

A. Vieillard-Baron
S.D. Qanadli
Y. Antakly
T. Fourme
Y. Loubières
F. Jardin
O. Dubourg

Transesophageal echocardiography for the diagnosis of pulmonary embolism with acute cor pulmonale: a comparison with radiological procedures

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A. Vieillard-Baron (✉) · T. Fourme ·
Y. Loubières · F. Jardin
Intensive Care Unit,
Hôpital Ambroise Paré,
9 avenue Charles de Gaulle,
F-92104 Boulogne Cedex, France
Fax: +331 49 09 58 92

S. D. Qanadli
Department of Radiology,
Hôpital Ambroise Paré,
9 avenue Charles de Gaulle,
F-92104 Boulogne Cedex, France

Y. Antakly · O. Dubourg
Department of Cardiology,
Hôpital Ambroise Paré,
9 avenue Charles de Gaulle,
F-92104 Boulogne Cedex, France

Abstract *Objective:* The goal of the study was to assess prospectively the value of transesophageal echocardiography (TEE) for the diagnosis of massive pulmonary embolism complicated by acute cor pulmonale.

Design: A prospective study conducted on 44 consecutive patients.

Setting: A general intensive care unit (ICU) of a university hospital.

Patients and methods: Between May 95 and October 96, 44 consecutive patients with clinically suspected acute pulmonary embolism underwent transthoracic echocardiography (TTE), completed by TEE when acute cor pulmonale was present (30 patients). The results of the echocardiographic studies were compared with radiological investigations by helical CT or contrast angiography.

Results: The high sensitivity and specificity of the presence of acute cor pulmonale on TTE for the diagnosis of pulmonary embolism was confirmed. Nineteen patients only underwent TEE. The sensitivity and the specificity of TEE in detecting a

proximal pulmonary embolism were 84% and 84%, respectively. Its main limitation concerned the left pulmonary artery, in which only one thrombus was visualized by TEE whereas six were present on helical CT, and lobar pulmonary arteries which could not be visualized with TEE. Thus, the overall sensitivity of TEE for the detection of pulmonary embolism with acute cor pulmonale was only 58%.

Conclusion: In comparison with radiological procedures, TEE had limited accuracy for detecting pulmonary embolism with acute cor pulmonale. When the pulmonary embolism was located in the main or right pulmonary artery, TEE could clarify the diagnosis within a few minutes without further invasive diagnostic procedures. However, a negative TEE did not exclude left proximal or lobar pulmonary embolism.

Key words Pulmonary embolism · Transesophageal echocardiography · Acute cor pulmonale · Helical CT

Introduction

Thrombolytic therapy has proved to accelerate reperfusion greatly when the pulmonary artery is occluded by a recent thrombus [1, 2]. In massive pulmonary embolism with circulatory failure, the use of fibrinolytic agents may thus be useful as soon as the diagnosis is established. However, the conventional diagnostic procedure

using contrast angiography may be hazardous in these patients [3, 4] and sometimes we have observed severe worsening of circulatory failure during angiography. Several studies have established the high accuracy of helical CT for the diagnosis of massive pulmonary embolism [5, 6] and since then we have given preference to helical CT over angiography whenever pulmonary embolism is associated with circulatory failure or acute

cor pulmonale. However, helical CT requires that the patient be taken to the Department of Radiology and moving him involves a small risk of recurrent embolism. Thus, should bedside evaluation for pulmonary embolism be available simultaneously with the start of hemodynamic support, this would be the best technique in critically ill patients (particularly in mechanical ventilated patients) because of speed and reduced risk.

Some studies demonstrated that the bedside diagnosis of acute cor pulmonale using transthoracic echocardiography (TTE) had a good positive predictive value for massive pulmonary embolism [7, 8]. However, since other clinical conditions may produce acute cor pulmonale [9], thrombolysis, with its risk of severe bleeding, cannot be instituted without direct visualization of the thrombus and this may be achieved using transesophageal echocardiography (TEE) [10–12]. Because TEE is a non-invasive technique, several investigators have proposed its use at the bedside to diagnose pulmonary embolism with acute cor pulmonale [13, 14].

The purpose of the present study was to assess prospectively the reliability of echocardiographic examination, including TTE and TEE, for the diagnosis of massive pulmonary embolism. Echocardiographic data were compared with helical CT or contrast angiography, as reference methods.

Material and methods

Patients

Forty-four patients, 17 men and 27 women, mean age 64 years (range 20–89 years), with clinical suspicion of acute pulmonary embolism were studied prospectively from May 95 to October 96. Standard chest X-rays, ECG and blood gas anomalies were compatible with the diagnosis. All patients were hospitalized in the Intensive Care Unit (ICU) or in the Department of Cardiology. Patients were excluded if they had previous cardiopulmonary disease or contraindications of iodinated contrast agents.

The study was approved by the Ethics Committee of our hospital.

Echocardiography

All patients underwent TTE at admission and, when an echocardiographic pattern of acute cor pulmonale was present, the echocardiographic study was completed by a TEE. TTE was performed with an ATL CX 200 interfaced with a 2.5 MHz transducer. The diagnosis of acute cor pulmonale was based on the presence of a right ventricular/left ventricular area ratio greater than 0.6 at end-diastole on an apical four-chamber view associated with paradoxical motion of the interventricular septum and a right ventricular free wall thickness less than 7 mm, as previously described [9].

TEE was performed with the same echograph using a multi-plane 5 MHz probe. Patients were placed on the left side after superficial anesthesia of the pharynx with 2% lidocaine spray. The hemodynamic and respiratory statuses of the patients were moni-

tored and oxygen was delivered through a nasal tube. The main pulmonary artery and the right pulmonary artery were visualized on the long- and short-axis views and, thereafter, the probe was rotated back about 90° to visualize the left pulmonary artery. The intravascular thrombotic clots were divided into two types according to the Wittlich classification: type A mobile thrombi and type B wall-adherent thrombi [15].

All investigations were videotaped and were interpreted by an experienced echocardiographer. Radiological studies were independently interpreted by a radiologist.

Radiological studies

Helical CT is used as the reference method at Ambroise Paré hospital when acute cor pulmonale is present. It was performed on CT-Twin Scanners (Elscont, Haifa, Israel) within 24 h following TEE using the following parameters: collimation, 5 mm; table speed, 5 mm/s (pitch: 1.5). The acquisition volume ranged from the base of the lung to the aortic arch. The effective slice thickness was 2.7 mm reconstructed at 1.3 mm intervals. One hundred fifty milliliters of 25% iodinated contrast material was injected at a rate of 4 ml/s. The scanning time was 21 s in apnea if possible. The direct signs of pulmonary embolism were partial or complete filling defects, railway track or mural defect. When helical CT was not possible or negative, or when there was no acute cor pulmonale, the patient underwent a conventional contrast pulmonary angiography, using the transfemoral venous approach and Seldinger's technique. Two selective angiograms (anteroposterior and oblique projections) were obtained for each lung.

Statistics

Sensitivity, specificity and negative and positive predictive values of the TEE were calculated for the global diagnosis of pulmonary embolism, proximal pulmonary embolism and thrombi in the right and main pulmonary artery.

Results

Transthoracic echocardiography

An echocardiographic pattern of acute cor pulmonale was present in 30 patients (68%) and a thrombus visualized in the right atrium in one of them. In the remaining 14 patients, echocardiographic study was normal.

Transesophageal echocardiography

Of the 30 patients with an acute cor pulmonale, TEE was not available in 9 for technical reasons (no experienced echocardiographer in emergency or patients without empty stomach), one patient refused TEE examination and failure to introduce the probe occurred in the last patient. TEE was thus performed in 19 patients with documented acute cor pulmonale by TTE, without serious side-effects. No patient was intubated because of the procedure. The main pulmonary artery

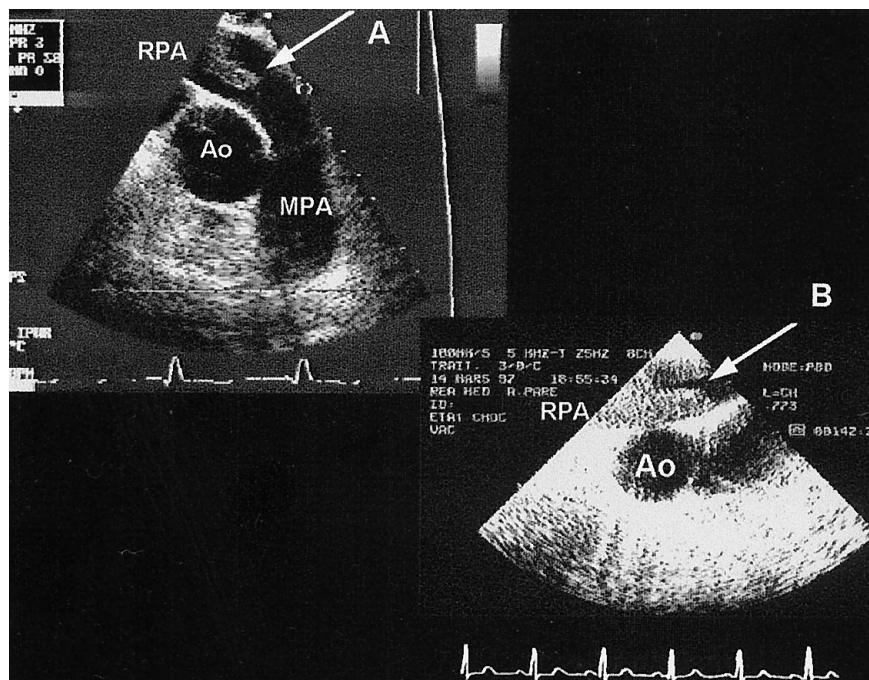


Fig. 1 Example of the two types of thrombus at TEE. **A** Mobile thrombus in the right pulmonary artery, **B** motionless, wall-adherent thrombus in the right pulmonary artery

and its right branch were easily visualized but the left pulmonary artery could not be visualized beyond its first 2 cm. TEE revealed suggestive intraluminal thrombi in 12 of the 19 patients (63%): in the right pulmonary artery in 11 patients, in the right, left and main pulmonary arteries in 1 patient. Among these 14 intraluminal thrombi, 10 were mobile (71%) and 4 motionless, wall-adherent (29%). Examples of a mobile and a wall-adherent thrombus are given in Fig. 1.

Radiological study

Helical CT (17 cases) or conventional contrast angiography (2 cases where helical CT was not possible) was performed in the 19 patients who underwent TEE. Pulmonary embolism was present in all patients: 13 had proximal pulmonary embolism (68%) and 6 had lobar pulmonary embolism (32%). There were 19 intraluminal thrombi: 12 in the right pulmonary artery, 1 in the main, and 6 in the left pulmonary artery.

A helical CT (ten patients) or a conventional contrast angiography (one patient) was performed in patients with acute cor pulmonale on TTE and in whom TEE was not available. Pulmonary embolism was present in ten patients: proximal in three patients, lobar in five and segmental and bilateral in two. Pulmonary

embolism was absent in one patient, who actually had aortic dissection. Conventional contrast angiography was performed in the 14 patients in whom TTE was normal. Pulmonary embolism was present in six patients (43%): two proximal, three lobar and one segmental.

Diagnostic value of transesophageal echocardiography

TEE revealed proximal pulmonary embolism in 12 patients. In one patient with a lobar pulmonary embolism on helical CT, an intraluminal artifact was present, mimicking a wall-adherent thrombus at the posterior face of the right pulmonary artery (one false-positive). TEE was normal in seven patients: five patients had a lobar pulmonary embolism and the two remaining patients had thrombi in the right and left pulmonary artery, respectively (two false-negatives). The sensitivity and specificity of TEE were 84% and 84%, respectively, for the diagnosis of proximal pulmonary embolism (one false-positive and two false-negatives). No lobar pulmonary embolism was diagnosed on TEE. Thus, sensitivity for the global diagnosis of pulmonary embolism with acute cor pulmonale was 58% (Fig. 2).

If only the main and right pulmonary arteries were considered, the sensitivity and specificity of TEE were 92% and 86%, respectively. On the other hand, because of the interposition of the left main bronchus, TEE visualized only one of the six thrombi in the left pulmonary artery seen on helical CT.

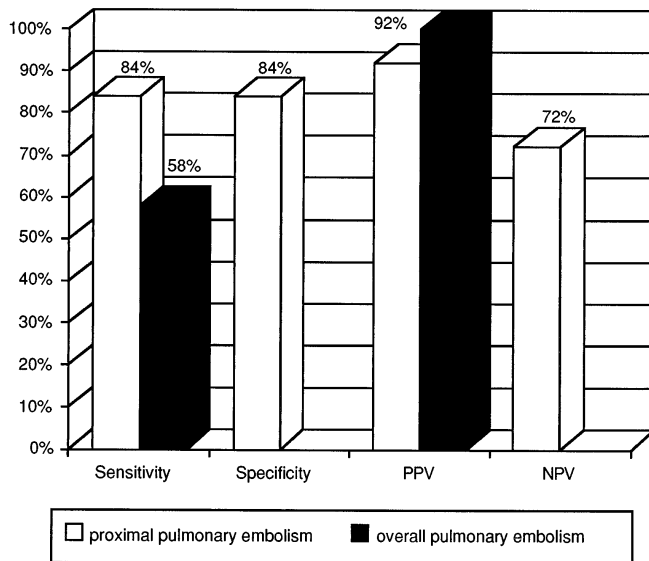


Fig.2 Diagnostic value of TEE; *PPV* positive predictive value, *NPV* negative predictive value

Discussion

In our Intensive Care Unit, many of our diagnostic procedures have made great strides forward due to the systematic use of bedside echocardiography [16]. For example, in a patient exhibiting a poor hemodynamic or respiratory tolerance, the echocardiographic demonstration of acute cor pulmonale, usually obtained within a few minutes, immediately suggests massive pulmonary embolism (7–9) and raises the question of thrombolytic therapy. Although it has not been demonstrated that thrombolysis improves final recovery in massive pulmonary embolism [17], this therapy makes patients more comfortable and, by accelerating pulmonary artery reperfusion, reduces acute cor pulmonale within several hours [1], which otherwise persists more than 1 week [8]. However, acute cor pulmonale may occur in clinical settings other than pulmonary embolism [9] and the initiation of thrombolysis requires visualization of the thrombus in the pulmonary circulation or in the right cavities. This is seldom obtained by TTE, but more often by TEE [10–13]. Consequently, some investigators have proposed the bedside use of TEE to diagnose massive pulmonary embolism and justify thrombolytic therapy [13, 14].

In the present study, the sensitivity of an echocardiographic pattern of acute cor pulmonale on TTE for the diagnosis of lobar or proximal pulmonary embolism was 90%, close to the 85% reported by Kasper et al. [18]. Transthoracic echocardiography visualization of thrombus in the right atrium was unfrequent (one case), as also reported by Wittlich et al. [15]. The sensitivity and specificity of TEE in proximal pulmonary

embolism were 84% and 84%, respectively, and 92% and 86%, respectively, when the main and the right pulmonary arteries were involved. Wittlich et al. [15] reported a high diagnostic accuracy of TEE in detecting proximal pulmonary embolism when compared to pulmonary angiography (sensitivity and specificity of 96% and 88%, respectively). Pruszczyk et al. reported a sensitivity and specificity of 80% and 100%, respectively [19]. In a recent study, Steiner et al. reported a sensitivity and a specificity of 82% and 92%, respectively, for the diagnosis of proximal pulmonary embolism [20]. When overall pulmonary embolism producing acute cor pulmonale is considered, and not only proximal embolism, the sensitivity of TEE decreased to 58%, close to the 59% sensitivity reported by Steiner et al. [20]. This poor sensitivity results from the lack of detection of proximal embolism in the left pulmonary artery and the inability of the technique to study lobar pulmonary arteries.

The left pulmonary artery was rarely visualized beyond its first 2 cm because of the interposition of the left main bronchus. Using a multiplane probe did not give us better results than those obtained by others, with either single plane [20] or biplane [15] probes. However, Pruszczyk et al. [19], using a single plane, had good results in detecting thrombi located in the distal part of the left pulmonary artery. Another limitation of the method might be an artefact at the level of the posterior wall of the right pulmonary artery simulating a wall-adherent thrombus. This artefact was responsible for a false-positive diagnosis in our study. The artefacts described by Wittlich and Steiner had the same appearance [15, 20]. The question of whether the use of a biplane or a multiplane transesophageal probe would improve specificity requires additional study.

Among the 14 intraluminal thrombi at TEE, 10 were mobile (71%) and 4 motionless, wall-adherent (29%). These results are identical with Wittlich's study (69–85% of the thrombi were mobile).

TEE study in a dyspneic patient may be cumbersome and worsen the respiratory status. TEE was a safe procedure in our series (with the exception of one patient in whom probe introduction failed) as well as in those of Wittlich and Pruszczyk. In critically ill patients, some investigators have proposed combining mechanical ventilation with TEE [19]. The greatest care should be taken in doing so, because mechanical ventilation, by increasing right ventricular afterload [21], may markedly worsen the circulatory status in massive pulmonary embolism and induce sudden cardiac arrest.

Our study group is small, so a careful interpretation of the results is required. However, the diagnostic value of TEE in massive pulmonary embolism is close to the results in others studies [15, 19, 20]. The choice of helical CT as the reference method may not have an impact on our results. Indeed, all patients with acute cor pulmo-

nale have lobar or proximal pulmonary embolism, which can be accurately diagnosed by helical CT [5, 6], and not subsegmental pulmonary embolism where helical CT can be criticized.

In conclusion, despite a limited accuracy for detecting overall pulmonary embolism in patients with acute cor pulmonale, TEE, when positive, can clarify the diagnosis of proximal pulmonary embolism at the bedside within a few minutes. This method reduces the need of

further diagnostic procedures, such as helical CT or contrast angiography. TEE can also exclude other causes simulating clinical pulmonary embolism, such as right ventricular dysfunction or pericardial tamponade. TEE is of special interest for mechanically ventilated patients in whom radiological procedures can be invasive. However, a negative TEE does not exclude pulmonary embolism and a radiological study is essential for complete diagnosis.

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