Infective endocarditis continues to be a serious illness with high morbidity and mortality. Early diagnosis is crucial. Prior to echocardiography, the diagnosis of infective endocarditis was based on stringent clinical criteria. However, such criteria are overly strict and insensitive, requiring histologic confirmation of infective endocarditis. Noting the limitation of schemas based on mere clinical criteria, Durack et al proposed a new set of diagnostic criteria that incorporated echocardiographic findings (26). In fact, the diagnosis of endocarditis may be based solely on echocardiographic findings when blood cultures are negative. These criteria have subsequently come to be known as the Duke criteria. In a retrospective study, the Duke group demonstrated that the sensitivity of the clinical diagnosis of pathologically proven infective endocarditis was considerably improved by adding echo results to clinical, blood culture, and pathologic findings (sensitivity increased from 51 to 80%).

The criteria have been validated by the authors of numerous studies in a wide spectrum of patients, including children, adults, the elderly, prosthetic valve recipients, IV drug users, patients in tertiary care settings, patients in primary hospitals, and patients outside of the United States. In addition to improved sensitivity, studies have also shown the Duke criteria to be highly specific (42).

Despite these data, the initial Duke criteria has a few shortcomings which have prompted recent modifications (48).

The hallmark lesions of infective endocarditis are vegetations. Pathologically, a vegetation is an amorphous mass of fibrin and platelets containing large colonies of microorganisms and variable numbers of inflammatory cells. Size does not correlate well with micro-organism, with the exception of fungal vegetations, which are typically large. New vegetations are usually soft and friable. The "healing" process consists of sterilization, fibrosis, organization, endothelialization, and calcification. Although this sometimes translates echocardiographically into a more echo-dense and bright vegetation, the distinction between a new versus old vegetation is not reliable. Vegetations usually begin where the endocardium has been damaged by a jet of abnormal flow, such as one resulting from a regurgitant valve. They usually form in locations on which the jet impinges, such as the atrial aspect of the mitral valve, the ventricular aspect of the aortic valve, and on the right ventricular aspect of a ventricular septal defect. Although vegetations almost always occur on the valves, they can occasionally occur on unusual sites where the endocardium has been disrupted by abnormal flow.
Transthoracic echocardiography has proven to be useful for the diagnosis of infective endocarditis, but suboptimal images in up to 10-20% of patients, limited image resolution, and reduced ability to detect perivalvular abscesses in both native and prosthetic valve endocarditis have been major obstacles. TEE, on the other hand, consistently yields high quality images and superior resolution permitting detection of even small vegetations. A number of investigators have documented improved diagnostic accuracy of TEE compared to TTE.

TEE has been shown to be superior to TTE for detection of paravalvular abscess, an extremely important complication of infective endocarditis. Paravalvular abscesses are present in 5-30% of patients with infective endocarditis and have important therapeutic and prognostic significance. They typically appear as a relatively echo-free space in the paravalvular region. However, they may also appear as an echo-dense thickening of the wall of the aortic root or myocardium. The spectrum of paravalvular destruction varies from simple localized abscesses to large subannular aneurysms with or without perforation into cardiac chambers, extension in the pericardial space, or total disruption of the ventricular-aortic continuity and the mitral-aortic trigone. TEE allows prompt recognition of these conditions before widespread tissue destruction can occur. Earlier surgery may therefore improve the outcome in patients with endocarditis-associated abscesses, since more extensive, high-risk surgery is avoided.

Karalis et al found "subaortic" complications (eg. periaortic abscesses, destruction of the mitral-aortic annular fibrosa [MAIVF], aneurysms of the MAIVF, and aneurysms of both the mitral and aortic leaflets) to be particularly common in patients with aortic valve endocarditis(19). Therefore, many echocardiographers recommend performing TEE early in the course of all patients with aortic valve endocarditis to detect these complications.

Indications for TEE in patients with known or suspected endocarditis are currently controversial. Some echocardiographic experts have recommended TEE for all such patients. Others, partly influenced by a desire to contain medical costs, advocate TEE for select patients. Indications for TEE are also briefly discussed in the ACC-AHA Guidelines for the Clinical Applications for Echocardiography. TEE is probably not required when the clinical picture is clear, for example when TTE reveals a small focal vegetation and the patient is responding to treatment appropriately. Furthermore it is not required when there is a low index of suspicion for endocarditis (such as "fever workup" in the absence of new regurgitant murmur, predisposing cardiac abnormalities, or clinical features of endocarditis); and certainly not for all patients with bacteremia.

Even with the high-resolution images provided by TEE, the conclusive identification of vegetation is not always possible. There are situations in which the echocardiographic findings can be particularly confusing and even misleading. For example, vegetation due to infective endocarditis must be distinguished from other masses:

1. Ruptured chordae tendineae
2. Myxomatous degeneration and thickening of mitral leaflets
3. Focal, nonspecific thickening or calcium deposits on valves
4. Retained mitral leaflets and chordae after mitral valve replacement
5. Lambl's excrescences
6. Sutures, pledgets, and other prosthetic material for prosthetic valves
7. Thrombi, and small tumors.
8. Small tumors

In some instances, these conditions can be distinguished by their echocardiographic characteristics; but, always in these situations, echocardiographic findings need to be carefully correlated and integrated with other clinical and microbiologic features.

Although false positive TEE examinations for suspected endocarditis are uncommon, they do occur, perhaps even more commonly than with TTE, because as the ability of this imaging technology to resolve smaller and smaller structures increases, so does the number of non-vegetative abnormal masses detected. In a small percentage of patients, false negative results may be present, even with TEE. False negative studies usually result from valves that were structurally deformed prior to the endocarditis or from acoustic shadowing by calcified valves or prosthetic devices. Although a negative TEE does not rule out the presence of infective endocarditis completely, the probability of the disease is very low when it is normal. Furthermore, a negative TEE is associated with a good prognosis and a high likelihood that another source of fever will be found (22).

In spite of these limitations, TEE is playing an expanding role in the evaluation of patients with infective endocarditis. Its use substantially improves the ability to diagnose infective endocarditis, enhance the ability to detect its complications, and often facilitates the decision to undertake early surgery. The effect of improved and earlier detection of vegetations by TEE on morbidity and mortality remains to be determined.

**ECHO IN THE EVALUATION OF INFECTIVE ENDOCARDITIS**


