytic therapy has become the treatment of first choice.

The limitations of thrombolytic therapy and subsequent decision to operate remain essential for contraindications in this patient group. Bleeding, in particular cerebral bleeding with fatal or disabling outcome, represents the main hazard of thrombolytic therapy. With growing experience and understanding of the basic mechanisms of thrombolysis, most of the contraindications have been reevaluated and are now regarded as relative and of limited importance in patients with life-threatening thromboembolic disease [30]. Some authors recommend that, in a life-threatening thromboembolic state, thrombolytic therapy is not absolutely contraindicated even in cases of prolonged cardiopulmonary resuscitation, in the perioperative phase or in pregnancy [16, 18, 28]. On the other hand some conditions, such as active hemorrhage, recent cerebrovascular incident or neurosurgery within the past 3 months, known aortic aneurysm or active pancreatitis, are still regarded as absolute contraindications [17]. In these patients or if thrombolytic therapy fails, pulmonary embolectomy can still be performed with excellent results. It is clear that patient numbers for this indication are significantly smaller, consistent with our experience. From 1990 to 1994 pulmonary embolectomy was performed in only five patients (group II) after the failure of thrombolysis (3 patients) or absolute contraindication to thrombolytic therapy (2 patients). Early
results, in terms of hospital mortality or complication, did not differ from the outcome prior to this change in indication. Moreover, even long-term results show the same actuarial survival as the group treated earlier. Functional capacity also shows no differences to group I. In general, the results for all patients operated on with pulmonary embolectomy were excellent regarding functional class (NYHA) with the great majority of patients being in class I or II. Until now we have to resume that, in our experience, the second choice indication for pulmonary embolectomy does not result in a second choice outcome.

In conclusion, late results after pulmonary embolectomy in patients with acute fulminant pulmonary embolism are excellent in respect to functional class and late mortality. The early mortality is still high, and it is closely associated with preoperative cardiac arrest. Even in the age of thrombolytic therapy, pulmonary embolectomy remains a reasonable treatment in patients with contraindications to or failure of thrombolysis. Previous thrombolysis does not alter the perioperative risks, the occurrence of complications or late outcome.

References