Pulmonary Embolectomy by Catheter Device in Massive Pulmonary Embolism*

Jean-François Timait, M.D.; Philippe Reynaud, M.D.; Guy Meyer, M.D.; and Hervé Sors, M.D.

From 1982 to 1989, ECD was performed on 18 patients suffering from poorly-tolerated massive pulmonary embolism, for whom classic treatments (fibrinolytics and surgery) were impossible. Eleven of these 18 patients immediately improved (S group). This procedure was unsuccessful in other seven patients (F group). Thirteen patients survived (72 percent). The time lag between the first episode of pulmonary embolism and ECD was significantly shorter in the S group than in the F group (4.7 ± 5.4 days vs 18.3 ± 6.9 days, p = 0.0004). So was the elapsed time between the onset of hemodynamic impairment and ECD (13 ± 12 hours vs 59 ± 35 hours, p = 0.003). We conclude that ECD should be considered when other treatments are impossible especially when the first symptoms date back less than 15 days and the hemodynamic impairment less than 48 h.

Massive PE remains an important cause of mortality despite recent advances in medical therapy. In some cases, standard emergency therapies cannot be used because of age, contraindication or lack of CBP facilities. Other techniques like ECD must then be considered.

The first ECD attempts were performed on dogs in 1970.1,2 In most animals, pulmonary emboli could be removed resulting in a significant reduction of PAPm and PVR.5 In 1971, Greenfield et al6 reported the successful management of acute massive PE in two patients using ECD. In 1984, the same authors reported 26 attempts on patients suffering from massive PE.4 Clots were extracted in 23 patients (88 percent) and the overall long-term survival rate was 73 percent. We report here our experience with 18 consecutive patients submitted to this procedure from 1982 to 1989.

Materials and Methods

Patients

Over the past 7 years, 18 patients underwent ECD for massive PE. There were 9 men and 9 women, whose average age was 66 years (range, 34 to 78 years). A preexisting cardiovascular disease was present in 13 patients and included hypertension in 7 and ischemic heart disease in 6. A causative factor for PE was found in 15 patients and included surgery in 5 and medical disease in 10. Eleven patients had one or more recurrent PE episodes. The interval between the first clinical symptoms and ECD ranged from 1 to 30 days (mean, 10 days), while the time lag between the onset of hemodynamic impairment and ECD ranged from 4 h to 4 days.

From the Division of Pneumology and Intensive Care, Laennec Hospital, Paris, France. Manuscript received October 9; revision accepted January 22.

(mean, 30 h). On admission, 12 patients had acute shock with diffuse cutaneous vasoconstriction and peripheral cyanosis despite inotropic support. The other six had clinical symptoms of acute right ventricular failure and also required continuous inotropic support. Before ECD, two patients suffered cardiac arrest requiring closed-chest massage and were resuscitated.

Preoperative Investigations

The mean PAPm of the 17 patients who underwent preoperative right heart catheterization was 32 mm Hg (range, 22 to 54 mm Hg). The CI was measured by the thermodilution method in 11 patients and averaged 1.9 L/min/m² (range, 1.6 to 2.6 L/min/m²). Selective bilateral pulmonary angiography was performed in all patients and scored according to the method devised by Miller et al.7 The preoperative angiographic score averaged 26 (range, 21 to 31).

Indications for Embolectomy by Catheter Device

The indications for ECD were absolute contraindications to thrombolytic therapy in 13 patients (cerebral hematoma in 4, gastrointestinal hemorrhage in 2, recent surgery in 5, recent puncture of a noncompressive vessel in 4) and early failure of thrombolytic therapy in the other 5 patients (se, no clinical improvement within 2 to 3 h after initiating treatment). In all patients, pulmonary embolectomy under CBP was ruled out either because it was considered too hazardous or could not be performed on an emergency basis.

Technique

Following confirmation of the diagnosis by pulmonary angiogram, a right jugular or femoral venotomy was performed with the patient under local anesthesia. The catheter device (10 F, Meditech Inc, Watertown, MA) was inserted through the venotomy and positioned under fluoroscopy in the pulmonary artery. Injections of contrast media permitted direct visualization of the clots in the pulmonary arterial branches. Syringe suction on the catheter was used to capture emboli in the cup device. The catheter was then carefully withdrawn through the right side of the heart and out to the venotomy while maintaining syringe vacuum. When necessary, the procedure was repeated so as to improve clot extraction. Following embolectomy, a vena caval filter was inserted through the venotomy. Criteria used to assess the efficacy of ECD were aspiration of many fresh clots, immediate angiographic improvement and scintigraphic recovery within 48 h.

CBF = cardiopulmonary bypass; CI = cardiac index; ECD = embolectomy by catheter device; PAPm = pulmonary arterial mean pressure; PE = pulmonary embolism; PVR = pulmonary vascular resistance

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Follow-up

A formal follow-up of all discharged patients was carried out through hospital outpatient visits or by telephone interviews. Among the 13 patients discharged from the hospital, follow-up information was obtained from all but two. The mean follow-up was 43 months (range, 8 to 98 months).

Statistical Analysis

Univariate analysis of factors that might have affected the success (age, PAPm and time lags between first symptoms and ECD and between the onset of hemodynamic impairment and ECD) was performed by the nonparametric Wilcoxon test, the Fisher exact test or the Student t test as appropriate. The same tests were used to compare death rate and angiographic recovery.

RESULTS

Embolectomy by catheter device was attempted via the right jugular vein in 15 patients and via the right common femoral vein in 3.

In 11 patients (S group), clots between 3 and 17 cm long were removed at the time of the embolectomy which brought immediate clinical and angiographic improvement (Fig 1 [mean decrease in Miller index, 4; range, 3 to 5; p=0.05]). Two patients died, one of irreversible neurologic damage due to prolonged cardiac arrest prior to ECD and the other of irreversible septic shock due to postoperative peritonitis.

In seven patients, ECD was unsuccessful (F group). In two of them, ECD could not be carried out because of inferior vena caval configuration (one patient) or symptomatic ventricular arrhythmia during the passage of the catheter through the heart (one patient). In the other five patients, only small clot fragments were removed. Three patients of this group died from irreversible right heart failure and persistent shock during the postoperative course.

The overall mortality was 28 percent. In the F group, mortality was 43 percent as compared with 18 percent in the S group (p=0.33).

The time lags between the first clinical episode and ECD and between the ill-tolerated phase and ECD were significantly shorter in the S group than in the F group, while age, Miller index and preoperative PAPm did not differ between both groups (Table 1).

In the F group, two patients had PAPm >50 mm Hg attesting to chronic thromboembolism, although they presented no clinical evidence of this disease and the pulmonary angiogram disclosed a coexisting acute PE. One of them subsequently underwent a surgical embolectomy under CPB, enabling the removal of clots adhering to the right and left pulmonary arteries.

Two patients had reversible acute renal failure caused by shock and/or infusion of large doses of...
Table 1—Univariate Analysis of Risk Factors for ECD Failure*

<table>
<thead>
<tr>
<th>Results</th>
<th>F Group†</th>
<th>S Group‡</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>7</td>
<td>11</td>
<td>...</td>
</tr>
<tr>
<td>Age, yr</td>
<td>71 ± 3</td>
<td>63 ± 15</td>
<td>0.26</td>
</tr>
<tr>
<td>Miller Index</td>
<td>26 ± 3</td>
<td>26 ± 2</td>
<td>0.92</td>
</tr>
<tr>
<td>Time lag, days§</td>
<td>18 ± 7</td>
<td>5 ± 5</td>
<td>0.0004</td>
</tr>
<tr>
<td>Time lag, hours∥</td>
<td>59 ± 38</td>
<td>13 ± 12</td>
<td>0.003</td>
</tr>
<tr>
<td>PAPm, mm Hg</td>
<td>39 ± 12</td>
<td>30 ± 5</td>
<td>0.07</td>
</tr>
</tbody>
</table>

*Values expressed as mean ± SD.
†F group = ECD failures.
‡S group = ECD successes.
§Time lag between first clinical symptoms and ECD.
∥Time lag between onset of hemodynamic impairment and ECD.

contrast medium and five suffered from hematomas in the groin area requiring hemostasis with the patient under local anesthesia. No patient had hemorrhagic pleural effusion, ventricular perforation or rupture of pulmonary arteries during ECD or recurrent embolism in the postoperative course.

Two patients of the S group and one of the F group died 8, 27 and 63 months, respectively, after ECD as a result of cancer (one patient), recurrent PE (one patient) and unknown cause (one patient). Among the eight survivors on whom follow-up information was available, six showed no signs of cardiac or pulmonary functional limitation and two patients complained of exertional dyspnea (one in the S group and one in the F group).

**Discussion**

Currently, thrombolysis is widely accepted as the front-line treatment for hemodynamically compromised patients with massive PE (ie, Miller index >20) provided this treatment is not contraindicated.6 Embolectomy by catheter device may be considered for shocked patients for whom thrombolytic therapy is contraindicated or has failed and surgical embolectomy under CBP seemed hazardous.

During a 7-year period, 18 out of about 1,700 patients (1 percent) who were referred to our institution for confirmed PE underwent ECD. Thirteen patients survived and five (28 percent) died during the hospital stay. The procedure was successful in extracting clots in 11 patients and even if it did not result in massive de-obstruction, it yielded immediate clinical improvement. In massive PE, the relationship between PVR and pulmonary vascular obstruction shows a hyperbolic tendency with a major increase in PVR when vascular obstruction exceeds 60 percent.7 In hemodynamically compromised patients, even a small decrease in vascular obstruction is usually associated with a major and sustained clinical improvement.

Our results are in line with the findings of Greenfield and Langham4 who reported a significant clot extraction in 23 out of 26 patients and an in-hospital mortality rate of 27 percent, which is very similar to that of pulmonary embolectomy under CBP.8,9 This latter procedure carries a higher mortality in patients more than 70 years old or with previous cardiopulmonary diseases, preoperative cardiac arrest or shock.10 These patients are poor candidates for surgical embolectomy and should, in our opinion, be offered ECD when medical therapy is contraindicated. In addition, ECD could be an alternative to surgical embolectomy when the full heparinization required by CBP is contraindicated. Finally, it may be preferred for the most compromised patients when CBP facilities are unavailable and referral to a surgical center seems hazardous. These limitations and the fact that few medical centers have gained experience in ECD may account for the infrequent use of this technique and the scarcity of published material.

Embolectomy by catheter device failed to significantly reduce vascular obstruction in 5 of our 18 patients. Our results indicate that failures are mainly associated with chronic PE resulting from multiple embolic episodes. This is suggested by a longer clinical history and a somewhat higher mean PAPm in the patients who did not benefit from the procedure. In these patients, the presence of organized and adherent thrombi in the pulmonary arteries is probably the main cause of ECD failure. Therefore, in an attempt to improve the efficacy of this method, ECD ideally should be performed on patients with a recent and massive PE (ie, first symptoms within the last 15 days and last clinical episode within the 48 h preceding the angiography) and a PAPm less than 50 mm Hg.

Additional measures which could improve efficacy and safety are: (1) prior institution of a partial bypass in the angiography room or at bedside in the most severely compromised patients; (2) addition of a fiberoptic system in the ECD catheter to visualize the thrombi under angioscopy and allow a better approximation of the cup device to the embolus;11 (3) use of a flexible plastic sleeve for percutaneous introduction of the ECD catheter in order to reduce the blood loss at the puncture site during the removal of the ECD catheter.

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**References**


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