Outcome of pulmonary embolectomy for acute pulmonary thromboembolism: analysis of 32 patients from a multicentre registry in Japan

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Abstract

OBJECTIVE: Massive pulmonary embolism is relatively rare but a potentially life-threatening condition. The purpose of this study was to analyse the outcome of pulmonary embolectomy in registered data from the Japanese Society of Pulmonary Embolism Research (JaSPER).

METHODS: From 1994 to 2006, 1661 cases of acute pulmonary embolism were registered in the JaSPER database. Retrospective analysis of 32 patients undergoing pulmonary embolectomy was conducted. The overall incidence of pulmonary embolectomy was 1.9% [95% confidence interval (CI): 1.8–3.2%]. The mean age of patients was 57 years and 66% were female.

RESULTS: Overall mortality of pulmonary embolectomy was 18.8% [95% CI: 5.2–25.6%]. Most of the patients had massive or submassive pulmonary thromboembolism, and three patients experienced cardiopulmonary arrest before embolectomy. Ten patients received preoperative percutaneous cardiopulmonary bypass, and mortality was 30% in this subgroup.

CONCLUSIONS: Pulmonary embolectomy is an effective therapeutic option for patients with massive or submassive pulmonary embolism. Prompt triage of patients with haemodynamic instability is important.

Keywords: Massive pulmonary thromboembolism • Pulmonary embolectomy • Percutaneous cardiopulmonary bypass • Fibrinolysis

INTRODUCTION

Pulmonary embolectomy is an important therapeutic option for acute massive or submassive pulmonary thromboembolism (PTE). Although it is only feasible in tertiary cardiovascular centres, the chance of survival is increasing owing to improved transportation, advances in life support technology, and quick triage using computed tomography (CT) and echocardiography. Most patients with massive PTE die within several hours after onset; however, approximately half of cases of massive PTE occur in the hospital, so there is a longer therapeutic window for intervention in these patients [1]. With prompt intervention, there is still a chance to save critically ill PTE patients who have haemodynamic instability. Fibrinolysis for massive and submassive PTE is effective in reducing right ventricular (RV) load but it remains controversial for improvement of survival [2]. The risk of bleeding such as intracranial haemorrhage is the most serious adverse effect of fibrinolytic therapy [3,4].

Although surgical pulmonary embolectomy requires administration of anticoagulant agents, the haemorrhagic burden is light since the cardiopulmonary bypass time is usually less than 90 min. We analysed the outcome of surgical embolectomy collected in a multicentre registry in Japan.

PATIENTS AND METHODS

From 1994 to 2006, the Japanese Society of Pulmonary Embolism Research (JaSPER) conducted retrospective registration of pulmonary embolism patients every 4 years in Japan. Questionnaires were sent to institutes attending JaSPER, and data were collected from 60 institutes. Acute pulmonary embolism was defined as the acute onset of illness with duration of less than 2 weeks. Collected data were recorded in the database. The database included the following categories: patient characteristics including age, sex, body mass index, hospitalization before onset, predisposing factors and underlying disorders; symptoms at onset including dyspnoea, chest pain, cough, haemoptysis, leg swelling or syncope; preoperative haemodynamics including shock (systolic blood pressure <80 mmHg) or cardiopulmonary arrest (CPA); and preoperative treatment including anticoagulant administration, fibrinolysis (t-PA, urokinase), artificial ventilation, catheter embolectomy, percutaneous cardiopulmonary support (PCPS) or insertion of a caval filter [inferior vena cava (IVC) filter]. Diagnostic modalities for pulmonary embolism such as echocardiography, perfusion scintigraphy, CT, magnetic resonance angiography and pulmonary angiography were also recorded. Thirty-day mortality was evaluated as the study outcome. Causes
of death and complications were not recorded. Among 1661 cases registered in the database, we found 32 patients who underwent pulmonary embolectomy for PTE. Retrospective analysis of these 32 patients was performed. The overall incidence of pulmonary embolectomy was 1.9% [95% confidence interval (CI): 1.8–3.2%; Table 1]. There were 432 patients having CPA or shock in JaSPER registry. Therefore, incidence of massive/submassive PTE was 25.5% (423 of 1661) and incidence of pulmonary embolectomy in massive/sub-massive PTE was 7.57% (95% CI: 5.0–8.9%). Patient characteristics are shown in Table 2. The mean age of patients was 57 years, ranging from 18 to 82 years. There were 21 females (66%) and 11 males (34%).

RESULTS

Analysis of the predisposing factors for PTE showed that 20 patients had underlying disorders including cerebrovascular accident in four, malignancy in three, pelvic tumour in two and hip joint operation in two. There were 17 patients who had PTE during hospitalization and 15 patients who had out-of-hospital PTE. Sixteen patients had a recent history of surgery, and eight patients (25%) had a history of bed rest longer than 1 week due to stroke, fracture or other reasons (Fig. 1). Preoperative symptoms and haemodynamics are shown in Fig. 2. There were three patients (9%) who had CPA, 23 patients (72%) developed shock, three patients (9%) who were normotensive with RV dysfunction and three patients (9%) with an unknown haemodynamic condition (Fig. 2). The diagnosis of PTE was made by enhanced chest CT in 21 patients, echocardiography in 14, pulmonary angiography in 13, lung perfusion scintigraphy in nine and transoesophageal echocardiography in three. The current trend for the use of procedures to diagnose pulmonary embolism has shifted from perfusion scintigraphy to echocardiography and chest CT (Fig. 3a).

There were six deaths (operative mortality 18.8%; 95% CI: 5.2–25.6%). The relationship between preoperative haemodynamic status and mortality is shown in Table 2.

Fibrinolytic therapy was attempted but failed in eight patients before embolectomy, and two patients who had preoperative fibrinolysis died after embolectomy. PCSP was introduced before embolectomy in 10 patients. Three patients died but seven patients survived in this subgroup (operative mortality 30%). The mortality of patients with preoperative CPA was 33.3% (Fig. 3b). A perioperative IVC filter was inserted in 15 of 23 patients (57.7%) who survived, but in only one of six patients (16.7%) who died.

DISCUSSION

Pulmonary embolectomy for acute massive PTE was accompanied by high mortality in the past, ranging from 20 to 57% in studies published before 1990 [5–12]. Most previous studies reported mortality above 30%. However, more recent reports indicated that outcome could be improved by triage based on RV dilatation and the use of early aggressive surgical

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**Table 1: Number of patients undergoing pulmonary embolectomy in JaSPER database**

<table>
<thead>
<tr>
<th>Survey</th>
<th>Registration term</th>
<th>Embolectomy</th>
<th>Acute PTE</th>
<th>Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>1994.11–1997.10</td>
<td>7</td>
<td>309</td>
<td>2.3</td>
</tr>
<tr>
<td>2nd</td>
<td>1997.11–2000.9</td>
<td>7</td>
<td>257</td>
<td>2.7</td>
</tr>
<tr>
<td>3rd</td>
<td>2000.10–2003.8</td>
<td>10</td>
<td>456</td>
<td>2.2</td>
</tr>
<tr>
<td>4th</td>
<td>2003.9–2006.8</td>
<td>8</td>
<td>639</td>
<td>1.3</td>
</tr>
<tr>
<td>Total</td>
<td>1994.11–2006.8</td>
<td>32</td>
<td>1661</td>
<td>1.9 [95% CI: 1.8–3.2]</td>
</tr>
</tbody>
</table>

PTE, pulmonary thromboembolism; 95% CI, 95% confidence interval.

**Table 2: Patient characteristics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Alive (n = 26)</th>
<th>Dead (n = 6)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>57.8 ± 17.2</td>
<td>55.5 ± 17.5</td>
<td>ns</td>
</tr>
<tr>
<td>Female gender</td>
<td>18</td>
<td>3</td>
<td>0.33</td>
</tr>
<tr>
<td>Out-of-hospital onset</td>
<td>11</td>
<td>4</td>
<td>0.27</td>
</tr>
<tr>
<td>Preoperative haemodynamics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPA</td>
<td>2</td>
<td>1</td>
<td>0.48</td>
</tr>
<tr>
<td>Shock</td>
<td>18</td>
<td>5</td>
<td>0.45</td>
</tr>
<tr>
<td>PCPS use before embolectomy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perioperative IVC filter</td>
<td>15</td>
<td>1</td>
<td>0.086</td>
</tr>
<tr>
<td>Preoperative fibrinolysis</td>
<td>6</td>
<td>2</td>
<td>0.48</td>
</tr>
<tr>
<td>Preoperative EVT</td>
<td>5</td>
<td>0</td>
<td>0.42</td>
</tr>
</tbody>
</table>

EVT, endovascular treatment (catheter embolectomy).

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**Figure 1:** Predisposing factors for pulmonary thromboembolism.

**Figure 2:** Preoperative symptoms and haemodynamics. (a) Symptoms at the onset of PTE. (b) Haemodynamics at onset. Patients who had PCPS due to refractory shock or CPA were included in the PCPS group. Patients with shock and RV dysfunction were included in the shock group. PCPS, percutaneous cardiopulmonary bypass.
intervention. Stein et al. [13] reviewed 1300 cases of pulmonary embolectomy in the literature from 1961 to 2006 and reported that overall mortality was 30%; however, the mortality of surgical embolectomy after 1985 was improved to 20%. Since the mortality of patients with preoperative CPA was as high as 59% compared with 29% for patients without CPA, they emphasized the importance of rapid triage and early surgical intervention for patients with unstable haemodynamics due to acute massive or submassive PTE [13]. Several recent studies have reported excellent outcomes for surgical embolectomy: Vohra et al. [14] reported 19% mortality in 21 patients; Kadner et al. [15] reported 8% mortality in 25 patients; Leacchee et al. [16] reported 6% hospital mortality and 3-year survival of 83% in 47 patients; and Fukuda et al. [17] reported hospital mortality of 5.3% and 10-year survival of 84% in 19 patients.

This study elucidated the following facts for surgical pulmonary embolectomy in Japan: (i) the incidence of pulmonary embolectomy in registered PTE patients was approximately 2%; (ii) the operative mortality of surgical embolectomy was 18.8% despite the fact that most of the patients were critically ill, including three patients with preoperative CPA and 10 patients with preoperative PCPS; (iii) although PCPS is usually introduced in the situation where haemodynamics or the respiratory condition has deteriorated, the mortality of these severely ill patients was only 30%.

The problem of management of acute massive PTE is the narrow therapeutic window for the salvage of critically ill patients. It is estimated that approximately 10% of patients with symptomatic PTE die within 1 h of onset [18]. Kucher et al. [19] demonstrated poor outcome and high incidence of recurrence in massive PTE in patients from an international registry. They showed the following: (i) the 90-day mortality rate of massive PTE was 52.4%; (ii) most deaths occurred within several days after onset; and (iii) recurrent PTE was observed in 12.6% of patients with massive PTE. They recommended the need for rapid transfer to a specialized cardiovascular centre to perform specific management of PTE including insertion of an IVC filter, PCPS, catheter embolectomy and surgical embolectomy. In hospitalized patients, prompt triage is becoming popular using echocardiography and enhanced CT. Tokyo’s critical care unit (CCU) network reported that the median time from symptom onset to CCU admission for massive PTE was only 3.9 h [1].

PCPS is widely used in emergency departments in Japan to provide circulatory support for haemodynamic instability caused by acute myocardial infarction, severe arrhythmia, congestive heart failure or pulmonary embolism. In massive PTE, PCPS is recommended as an important heart-lung support [20]. The use of cardiopulmonary bypass for pulmonary embolism is not new. Gibbon proposed this concept for the treatment of severe pulmonary embolism in 1937. The concept of ‘portable cardiopulmonary bypass’ was introduced by Cooley et al. in 1961 [21]. The success of PCPS as a bridge to pulmonary embolectomy has been reported in both Japan and the UK [22,23].

In this study, 25% of patients received fibrinolytic therapy before embolectomy; however, mortality in this group was 25% (two of eight). Meneveau et al. [24] analysed the outcome of repeated thrombolytic therapy and surgical pulmonary embolectomy among 40 patients in whom initial thrombolytic therapy failed. They found that surgical embolectomy improved the in-hospital course of patients with massive PTE who did not respond to fibrinolysis. Although patients who undergo fibrinolysis have a risk of bleeding, rescue pulmonary embolectomy is justified as there is no effective alternative procedure. Management of bleeding is very important in this situation.

Recurrence of acute PTE is the most important cause of death in patients who survived the initial episode of acute PTE. An IVC filter is one of the options to prevent recurrence of PTE. Kucher et al. [19] demonstrated that the recurrence rate of PTE in patients receiving an IVC filter was significantly lower than in patients without an IVC filter. Sakuma et al. [25] demonstrated the same result from analysis of multicentre registry in Japan. In this study, only 57.7% of survived patients underwent periparative IVC filter insertion. Since the indication and adequate timing of IVC filter insertion is not known in this group of patients, further investigation of these issues is necessary.

In conclusion, pulmonary embolectomy is effective as a life-saving operation for acute massive and submassive pulmonary embolism patients who are contraindicated to fibrinolytic therapy or have failure of fibrinolysis.

Limitations of the study

Data were collected retrospectively from a data registry (JaSPER). The endpoint for analysis was 30-day survival after pulmonary embolectomy. Although avoidance of neurological complications due to cardiopulmonary collapse is an important goal as well as

Figure 3: Preoperative diagnostic procedures and treatments. (a) The diagnostic procedures in each period of data collection. (b) Preoperative treatment and survival. EVT, endovascular treatment.
survival, information on neurological complications was not collected in the database.

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Conflict of interest: none declared.

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