

# Massive Cerebral Infarction Caused by Paradoxical Embolism: Detection by Transesophageal Echocardiography

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Two days after coronary artery bypass, a 75-year-old woman had sudden dense left-sided hemiplegia. A transthoracic echocardiogram showed a suspicious mass in the right atrium and right ventricle, which was confirmed by transesophageal echocardiography. Transesophageal echocardiography further demonstrated an elongated mass across a patent foramen ovale. Deep femoral venous thrombosis and massive cerebral infarction were also noted by Doppler ultrasonography and head computed tomographic scanning, respectively. Paradoxical embolization was thought to be the cause of the stroke. (J AM SOC ECHOCARDIOGR 1995;8:563-6.)

Although paradoxical embolism has been a well-described entity for more than a century as a complication of right to left intracardial shunting, the diagnosis has been largely presumptive in many cases.

The capabilities of echocardiography, particularly transesophageal echocardiography, have greatly increased the reliability of making the diagnosis in the appropriate clinical setting. The case presented reports a patient who had a stroke as a result of a paradoxical embolus after coronary artery bypass. The diagnosis was made by transesophageal echocardiography.

## CASE REPORT

A 75-year-old woman with a history of hypertension was seen with chest pain and subsequently found to have an inferior wall myocardial infarction. Cardiac catheterization demonstrated triple-vesel disease, and she underwent five-vessel coronary artery bypass. Two days after surgery, the patient was noted to have sudden-onset dense left-sided hemiplegia. An initial head computed tomographic (CT) scan revealed a probable infarct in the territory of the right middle cerebral artery.

Transthoracic echocardiography was done the next day,

and an ill-defined mass was noted in the right atrium and right ventricle. Transesophageal echocardiography was recommended for better definition of the cardiac mass. With a Hewlett-Packard 5 MHz, 64-element, rotational-array omniplane probe (Hewlett-Packard Co., Andover, Mass.), a large lobulated mass consistent with a thrombus was noted astride a patent foramen ovale (PFO). Portions were noted in both atria and both ventricles (Figure 1). The interatrial septum was also noted to bulge toward the left atrium throughout the cardiac cycle. A tricuspid regurgitant velocity of 2.5 m/sec indicated elevated right-sided pressures. No color flow could be demonstrated across the interatrial septum with the mass in situ, and no contrast study was performed.

Repeat head CT scan within 48 hours confirmed a definite large area of infarction in the territory of the right middle cerebral artery, with significant mass effect and compression of the lateral ventricles (Figure 2). Doppler ultrasonography of the lower extremities showed extensive deep venous thrombosis of the right femoral veins (Figure 3). Her condition continued to deteriorate neurologically and she had significant respiratory distress necessitating endotracheal intubation. Because her condition was deemed terminal, no further studies were performed. She died on the fourth postoperative day. The family declined an autopsy. The echocardiographic diagnosis was paradoxical embolization of a large thrombus across a PFO with a resulting massive cerebral vascular accident.

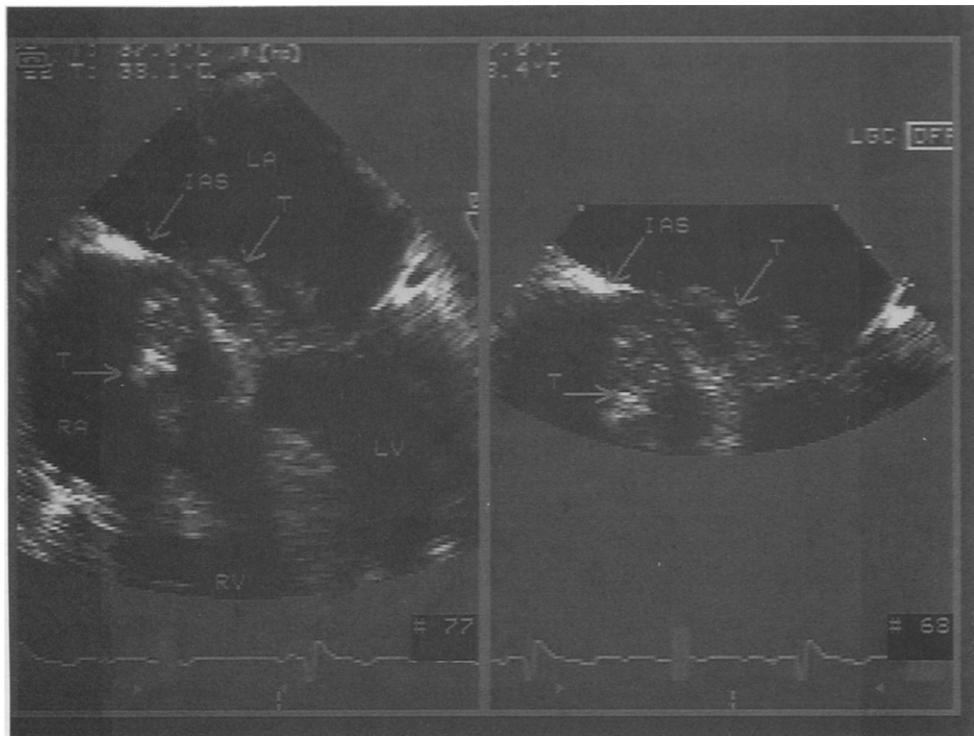
## DISCUSSION

The advent of echocardiography and particularly transesophageal echocardiography has greatly facil-

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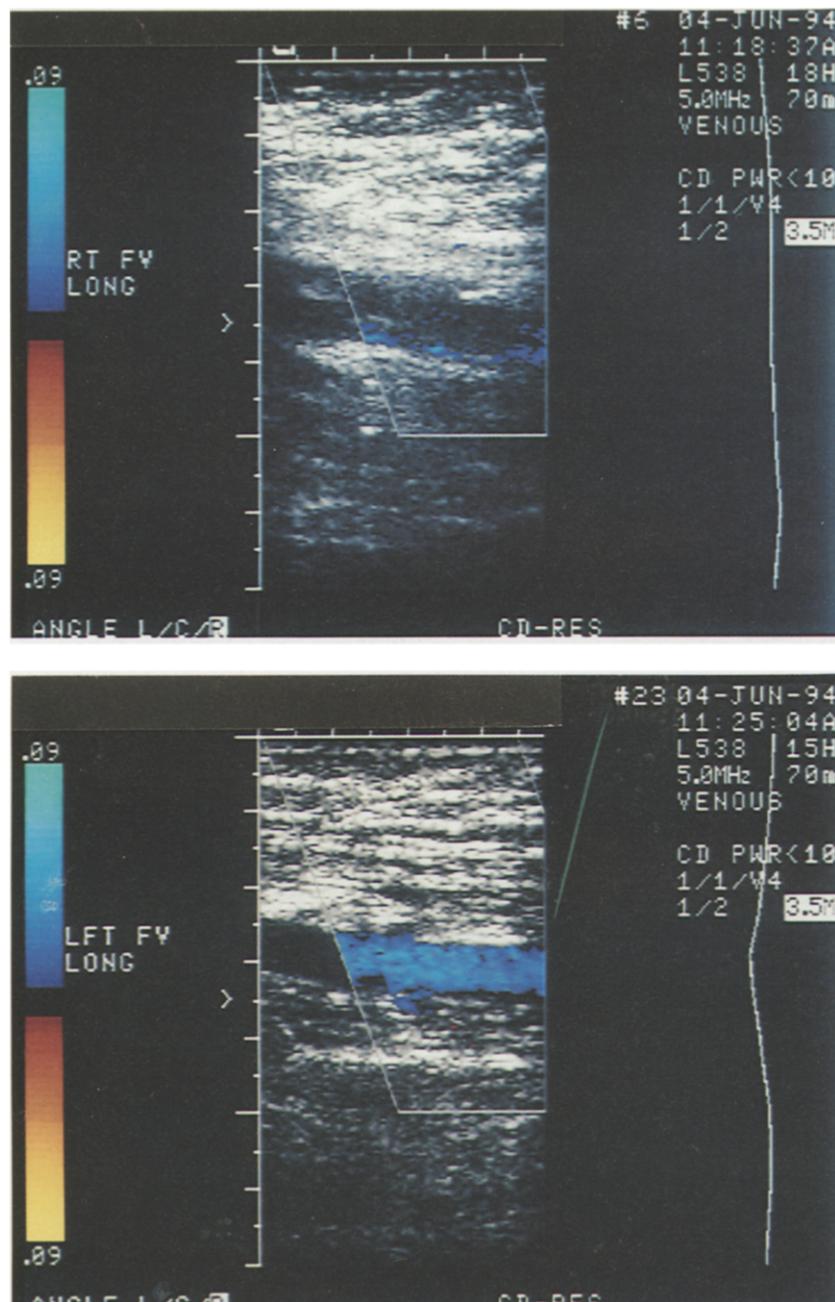
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**Figure 1** Transesophageal echocardiogram demonstrates thrombus (*T*) present with right ventricle (*RV*), right atrium (*RA*), across interatrial septum (*IAS*), and into left atrium (*LA*) and left ventricle (*LV*).



**Figure 2** CT scan of head demonstrates large area of infarction in right middle cerebral artery territory with midline shift and compression of lateral ventricles.



**Figure 3** Color-flow mapping of right and left femoral veins demonstrates venous thrombosis in right femoral vein (RT FV) with marked reduction in flow (flow is shown in blue). Left femoral vein (LFT FV) appears normal by comparison.

tated the diagnosis of paradoxical embolism. Transesophageal echocardiography allows clearer visualization of the interatrial septum and, combined with microbubble contrast studies, is currently the gold standard for detection of PFO.<sup>1</sup>

Four criteria must be met to satisfy the diagnosis

of paradoxical embolism, as first described by Cohnheim<sup>2</sup> in 1877: (1) venous thrombosis, (2) an abnormal communication between right and left circulations, (3) evidence of systemic embolization, and (4) pressure gradient favoring right to left shunting at some point during the cardiac cycle. The most

definite diagnostic criterion is finding a thrombus lodged across the intracardiac shunt.<sup>2</sup>

The most common intracardiac shunt associated with presumptive and definite cases of paradoxical embolus is PFO in 72% of cases.<sup>3</sup> This case satisfies all the criteria for the diagnosis of paradoxical embolism. Few reports have actually documented definitive diagnosis of impending paradoxical embolus. In these patients a thrombus across a PFO was diagnosed and confirmed at surgery.<sup>4-6</sup>

In the absence of right ventricular systolic hypertension, three mechanisms might be operative in causing right to left shunting in patients with PFO. These include the following: (1) transient spontaneous reversal of left to right atrial pressure differential during the cardiac cycle, (2) sustained elevation of right atrial pressure above left atrial pressure induced by respiratory maneuvers, and (3) aberrant flow redirection across the foramen ovale as a result of a large right atrial mass.<sup>7</sup>

In a study comparing younger adults with stroke and control subjects, the high prevalence of PFO suggested paradoxical embolism as a cause, particularly when no other cause was found. The control group included patients undergoing contrast echocardiography studies before neurosurgical procedures to exclude right to left intracardiac shunting, which might predispose to air embolism. Peripheral venous thrombosis was thought to be clinically silent in about 50% of the cases of stroke. Factors that may predispose to venous thrombosis such as immobility after major surgery may be expected to increase the number of cases.<sup>8</sup>

In this patient with peripheral venous thrombosis

and cerebral infarction, transesophageal echocardiography allowed direct visualization of a mass consistent with thrombus crossing a PFO. A pathophysiological mechanism of paradoxical embolism is suggested.

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