

Transesophageal Echocardiography in the Intensive Care Unit: Impact on Diagnosis and Decision-Making

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Summary: Transesophageal echocardiography (TEE) is widely used in the management of patients in intensive care units. The present study assesses the specific value of this technique in various categories of these patients. We reviewed 113 studies performed in 100 such patients for: suspected aortic dissection (25), suspected endocarditis (33), source of emboli assessment (19), hemodynamic instability (15), and miscellaneous (21). TEE provided diagnostic information in all patients with aortic dissection, in 53% of the cases with hemodynamic instability, in 50% of the cases with septic states with high likelihood of endocarditis, and in 29% of the cases where the question was the source of emboli. When the clinical probability for endocarditis was low, all transesophageal echocardiograms performed in septic patients were negative. The information provided by TEE was considered crucial in one-third of the positive cases; in about one-half of these special cases, the results were instrumental for further surgical management. There were no significant side effects related to the procedure. TEE is easily performed in the intensive care unit setting and yields useful information in almost half of the cases. Special benefit is expected in suspected aortic disease, hemodynamic instability, suspected endocarditis, and embolic events. The overall yield as screening procedure in febrile patients is low.

Key words: echocardiography, transesophageal, intensive care, aortic dissection, emboli, endocarditis, hypotension

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Introduction

Transesophageal echocardiography (TEE) has emerged as a powerful diagnostic tool,¹⁻⁴ and the advent of biplane probes has improved its yield.^{5, 6} Patients in the intensive care unit (ICU), in particular, should benefit from the diagnostic capabilities of TEE. In many of these patients, conventional transthoracic echocardiography (TTE) provides low-quality images because of technical constraints related to limited mobilization, mechanical ventilation, or postoperative status. In addition, some of these patients have clinical conditions for which TEE is recognized as especially useful, such as aortic dissection,^{7, 8} prosthetic valve dysfunction,⁹ or hypotension.¹⁰ The use of TEE in the intensive care unit has been reported in both the adult^{11, 12} and pediatric population,¹³ but its precise value in the various categories of patients in ICUs has not been systematically addressed. This study evaluates the use of TEE in these patients at Stanford University Medical Center.

Methods

Patient Population

TEE studies, consecutively performed between June 1988 and August 1991 in 103 intensive care unit patients, were retrospectively reviewed. Complete medical records were unavailable in three of these patients. Therefore, the study population consisted of 100 patients (age 58 ± 17 , 54 men, 46 women) who underwent 113 transesophageal studies. Results of transthoracic studies obtained prior to the transesophageal study were available in 64 cases. The following clinical and echocardiographic variables were reviewed: (1) intensive care unit setting (general medical, coronary, surgical); (2) reason for intensive care unit admission; (3) reason for the study; (4) time from intensive care unit admission to transesophageal study; (5) ventilatory and hemodynamic status at time of the study; (6) TEE results; (7) complications; (8) data from available complimentary studies (TTE, computed tomography, magnetic resonance imaging, angiography) performed either before or after the transesophageal study; (9) surgery or autopsy results. Five categories of indications for TEE were defined: (1) suspected aor-

tic disease; (2) suspected infective endocarditis (IE): patients in this group had a persisting, unexplained septic state that raised the suspicion of endocarditis; (3) source of emboli in patients with well documented systemic embolic events; (4) hemodynamic instability in which the study was requested because of unexplained hypotension; and (5) miscellaneous: patients with various clinical presentations, each of them represented in too small numbers to qualify for a separate category. The yield of TEE was defined in each category as the percentage of studies that either (a) had positive findings, with diagnostic and/or therapeutic implications in a given clinical situation; (b) confidently excluded a diagnosis making further investigation or treatment unnecessary. Studies in which findings were unexpected or had a potential major impact on subsequent patient management were considered to provide crucial diagnostic information and were recorded as a separate category.

Transesophageal Echocardiography Imaging

Studies were performed at bedside using a 5 MHz transducer mounted on the end of a 100 cm gastroscope (Hewlett Packard Co. Medical Products GR, Andover, Mass.). The first 87 studies were performed with a monoplane probe and the remaining 26 were performed with a biplane probe (14.3 mm width at tip). Nasogastric tubes were withdrawn if there were any difficulties inserting the TEE probe. Sedation with midazolam or fentanyl and, occasionally, paralysis with pancuronium were used in awake or agitated patients. In awake patients, the posterior pharynx was anesthetized with a commercially available spray containing benzocaine 14% and tetracaine 2% (Cetacaine®). Awake, nonintubated patients were placed, whenever possible, in left lateral decubitus position—as recommended for any TEE study—to protect the airway. Blood pressure, heart rate, and oxygen saturations were carefully monitored. Antihypertensive medication was supplemented, if needed, in patients with aortic dissection.

Results

A total of 113 studies were reviewed in 100 patients. Of these, 59 (52%) were performed in the cardiovascular surgery ICU, 39 (34%) in the medical ICU, and 15 (13%) in the coronary care unit. Twenty-five studies were requested for aortic dissection, 33 for suspected endocarditis, 19 for source of emboli, 15 for hemodynamic instability, and 21 for various reasons (Fig. 1). The average time interval from admission to the intensive care unit and the TEE study was 10 ± 16 days (range 1–90 days). Seventy-four studies (65%) were performed during mechanical ventilation.

Transesophageal Echocardiography Findings

Of the 113 studies, 51 showed findings that were considered significant, accounting for an overall yield of 45%.

Aortic disease group: Twenty-five patients with either known or suspected aortic dissection or rupture were studied. TEE was

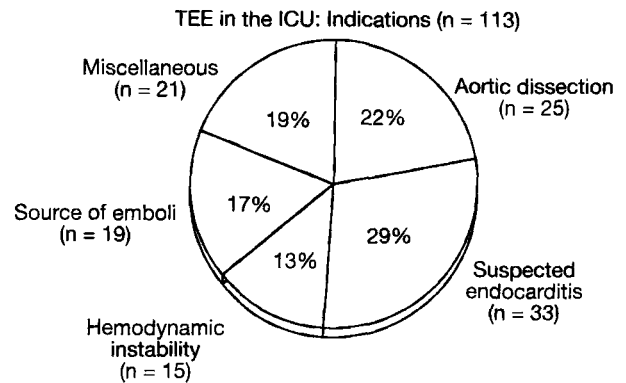


FIG. 1 Distribution of the 113 studies according to indication for the study.

negative in eight patients; aortic dissection was excluded in each one by at least one other complimentary study. Aortic dissection was diagnosed by TEE in 16 patients, all of whom had confirmation of the diagnosis either at surgery (11 cases) or by complementary studies (5 cases). The probe could not be advanced more than 30 cm in one patient with low probability of dissection; he died subsequently of terminal lung cancer and pneumonia. Including the negative studies, the yield of TEE in this group was, thus, 100%. In one patient with a type B aortic dissection, TEE diagnosed aortic rupture (Fig. 2) prompting emergency surgery. Eleven transthoracic studies were performed preceding TEE. Aortic dissection was found in six cas-

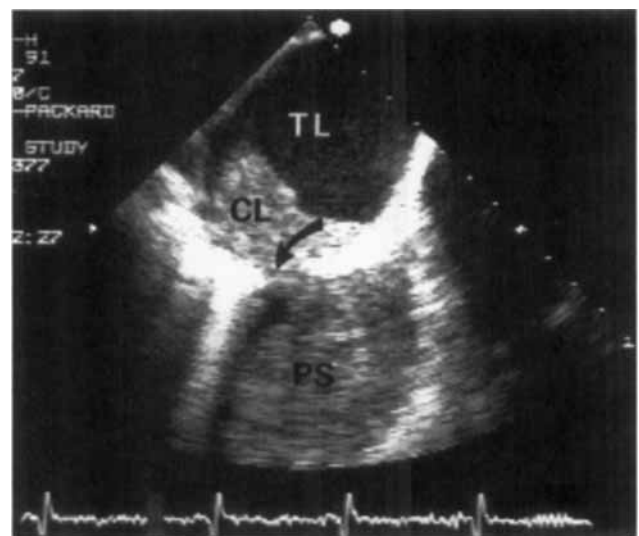


FIG. 2 Cross-sectional image of the descending thoracic aorta obtained in the horizontal plane in a patient with type B aortic dissection and aortic rupture. A lack of continuity is evident in the posterior aortic wall (arrow). A large clot extends from the aortic lumen through this communication and fills a large pseudoaneurysm cavity. CL = clot, PS = pseudoaneurysm, TL = true aortic lumen.

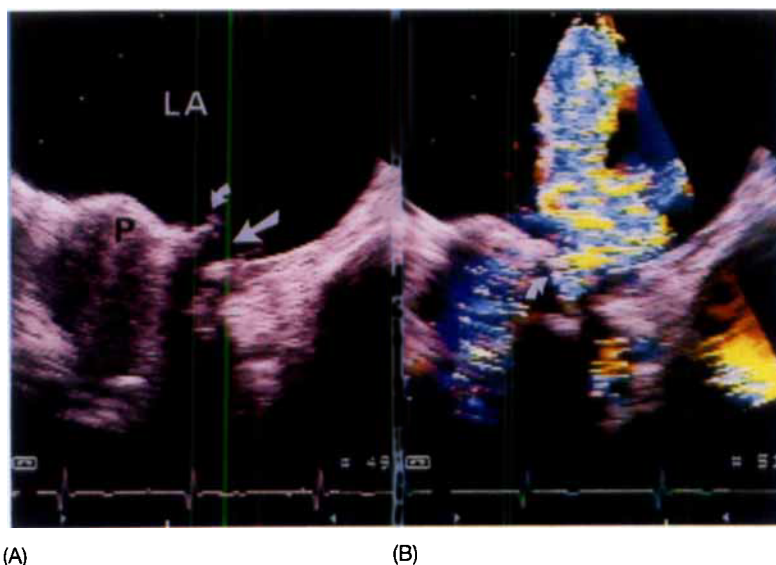


FIG. 3 Vertical plane image of a dehiscence St. Jude prosthetic valve in the mitral position. (A) Frozen systolic frame shows a lack of tissue continuity (straight arrow) at the anterior aspect of the prosthesis. A mass of soft echoes is seen at the same place (curved arrow) suggestive of vegetation. In real time the rocking motion of the prosthetic valve could be easily appreciated. (B) Color-flow Doppler demonstrates a high velocity turbulent flow originating at the same site (arrow), consistent with severe paravalvular regurgitation. LA = left atrium; P = prosthetic valve.

es by transthoracic study but in only one of these patients did the study suggest a type A dissection. Aortic regurgitation, when present, was correctly assessed.

Suspected infective endocarditis group: Thirty-three studies were performed in 31 septic patients: 17 studies in 15 patients with prosthetic valves and 16 studies in 16 patients with native valves. In the 15 patients with prosthetic valves and 1 patient with native valves, mitral incompetence murmur and congestive heart failure were considered to have a high pre-TEE likelihood of IE. Findings diagnostic or highly suggestive of IE were reported in nine studies: prosthetic valve vegetation in seven cases, paravalvular regurgitation and small vegetation in one case (Fig. 3), and flail native mitral valve with torn chordae in one case. In four of these nine patients, the transesophageal findings prompted immediate surgery that confirmed the TEE findings. Of the five patients managed conservatively, two were discharged after prolonged antibiotic courses and three died in the hospital. Autopsy was performed in two patients and it confirmed the TEE diagnosis in one case; in the other case, a degenerative bioprosthetic valve, the TEE suspicion of vegetation was not confirmed. All nine positive studies were in patients with an increased likelihood for endocarditis: eight patients with prosthetic valves, five of whom had also a clinical picture suggestive of endocarditis, and one patient with fever, congestive heart failure, and a mitral regurgitation murmur. If the studies performed in patients with an increased pre-TEE likelihood of IE are considered separately, the TEE yield in this subgroup would be 50% (9 of 18 studies). Among these nine positive TEE studies, five were preceded by a transthoracic recording; two were technically limited, one was negative, one showed a suspected vegetation, and one demonstrated mitral regurgitation in a prosthetic valve but showed no vegetation. The remaining 24

studies were negative for endocarditis. Of these patients, 13 were discharged without a diagnosis of IE. Nine patients died in the hospital and five of these had autopsies that were negative for endocarditis. Two patients subsequently developed a clinical picture highly suggestive of IE (at 30 and 23 days, respectively, after the first study) and repeat TEE studies were positive for endocarditis. Of these 24 negative TEE studies, 18 were preceded by transthoracic studies: 15 were negative and 3 raised the suspicion of a vegetation. None of the patients with native valves and no clinical features of endocarditis had a TEE study diagnostic of IE and in none of them was a diagnosis of IE made later. Thrombi in the superior vena cava that have been reported in septic patients with long standing right heart catheters¹⁴ were not found in this series.

Source of emboli group: Nineteen studies were performed in 17 patients because of systemic emboli. Findings with high probability of an association with the embolic event were reported in five studies: a mitral valve vegetation in one patient, multiple vegetations in one patient with systemic lupus erythematosus, a left atrial appendage clot in one patient, a change in the size of a known mitral valve vegetation in one patient, and mobile intraluminal aortic clots in one patient. This gives an overall diagnostic yield of 26%. In two patients with recurrent systemic emboli, TEE prompted surgery that confirmed the findings of mitral valve vegetation and protruding intraluminal aortic thrombi (Fig. 4). Findings possibly associated with the embolic event, such as spontaneous contrast, atherosclerotic aorta, and patent foramen ovale were reported in seven studies. In nine cases a transthoracic study preceded the TEE. In three cases the recordings were technically inadequate. One patient had a false positive study for left atrial mass, two studies were negative while the TEE was positive for left atrial appendage clot,

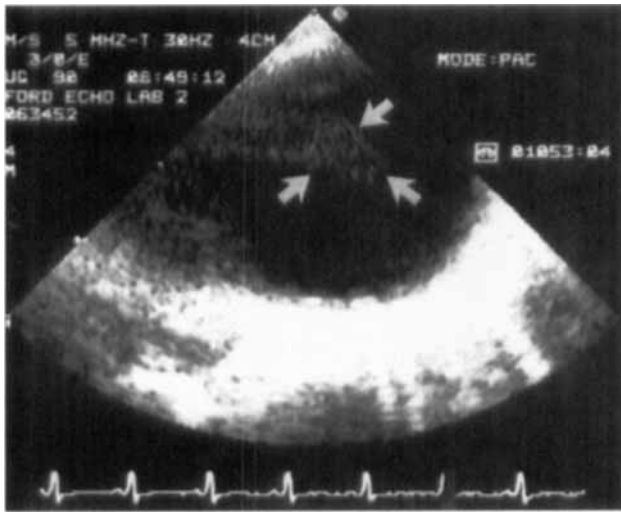


FIG. 4 Horizontal plane image of the descending thoracic aorta. A big, elongated mass of soft echoes (arrows), suggesting intraluminal thrombus, extends across the lumen. In real time the high mobility of this thrombus was easily appreciated.

two studies were negative in concordance with the TEE, and one was positive for a patent foramen ovale confirmed by TEE.

Hemodynamic instability group: Fifteen patients were studied because of unexplained hypotension. In four of these studies, TEE demonstrated significant pathology: compressing pericardial clot/fluid collection after cardiac surgery in two cases, severe mitral prosthetic paravalvular regurgitation in one case, and severe right ventricular dysfunction in one case. The

results of the transesophageal echocardiogram prompted an exploratory intervention in one patient with compressing mediastinal clot (Fig. 5) and the use of a right ventricular assist device in one patient with severe right ventricular hypokinesis. In another four patients, a small, hyperdynamic left ventricle was seen suggesting hypovolemia. Thus, the yield of TEE in this group was 53%. In 12 cases there was a transthoracic study preceding the TEE. Four recordings were technically inadequate; in the other eight cases there were no TEE findings that were completely missed by transthoracic echocardiogram, but the assessment of left ventricular function, heart compression, or valvular regurgitation was felt to be more accurate by TEE.

Miscellaneous group: Twenty-one studies were performed in 18 patients for various reasons including prosthetic valve assessment (8), suspected shunt in the presence of hypoxemia (3), follow-up studies of previously diagnosed vegetations or thrombi (3), suspected pulmonary emboli (2), suspected mediastinal mass by previous TEE (1), technically limited transthoracic echocardiograms (3), and mitral regurgitation assessment after aortic valve replacement (1). Significant diagnostic findings were reported in four studies: a right atrial clot and right ventricular enlargement in one patient with suspected pulmonary emboli, a mitral valve prosthesis vegetation with significant mitral regurgitation in a patient with congestive heart failure, and severe right ventricular hypokinesis in a patient with suspected right ventricular infarction. In one patient with an acute episode of hypoxemia and hypotension, the transesophageal study showed a clot located at the bifurcation of the main pulmonary artery (Fig. 6); this finding was subsequently confirmed by embolectomy. Transthoracic studies were performed in nine cases prior to TEE. Three recordings were technically inadequate,

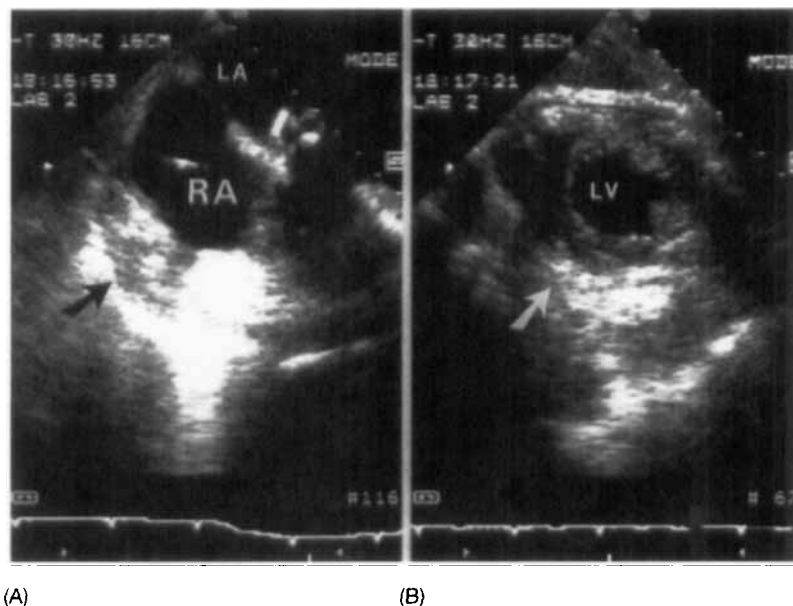


FIG. 5 Compressing pericardial clot in a patient after cardiac surgery. (A) Right side of the heart imaged from a four-chamber view in the horizontal plane. The clot (black arrow) is seen around the right atrium. (B) Short-axis view of the left ventricle using the horizontal plane from a transgastric window. The clot (white arrow) is seen anterior to the ventricle. LA = left atrium, LV = left ventricle, RA = right atrium.

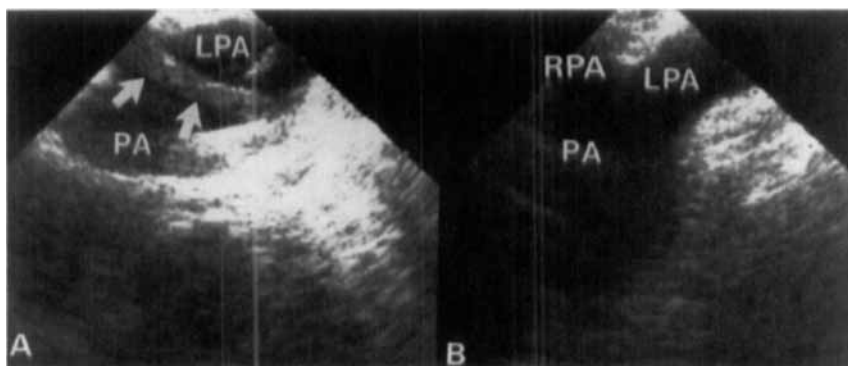


FIG. 6 Long-axis view of the pulmonary artery using the horizontal plane in a patient with pulmonary embolus. (A) Expanded image of the main pulmonary artery bifurcation. A mass (arrows) suggestive of thrombus is seen at the bifurcation of the main pulmonary artery, extending into the origin of the left and right pulmonary arteries. Its mobility could be assessed in real time. (B) Same area imaged after successful embolectomy. No residual thrombus is seen. LPA = left pulmonary artery, PA = main pulmonary artery, RPA = right pulmonary artery.

five were negative in concordance with the TEE, and one missed a perivalvular regurgitation that was shown by TEE.

Special Value of Transesophageal Echocardiography in Selected Cases

In 18 cases, representing more than one-third of the positive studies, the diagnostic information was considered crucial: significant native or prosthetic valve pathology in nine cases, hemomediastinum in two cases, aortic rupture in one case, aortic intraluminal mobile clots in one case, severe right ventricular dysfunction in two cases, atrial thrombi in two cases, and pulmonary artery thrombus in one case. In 10 of these cases the transesophageal study resulted in prompt surgical intervention.

Safety

Minor side effects were recorded in seven studies (transient hypotension in five and transient hypoxemia in two). There were no major side effects or complications.

Discussion

Transesophageal echocardiography is an attractive diagnostic method in the intensive care unit setting. It eliminates many of the technical constraints of TTE and is particularly useful in some of the common clinical situations encountered in critically ill patients. However, the precise value, limitations, and possible side effects of this technique in patients in ICUs have to be carefully defined. In this respect, assessing the relative benefit of TEE in different categories of patients in ICUs, would be particularly useful. The most frequent indication for transesophageal study in the present series was aortic dissection (22%) followed by endocarditis, source of emboli, and hemodynamic instability. This case distribution is somewhat different from that previously reported by Pearson *et al.*¹¹ who showed a high incidence of aortic dissection and source of emboli but a low pro-

portion of endocarditis. Oh *et al.*,¹² in their study, found hemodynamic instability by far the most frequent indication. Differences in patient populations and in trends for ordering TEE seem to be the explanation for these differences.

Transesophageal Echocardiography Findings in Various Patient Categories

Aortic dissection group: The high accuracy of TEE in the diagnosis of aortic dissection is well recognized, with reported sensitivities and specificities in the range of 99%.^{7,8} A negative study in a patient after an embolic event or with suspected endocarditis did not necessarily result in a change in management. On the other hand, a negative transesophageal echocardiogram for aortic dissection even in a high-risk population has a high negative predictive value.¹⁵ If one considers the information of the negative as well as the positive transesophageal studies as equally valuable in the setting of suspected aortic dissection, the diagnostic yield can be defined as 100% in this group.

Suspected endocarditis group: TEE is credited with a sensitivity of 90–100% for detection of vegetations, with a special benefit for small vegetations¹⁶ and in the presence of prosthetic valves.¹⁷ However, not all the 31 septic patients reported here had a typical picture of endocarditis. In some of these patients, a prolonged, unclear septic state was the only reason to perform TEE. Therefore, the 27% positive studies in this group do not represent TEE sensitivity in detecting endocarditis but its yield in a population defined as above. It is worth noting that all the positive studies were in patients with increased pre-test likelihood of endocarditis. The low yield of TEE in septic patients without clinical features of endocarditis has not been mentioned in previous reports.

Source of emboli group: TEE is recognized as a valuable tool in assessing patients after embolic events, with the ability to detect atrial or appendage masses,² patent foramen ovale,¹⁸ or aortic atherosclerotic debris¹⁹ with potential for embolization. In 12 of the 19 studies performed for this indication in this series, TEE demonstrated pathology that was either directly or poten-

tially related to the embolic event, prompting surgery in two cases. Good diagnostic yield in ICU patients with embolic events has been reported also by Pearson *et al.*¹¹

Hemodynamic instability group: Patients in this group had in common either an acute deterioration in the hemodynamic status or a prolonged need for inotropic support and vasoconstrictors in order to maintain an adequate systemic blood pressure. Immediate causes for hypotension were found in eight patients while in the other seven TEE gave useful information on left ventricular function and associated valvular pathology. Good yield of TEE in this category of patients has already been reported by Oh *et al.*¹² and by Chan.¹⁰ The latter study confirms the special usefulness of TEE in hypotensive patients after cardiac surgery. Of special interest are the patients whose main finding was a hyperdynamic ventricle suggesting hypovolemia. Pulmonary capillary wedge pressure has been shown to be misleading for assessment of volume status in certain circumstances.²⁰ Of the four patients with hyperdynamic ventricles, three had pulmonary capillary wedge pressures >20 mmHg. The present data suggest that in some of these patients TEE may be of critical importance for correct assessment of fluid requirements.

Miscellaneous group: This represents a heterogeneous group and it is therefore not reasonable to try to define the yield of TEE for these patients. However, the 19% positive studies underscore the usefulness of TEE in a variety of clinical conditions in critically ill patients. Of special interest is the diagnosis of pulmonary emboli in a patient with acute hypoxemia. This case adds to the body of evidence supporting the use of TEE in the diagnosis of acute pulmonary emboli.²¹

Overall Yield of Transesophageal Echocardiography

TEE provided significant diagnostic information in 45% of the studies. The highest diagnostic yield was obtained in patients with suspected aortic dissection (100%), hemodynamic instability (53%), and in septic patients with a high likelihood for endocarditis (47%). Useful diagnostic information was also obtained in one-third of the patients with embolic events. TEE was not useful as a screening procedure for infective endocarditis in septic patients without high clinical likelihood for endocarditis. To our knowledge, the low yield of TEE in this category of septic patients has not been clearly emphasized in previous works. In 16% of the cases, TEE provided crucial diagnostic information, directly affecting clinical decision making, and in 9% of cases it was essential for surgical decisions.

Limitations

Due to the retrospective nature of this analysis, some questions could not be answered accurately. While some transesophageal studies were preceded by unsatisfactory transthoracic studies, most of them were ordered because of the known high yield of TEE in a particular category of patients; thus, the question of the relative benefit of TEE versus TTE could not be systematically addressed in this population. Also, while major surgical decisions following significant findings could be docu-

mented, changes in the hemodynamic management as a result of the transesophageal echocardiographic data could not be systematically quantitated from the patients' charts. However, in a patient with hypotension and hyperdynamic ventricle on TEE, what often happened was a faster pace of weaning from inotropic support and an increase in the amount of fluid given. Therefore, it is possible that we underestimate the real impact of TEE on patient management in the intensive care unit. However, due to the large number of cases included, we believe the present study reflects the use of TEE in critical patients in a large medical center. The study also provides information on the expected yield of this technique in various groups of patients in ICUs. Finally, the majority of the patients (87) underwent monoplane TEE only, which may have further underestimated the value of TEE. Biplane and multiplane echo are certainly more comprehensive tools for assessment of the valves, ascending aorta, clots, and so forth.

Conclusions

Transesophageal echocardiography is easily performed and devoid of significant side effects in patients in ICUs, including mechanically ventilated patients. Useful diagnostic information is obtained in almost half of the cases. Based on the present data a high diagnostic yield is expected for suspected aortic pathology, hemodynamic instability, suspected endocarditis, and embolic events. In septic patients without clinical suspicion of endocarditis, TEE probably is less useful and thus should not be considered mandatory in the patient workup.

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