Atrial Septal Aneurysm Plus a Patent Foramen Ovale*

A Predisposing Factor for Paradoxical Embolism and Refractory Hypoxemia During Pulmonary Embolism

Philippe Estagnasi, MD; Kannel Djeendar, MD; Generici Le Bourdelles, MD; François Coste, MD; and Didier Dreyfuss, MD

We report three consecutive cases of patients who had refractory hypoxemia and paradoxical embolism during the course of pulmonary embolism. Transesophageal echocardiography showed an atrial septal aneurysm and a patent foramen ovale in all patients. The latter was detected by an early and massive passage of contrast from the right to the left atrium. We suggest that the presence of an atrial septal aneurysm plus a patent foramen ovale greatly enhances both magnitude of shunting and the risk of systemic embolism. The presence of an atrial septal aneurysm plus a patent foramen ovale should be considered and checked using transesophageal echocardiography in every patient with significant pulmonary embolism.

(CHEST 1996; 110:846-48)

Key words: atrial septal aneurysm; paradoxical embolism; patent foramen ovale; pulmonary embolism; refractory hypoxemia

A patent foramen ovale may be responsible for severe hypoxemia due to shunting when the right atrial pressure exceeds the left atrial pressure1 and for paradoxical embolism,2 especially during pulmonary embolism.3 The relative rarity of these complications, despite the very frequent occurrence of both pulmonary embolism4 and patent foramen ovale,5 is intriguing. This may suggest that there is a predisposing factor in patients experiencing these complications. An atrial septal aneurysm, described as a bulge in the fossa ovalis, is also a known cause of cardiac embolism.2 This malformation could greatly enhance the risk of complication during pulmonary embolism. Nevertheless, there have been no reports, to our knowledge, of the association of a patent foramen ovale and an atrial septal aneurysm being a risk factor of both severe hypoxemia and paradoxical embolism during pulmonary embolism.4 This may be because transesophageal echocardiography was not routinely practiced in previous studies. Transesophageal echocardiography is the best technique available today for detecting an atrial septal aneurysm.6,7 Nevertheless, even recent publications on the state of the art of transesophageal echocardiography do not mention the documentation of an atrial septal aneurysm during pulmonary embolism.8 Our report describes three patients with pulmonary embolism who suffered from refractory hypoxemia and stroke. Trans-

References
7 Couser JJ, Make BJ. Transtracheal oxygen decreased inspired minute ventilation. Ann Rev Respir Dis 1989; 139:627-31

*From Service de Réanimation Médicale, Hôpital Louis Mourier, Colombes, France.
Manuscript received September 28, 1995; revision accepted March 26, 1996.
Reprint requests: Dr. Dreyfuss, Service de Réanimation Médicale, Hôpital Louis Mourier, 92700 Colombes, France

846
Selected Reports
With pulmonary bilateral to-left shunt of the left atrium, several cerebral infarctions. Reports of this patient were compelling, and a few days later of refractory collapse. Autopsy confirmed severe bilateral pulmonary fibronectin emboli and showed the presence of both large atrial septal aneurysm and patent foramen ovale.

**DISCUSSION**

We believe this to be the first transesophageal echocardiography study of pulmonary embolism complicated by the association of severe hypoxemia and paradoxical embolism. The fortuitous discovery of an atrial septal aneurysm plus a massive right-to-left shunt through a patent foramen ovale in patient 1 prompted the systematic check for these two anatomic abnormalities using transesophageal echocardiography with contrast in the next two patients who presented with similar symptoms (cases 2 and 3). Transesophageal echocardiography showed a patent foramen ovale with an

---

**Table 1—Pressures, Blood Gas Analyses, and Venous Admixture Values**

<table>
<thead>
<tr>
<th>Patient</th>
<th>PAPd, mm Hg</th>
<th>RAP, mm Hg</th>
<th>PAOP, mm Hg</th>
<th>S02, %</th>
<th>QVA/QT, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28</td>
<td>14</td>
<td>11</td>
<td>68</td>
<td>31 (0.6)</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>13</td>
<td>13</td>
<td>85</td>
<td>51 (1)</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>8</td>
<td>6</td>
<td>74</td>
<td>63 (1)</td>
</tr>
</tbody>
</table>

*PAPd=diastolic pulmonary artery pressure; RAP=mean right atrial pressure; PAOP=mean pulmonary artery occlusive pressure; S02= mixed venous oxyhemoglobin saturation; QVA/QT=venous admixture calculated using standard formula: QVA/QT=(Cv02-Ca02)/(Cc'02-Ca02), where Cv02 is the pulmonary end-capillary O2 content, CaO2 is the arterial O2 content, and Cc'02 is the mixed venous O2 content.

1Numbers in parentheses indicate the FIO2.

---

**Figure 1.** Transesophageal four-chamber scan. Atrial septal aneurysm (arrows) bulging into the left atrium (LA). RA=right atrium; RV=right ventricle; LV=left ventricle.

**Figure 2.** Transesophageal four-chamber scan. Massive right-to-left passage of microbubbles from right atrium (RA) to left atrium (LA) and left ventricle (LV). Atrial septal aneurysm (arrows) bulging into LA. RV=right ventricle.
early and massive passage of contrast and an oscillating atrial septal aneurysm bulging into the left atrium in all three cases. No other source of cardiogenic embolism was found. All the patients died a few days later.

Patent foramen ovale and atrial septal aneurysm are both common and independent sources of cardiogenic embolism.\textsuperscript{2} Autopsy studies indicate that the incidence of patent foramen ovale in the general population is as high as 25%. A patent foramen ovale may open every time right atrial pressure exceeds left atrial pressure, such as during pulmonary embolism, during right ventricular infarction,\textsuperscript{3} or during mechanical ventilation using positive end-expiratory pressure.\textsuperscript{11} In view of the frequency of pulmonary embolism\textsuperscript{5} and patent foramen ovale,\textsuperscript{3} the low incidence of documented cases of severe right-to-left shunting through a patent foramen ovale and of paradoxical embolism during pulmonary embolism may seem astonishing. In most instances, hypoxemia during pulmonary embolism is due to the increased intrapulmonary shunt, the ventilation-perfusion inequalities, and the decreased mixed venous oxygen content.\textsuperscript{12} Moreover, systemic embolization seldom seems to be a complication of pulmonary embolism.

This discrepancy may be due to the need for another condition to be present in patients who suffer such dismal complications. An atrial septal aneurysm, which occurs less frequently, but which is strongly correlated with the presence of patent foramen ovale,\textsuperscript{3} may be this extracondition. Atrial septal aneurysm is detected in only 0.2 to 0.5% of unselected patients undergoing transthoracic echocardiography and in 4 to 10% of stroke cases.\textsuperscript{2} Although transthoracic echocardiography has detected the presence of an atrial septal aneurysm in some instances, this malformation usually is much more easily visualized by transesophageal echocardiography.\textsuperscript{6} This may explain why earlier reports failed to identify atrial septal aneurysm as being strongly associated with paradoxical embolism during pulmonary embolism. We suggest that a very large communication between the right and left atria may be created if an atrial septal aneurysm is associated with a patent foramen ovale. These anatomic features may be responsible for both refractory hypoxemia and paradoxical embolism in cases of elevated right-side pressures. The importance of right-to-left shunting in the three cases described here is indicated by the stroke and the massive and early passage of contrast during transesophageal echocardiography. Contrast administration has proved safe, even in the case of right-to-left shunting\textsuperscript{10} and is superior to monoplane color Doppler imaging, which is angle dependent, for detecting transatrial shunting.\textsuperscript{13} A thrombus may also be trapped more easily inside an atrial septal aneurysm bulging into the left atrium, which is the most frequently anatomically described pattern,\textsuperscript{14} as it was in our three patients.

The severity of these complications, especially brain embolism, is a strong incentive for early detection of these anatomic abnormalities of the atrial septum during pulmonary embolism. However, it is difficult to justify performing transesophageal echocardiography in every patient with pulmonary embolism in search of atrial septal aneurysm and patent foramen ovale, given the rarity of a systemic embolism as compared with the frequency of patent foramen ovale. Because an atrial septal aneurysm associated with a patent foramen ovale may be a strong indicator of an impending systemic embolism, it may be wise to detect it before this complication occurs in patients whose pulmonary embolism is severe enough to be associated with significant elevation of right atrial pressure. If an attempt at visualization with a transthoracic approach is not rewarding because of poor resolution, which is often the case in critically ill mechanically ventilated patients, transesophageal echocardiography should be promptly carried out. This would allow early attempts at closure of the patent foramen ovale by pharmacologic\textsuperscript{15} or invasive means,\textsuperscript{16} although the latter may be at high risk in such patients.

REFERENCES