Short-term results of retrograde pulmonary embolectomy in massive and submassive pulmonary embolism: a single-center study of 30 patients

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Received 7 April 2011; received in revised form 31 May 2011; accepted 7 June 2011; Available online 8 July 2011

Abstract

Objective: Surgical pulmonary embolectomy is usually reserved for critically ill patients with pulmonary embolism. The conventional antegrade technique of embolectomy may miss peripheral clots, rendering the patient amenable to developing pulmonary hypertension. Here, we present our experience with a new retrograde pulmonary embolectomy supplementing the current antegrade technique.

Methods: From January 2004 through December 2010, 30 consecutive patients underwent pulmonary embolectomy in our center. The study included 15 men and 15 women whose age ranged from 28 to 80 years, with mean age of 58 ± 15 years. All the patients except one were taken to the operating room with at least one imaging modality confirming the presence of a large thrombus in pulmonary-arterial vasculature.

Results: The most common presenting symptoms of patients was dyspnea (n = 27, 90%). The major indications for surgery were severe hemodynamic or respiratory compromise (n = 11, 36%). After performing antegrade embolectomy, retrograde flushing of the pulmonary veins was done. The in-hospital mortality in our study was 6.6% (2/30). Mean intubation time for the patients was 52.7 ± 36.5 h, with a range of 12—120 h. Mean intensive care unit (ICU) admission for the patients was 7 days with a range of 2—60 days.

Conclusions: As far as we know, this is the largest series of cases published so far regarding the immediate results of retrograde pulmonary embolectomy. This technique can successfully dislodge the remaining clots in distal pulmonary vasculature not directly visualized. Surgical pulmonary embolectomy is a safe method and should not be used as a last resort for patients with pulmonary embolism.

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Keywords: Pulmonary embolism; Outcome of retrograde pulmonary embolectomy; Retrograde pulmonary embolectomy

1. Introduction

Despite advances in diagnosis and therapy of acute pulmonary embolism, it is still associated with a high mortality and morbidity rate, with overall early mortality rates ranging between <1% and over 60% according to clinical severity [1—4]. The mainstay of therapy for pulmonary embolism is anticoagulation, mostly with heparin. Other treatment options include thrombolysis, catheter embolectomy and surgical embolectomy [1—7]. Surgical embolectomy is usually reserved either for those patients with massive pulmonary emboli, who present with cardiogenic shock (<5% of all patients) or those who are unresponsive to thrombolytic therapy or have contraindication for thrombolytic therapy [1—7].

Surgical embolectomy is however reported to be associated with high mortality rate, ranging from 16% to 64% [3]. The cause of death is usually right-ventricular failure, persistent pulmonary hypertension, pulmonary edema or massive parenchymal and intrabronchial hemorrhage [6]. Moreover, even if the patient has acceptable immediate result, the current antegrade technique of opening the main pulmonary trunk and removal of the clot may miss more peripheral clots and hence render the patient amenable to developing pulmonary hypertension [6,8—11]. Retrograde pulmonary embolectomy is a complementary surgical technique for removal of clots in pulmonary vasculature in addition to the conventional antegrade one. Although the technique of pulmonary vein flushing was first proposed long ago, it has not gained widespread use among surgeons. In this article, we present our experience with a new complementary retrograde pulmonary embolectomy technique performed on 30 consecutive patients who had acute massive and submassive pulmonary embolism.
2. Patients and method

From January 2004 through December 2010, 30 patients with massive and submassive pulmonary embolism underwent pulmonary embolectomy either after a trial of medical thrombolysis with streptokinase or without initiation of thrombolysis. The study included 15 (50%) men and 15 women whose ages ranged from 28 to 80 years, with mean age 58 ± 15 years. Risk factors for development of pulmonary emboli are presented in Table 1. In only two patients, deep venous thrombosis was confirmed preoperatively, and others had clinical findings of deep venous thrombosis. In three patients, no specific risk factor was found.

The most common presenting symptoms of patients were dyspnea, followed by chest pain and syncope (Table 2). Note that some patients had simultaneous symptoms. Eleven patients developed severe hemodynamic and/or respiratory compromise either before or during diagnostic work-ups, and three of them developed cardiac arrest and hence were emergently, within a few hours, taken to the operating room; one patient was taken to the operating room while resuscitation was still being done. As many as 19 patients had less critical condition and, therefore, the surgical option was not immediately considered for them; 10 were given intravenous thrombolytic therapy and, when no clinical or echocardiographic improvement was observed, were taken to the operating room, either urgently within 24—48 h or semi-electively within 3—5 days, as dictated by their clinical condition. The other nine patients were not given intravenous thrombolysis because of contraindications, such as recent surgery or large patent foramen ovale and, therefore, because of symptom severity were either urgently or semi-electively taken to the operating room. Indications for surgery are summarized in Table 3.

Echocardiography (either transthoracic or transesophageal) was performed in 24 patients (85%), chest computed tomography (CT) scan in 23 patients (82%) and pulmonary angiography in one patient. The patients were taken to operating room with at least one imaging modality confirming the presence of a large thrombus in either the main pulmonary artery or one of the two main branches. One exception was the patient who had a cardiac arrest in the emergency room who, with strong clinical suspicion of pulmonary embolism, was taken to the operating room without any imaging study. In all the patients who underwent echocardiography, moderate to severe dysfunction of the right ventricle and elevated pulmonary-artery pressure (defined as systolic pulmonary-arterial pressure above 30 mmHg) was noted. Three patients underwent coronary artery bypass grafting (CABG) simultaneously with embolectomy, as one patient was scheduled for CABG before and the other two underwent coronary angiography during diagnostic work-ups, leading to the detection of coronary artery disease. One patient underwent Bentall procedure, as she had large ascending aortic aneurysm detected in echocardiography. An inferior-vena-cava filter was inserted for one patient intra-operatively. All the patients were anticoagulated with unfractioned heparin and then warfarin, if they survived.

The plan to supplement the conventional antegrade embolectomy method with our unique retrograde technique was first discussed in the department of cardiac surgery. It was then approved by the Ethics Committee of Shiraz University of Medical Sciences and first performed in 2004 on a critically ill patient. The surgical plan was discussed with either the patient or their caretakers and informed consent was obtained.

3. Surgical technique

The chest was entered through a median sternotomy. Total cardiopulmonary bypass (bivacal cannulation) was initiated. First, the right atrium and the right ventricle were inspected for evidence of clot. Then, the main pulmonary artery was opened distal to the pulmonary valve and the incision was extended up to the bifurcation of the artery. The clots were removed by means of atrumatic forceps, bolus saline flush and suction. After performing conventional embolectomy, the interatrial septum was opened through an incision made on the area corresponding to fossa ovalis, and atrial septostomy was done. The pulmonary vein orifices in the left atrium were identified, and an endotracheal tube of size 5-French to 5.5-French (with its cuff inflated) was inserted in each one by one. Afterward, oxygenated blood was infused from the pump with a mean pressure of 30—45 mmHg for 60—120 s to each pulmonary vein. The pulmonary veins filled with blood in a retrograde fashion, and blood and small thrombi fragments began to appear in the pulmonary artery and were washed out. For each vein, 750—1000 ml of oxygenated blood was infused by the pump in 1—2 min; hence, a total of 4000 ml of oxygenated blood was infused through the pulmonary veins in 8 min. The atrial septal defect was closed, and the pulmonary-artery pressure before and after cardiopulmonary bypass was recorded.

Table 1. Risk factors for pulmonary emboli.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep vein thrombosis</td>
<td>14 (46%)</td>
</tr>
<tr>
<td>Surgery</td>
<td>7 (23%)</td>
</tr>
<tr>
<td>Cancer</td>
<td>2 (7%)</td>
</tr>
<tr>
<td>Hypercoagulability</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>Smoking</td>
<td>1 (3%)</td>
</tr>
<tr>
<td>None</td>
<td>3 (10%)</td>
</tr>
</tbody>
</table>

Table 2. Presenting symptoms of patients.

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyspnea</td>
<td>27 (90%)</td>
</tr>
<tr>
<td>Chest pain</td>
<td>7 (23%)</td>
</tr>
<tr>
<td>Syncope</td>
<td>2 (7%)</td>
</tr>
</tbody>
</table>

Table 3. Indications for surgery.

<table>
<thead>
<tr>
<th>Indication</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe hemodynamic compromise</td>
<td>11 (36%)</td>
</tr>
<tr>
<td>Lack of response to thrombolysis</td>
<td>10 (30%)</td>
</tr>
<tr>
<td>Contraindication for thrombolysis</td>
<td>7 (23%)</td>
</tr>
<tr>
<td>Patent foramen ovale</td>
<td>2 (6%)</td>
</tr>
</tbody>
</table>
4. Results

During the operation, all the patients had clots in the main pulmonary artery with varying degrees of extension to one or both main branches and even in smaller branches. Two patients had a thickened pulmonary arterial wall, which could be a sign of previous organized emboli. The in-hospital mortality was 6.6% (2/30); a 60-year-old woman died during the operation due to severe right-ventricular dysfunction and a 79-year-old man after 2 months of intensive care unit (ICU) stay due to renal and heart failure. Another patient, a 65-year-old man, died after 6 months due to renal-cell-cancer-related complications.

Postoperative complications included one patient who had wound infection and dehiscence and stayed in the ICU for 2 months and finally died due to renal and heart failure; other patients had acceptable postoperative course and were discharged.

Mean intubation time for the patients, excluding the one who died during the operation, was 52.7 ± 36.5 h, with a range of 12–120 h. The mean ICU admission period for the patients was 7 days, with a wide range of 2–60 days.

5. Discussion

As far as we know, this is the largest series of cases published so far regarding the immediate results of retrograde pulmonary embolectomy in massive pulmonary embolism. Surgical pulmonary embolectomy was first performed in 1961 and involved introduction of a suction tip into the pulmonary artery and compression of the lungs repeatedly to remove the peripherally lodged emboli. This technique may cause pulmonary-arterial-wall injury and massive endobronchial injury [9,12,13]. Nowadays, this antegrade technique of pulmonary embolectomy is the method of choice in many centers, with some modifications including avoidance of lung compression and direct visual clot removal to minimize the risk of pulmonary-artery injury [3,7,14,15]. Retrograde pulmonary embolectomy was first performed in 1966 but, since then, it was not widely used till 2004, when a few cases were reported [6,9,16,17]. The largest series published so far is by Spagnolo et al., who performed antegrade pulmonary embolectomy supplemented by retrograde technique on 21 patients, with no in-hospital mortality [6]. Retrograde pulmonary embolectomy can successfully dislodge the remaining clots in distal pulmonary vasculature not directly visualized. This will help to prevent consequent pulmonary hypertension due to remaining clots without mechanical injury to pulmonary arterial wall with devices, such as gallbladder stone forceps or Fogarty catheters [6,8,9]. Retrograde pulmonary embolectomy will also minimize the risk of distal air embolism, as proposed by Spagnolo et al. to be a possible cause of subsequent lung injury [6].

Our technique is unique in this aspect that we create an atrial septal defect and therefore directly visualize the orifice of the pulmonary veins and then flush them one by one. This technique is shown to evacuate more clots and may prevent consequent pulmonary hypertension as a result of the organization of the remaining clots, while the passive filling of the left atrium, performed by other authors, may not be as efficacious [8]. The pressure used for retrograde filling of the pulmonary veins was about 15–17 mmHg in the earlier cases, as it seemed to be an acceptable pressure for pulmonary vasculature; but, later, we gradually increased the pressure to 30–45 mmHg and the time of infusion to 120 s to evacuate more clots without any side effects [8].

A review of published reports reveal that the results of surgical pulmonary embolectomy have improved, with mortality rates decreasing from 57% in the 1960s to 26% in 1990s and 6–8% in 2000s [3]. Mortality rates for surgical pulmonary embolectomy increase to 30–45% when surgery is performed on critically ill patients, who have massive pulmonary embolism. This rate increases to 60–80% for those who develop cardiac arrest before operation [3,6,7]. It has been suggested that this high death rate is the consequence of reserving pulmonary embolectomy as a treatment of last resort for patients in severe shock and for those patients in whom less invasive forms of treatment have failed [6]. The causes of death in patients who undergo pulmonary embolectomy have been attributed to right-heart failure secondary to persistent pulmonary hypertension, intra-alveolar and interstitial pulmonary edema with normal left-sided pressures, and massive parenchymal and intrabronchial hemorrhage [6]. In our study, the in-hospital mortality rate was nearly 6.6% (2/30), which was well within the range of mortality rate of recent series [3,6,7]. One patient who died during operation had experienced cardiac arrest prior to that and was undergoing resuscitation while being transported to the operating room, and the other one died after 2 months of ICU stay, due to heart and renal failure.

Another issue worth mentioning is the indication of surgery for pulmonary embolism. While current guidelines still propose thrombolytic therapy as the preferred therapy for patients with pulmonary embolism, recent studies have debated this recommendation [1,2,5]. Previously, surgical embolectomy was the last choice because of high mortality rates but with improvement in surgical techniques and, hence, mortality rates, surgical embolectomy can safely be performed with acceptable results in patients with massive and even submassive embolism [3,6,7]. Although very few studies have compared medical versus surgical treatment for pulmonary emboli, it seems that surgical treatment can be safely used in these patients [6]. In our study, we performed surgical embolectomy for 11 patients (36%) before any attempt for thrombolysis, and the overall mortality and morbidity was acceptable.

In our university hospitals, the above-mentioned guideline is quite followed; while thrombolytic therapy is given to patients with massive and submassive pulmonary embolism who have hemodynamic and/or respiratory compromise, right-ventricular dysfunction and positive troponin, those with contraindications for thrombolytic therapy, lack of response to thrombolytic therapy or those who are critically ill are usually given surgical options. However, with improved surgical results observed in recent years in our university hospitals and in many studies performed in other institutions and the strong debate current surrounding the validity of current guidelines, more patients, especially the ones showing signs of hemodynamic compromise, are referred to cardiac surgeons as first line, and the need for comparing
the outcome of surgical and medical therapy in the management of pulmonary embolism is truly felt.

Finally, it can be concluded that surgical pulmonary embolectomy, especially if complemented by the retrograde technique, is a safe method and should not be used as a last resort for patients with pulmonary embolism. The immediate and long-term results of retrograde embolectomy should be further assessed in prospective studies and compared with optimal medical therapy to establish this method as a routine surgical technique and a possible safe alternative to medical therapy.

References