

Bacterial Endocarditis

The Critical Diagnostic Role of TEE

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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

1. Von Reyn CF, Levy BS, Arbeit RD, Friedland G, Crumpacker CS: Infective endocarditis: An analysis based on strict definitions. *Ann Int Med* 94:505 (1981).
2. Erbel R, Rohmann S, Drexler M, Mohr-Kahaly S, Gerharz CD, Iverson S, Oelert H, Meyer J: Improved diagnostic value of echocardiography in patients with infective endocarditis by TEE. A prospective study. *Eur Heart J* 9:43 (1988).
3. Daniel WG, Schroder E, Mugge A, Lichtlen PR: Transesophageal echocardiography in infective endocarditis. *Am J Cardiac Imaging* 2:78 (1988).
4. Mugge A, Daniel WG, Frank G, Lichtlen PR: Echocardiography in infective endocarditis: Reassessment of prognostic implications of vegetation size determined by the transthoracic and the transesophageal approach. *JACC* 14:631 (1989).
5. Chan KL, Daniel L, Rakowski H, Ascah C, Baird M: Transesophageal echocardiography is crucial in the management of endocarditis. *Circ* 80:II:668 (1989) abstr.
6. Klodas E, Edwards WD, Khandheria BK: Use of transesophageal echocardiography for improving detection of valvular vegetations in subacute bacterial endocarditis. *J Am Soc Echo* 2:386 (1989).

7. Karalis DG, Chandrasekaran K, Wahl JM, Ross J, Mintz GS: TEE recognition of mitral valve abnormalities associated with aortic valve endocarditis. *Am Heart J* 119:1209 (1990).
8. Jaffe WM, Morgan DE, Pearlman AS, Otto CM: Infective endocarditis, 1983 - 1988: Echocardiographic findings and factors influencing morbidity and mortality. *JACC* 15:1227 (1990).
9. Shapiro SM and Bayer AS: Transesophageal and Doppler echocardiography in the diagnosis and management of infective endocarditis. *Chest* 100:1125 (1991).
10. Kan M, Chen Y, Lee AY: Comparison of TEE to transthoracic color Doppler echo in the identification of intracardiac mycotic aneurysms in infective endocarditis. *ECHO* 8:643(1991).
11. Steckelberg JM, Murphy JG, Ballard D, Bailey K, Tajik AJ, Taliercio CP, Giuliani ER, Wilson WR: Emboli in infective endocarditis: The prognostic value of echocardiography. *Ann Int Med* 114:635 (1991).
12. Daniel WG, Mugge A, Martin RP, Lindert O, Hausmann D, Daniel BN, Laas J, Lichtlen PR: Improvement in the diagnosis of abscesses associated with endocarditis by TEE. *NEJM* 324:795 (1991).
13. Sanfilippo AJ, Picard MH, Newell JB, Rosas E, Davidoff R, Thomas JD, Weyman AE: Echocardiographic assessment of patients with infectious endocarditis: Prediction of risk for complications. *JACC* 18:1191 (1991).
14. Pedersen WR, Walker M, Olson JD, Gobel F, Lange HW, Daniel JA, Rogers J, Longe T, Kane M, Mooney MR, Goldenberg IF: Value of transesophageal echocardiography as an adjunct to transthoracic echocardiography in evaluation of native and prosthetic valve endocarditis. *Chest* 100:351 (1991).
15. Rohmann S, Erbel E, Darius H, Gorge G, Makowski T, Zolz R, Mohr-Kahaly S, Nixdorff U, Drexler M, Meyer J: Prediction of rapid versus prolonged healing of infective endocarditis by monitoring vegetation size. *J Am Soc Echocardiogr* 4:465 (1991).
16. Shively BK, Gurule FT, Roldan CA, Leggett JH, Schiller NB: Diagnostic value of TEE compared with transthoracic echo in infective endocarditis. *JACC* 18:391 (1991).
17. Rohmann S, Seifert T, Erbel R, et al. Identification of abscess formation in native-valve infective endocarditis using transesophageal echocardiography: Implications for surgical treatment. *Thorac Cardiovasc Surgeon* 39:273-80 (1991).
18. Birmingham GD, Rahko PS, Ballantyne F: Improved detection of infective endocarditis with TEE. *Am Heart J* 123:7741 (1992).
19. Karalis DG, Bansal RC, Hauck AJ, Ross JJ, Applegate PM, Jutzy KR, Mintz GS, Chandrasekaran K: Transesophageal echocardiographic recognition of subaortic complications in aortic valve endocarditis. Clinical and surgical implications. *Circulation* 86:353 (1992).
20. Shively BK: Transesophageal echocardiography in endocarditis. *Cardiol Clinics* 11:437 (1993).
21. San Roman A, Vilacosta I, Zamorano J, Almeria C, Sanchez-Harguindey L: Transesophageal echocardiography in right-sided endocarditis. *JACC* 21:1226 (1993).
22. Sochowski RA, Chan KL: Implications of negative results on a monoplane transesophageal echocardiographic study in patients with suspected endocarditis. *JACC* 21:216 (1993).

23. Khandheria BK: Suspected bacterial endocarditis: To TEE or not to TEE. *JACC* 21:222 (1993).
24. Murphy JG, Foster-Smith K: Management of complications of infective endocarditis with emphasis on echocardiographic findings. *Inf Dis Clinics NA* 7:153 (1993).
25. Mugge A: Echocardiographic detection of cardiac valve vegetations and prognostic implications. *Inf Dis Clinics NA* 7:877 (1993).
26. Durack DT, Lukes AS, Bright DK: New criteria for diagnosis of infective endocarditis: Utilization of specific echocardiographic findings. *Am J Med* 96:200 (1994).
27. Bayer AS, Ward JI, Ginzton LE, Shapiro SM: Evaluation of new clinical criteria for the diagnosis of infective endocarditis. *Am J Med* 96:211 (1994).
28. Lowry R.W, Zoghbi WA, Baker WB, Wray RA, Quinones M: Clinical impact of transesophageal echocardiography in the diagnosis and management of infective endocarditis. *Am J Cardiol* 73:1089-1091 (1994).
29. Vilacosta I, Sarria C, San Rumon JA, et al: Usefulness of transesophageal echocardiography for diagnosis of infected transvenous pacemakers. *Circulation* 89:2684-2687 (1994).
30. Vuille C, Nidorf M, Weyman AE, Michael H, Picard: Natural history of vegetations during successful medical treatment of endocarditis. *Am Heart J* 128:1200-9 (1994).
31. Yvorchuk KJ, Chan K. Application of transthoracic and transesophageal echocardiography in the diagnosis and management of infective endocarditis. *J Am Soc Echocardiogr* 14:294-308 (1994).
32. Dodds GA, Durack DT: Criteria for the diagnosis of endocarditis and the role of echocardiography. *Echocardiogr* 12:663-668 (1995).
33. Mugge A, Daniel WG: Echocardiographic assessment of vegetations in patients with infective endocarditis: *Echocardiogr* 12:651-661 (1995).
34. Fengqi L, Junbo GE, Kupferwasser I, Meyer J, Mohr-Kahaly S, Rohmann S, Erbel R: Has transesophageal echocardiography changed the approach to patients with suspected or known infective endocarditis? *Echocardiogr* 12:637-650 (1995).
35. San Roman JA, Roman S, Vilacosta I: Role of transesophageal echocardiography in right-sided endocarditis. *Echocardiogr* 12:669-672 (1995).
36. Essop R. Transesophageal echocardiography in infective endocarditis: The standard for the 1990s? *Am Heart J* 130:402-404 (1995).
37. Tingleff J, Egeblad H, Gotzche CO, et al. Perivalvular cavities in endocarditis: abscesses versus pseudoaneurysms? A transesophageal Doppler echocardiographic study in 118 patients with endocarditis. *Am Heart J* 30:93-97 (1995).
38. Werner GS, Schulz R, Fuchs JB, et al. Infective endocarditis in the elderly in the era of transesophageal echocardiography: Clinical features and prognosis compared with younger patients. *Am J Med* 100:90-7 (1996).
39. Dodds GA, Sexton DJ, Durack DT, Bashore TM, Corey GR, Kisslo J: Negative predictive value of the Duke criteria for infective endocarditis. *Am J Cardiol* 77:403-407 (1996).
40. Lindner JR, Case A, Dent JM, Abbott RD, Scheld WM, Kaul S: Diagnostic value of echocardiography in suspected endocarditis. An evaluation based on the pretest probability of disease. *Circulation* 93:730-736 (1996).
41. Shanewise JS, Martin RP. Assessment of endocarditis and associated complications with transesophageal echocardiography. *Crit Care Clinics* 12:411-427 (1996).

42. Hoen B, Beguinot I, Rabaud C, et al. The Duke criteria for diagnosing infective endocarditis are specific: analysis of 100 patients with acute fever or fever of unknown origin. *Clin Infect Dis* 23:298-302 (1996).
43. Rohmann S, Erbel R, Darius H, Makowski T, Meyer J. Effect of antibiotic treatment on vegetation size and complication rate in infective endocarditis. *Clin Cardiol* 20:132-140 (1997).
44. Fowler VG Jr, Zi J, Corey R, et al. Role of echocardiography in evaluation of patients with staphylococcus aureus bacteremia: Experience in 103 patients. *J Am Coll Cardiol* 30:1072-8 (1997).
45. De Castro S, d'Amati G, Cartoni D, et al. Valvular perforation in left-sided infective endocarditis: A prospective echocardiographic evaluation and clinical outcome. *Am Heart J* 134:656-64 (1997).
46. Heiro M, Nikoskelainen J, Hartiala JJ, Saraste MK, Kotilainen PM. Diagnosis of infective endocarditis: Sensitivity of the Duke vs von Reyn criteria. *Arch Intern Med* 158:18:34 (1998).
47. Bayer AS, Bolger AF, Taubert KA, et al. From Ad Hoc Writing Group of the Committee on Endocarditis, American Heart Association. Diagnosis and management of infective endocarditis and its complications. *Circulation* 98:2936-48 (1998).
48. Li JS, Sexton DJ, Mick N, et al. Proposed modifications to the Duke criteria for the diagnosis of infective endocarditis. *Clin Infect Dis* 30:633-8 (2000).
49. Roe MT, Abramson MA, Li J, Heinte SK, Kিস্তো J, Corey GR, Sexton DJ. Clinical information determines the impact of transesophageal echocardiography on the diagnosis of infective endocarditis by the Duke criteria. *Am Heart J* 139:4945-51 (2000).
50. Ryan EW, Bolger AF. Transesophageal echocardiography (TEE) in the evaluation of infective endocarditis. *Cardiol Clinics* 18:773-787 (2000)
51. Donal E, Abgueguen P, Coisne D, et al. Echocardiographic features of *Candida* species endocarditis: 12 cases and a review of published reports. *Heart* 86:179-182(2001).
52. DiSalvo G, Habib G, Pergola V, et al. Echocardiography predicts embolic events in infective endocarditis. *J Am Coll Cardiol* 37:1069-76(2001).
53. Shapiro S, Kupferwasser LI. Echocardiography predicts embolic events in infective endocarditis (editorial). *J Am Coll Cardiol* 37:1077-1079 (2001).
54. Bolger AF. Endocarditis beyond the annulus: Eat your heart out. *J Am Coll Cardiol* 2002;39:1212-1213
55. Graupner C, Vilacosta I, San Roman JA, et al. Periannular extension of infective endocarditis. *J Am Coll Cardiol* 2002;39:1204-11.
56. Jacob S, Tong AT. Role of echocardiography in the diagnosis and management of infective endocarditis. *Curr Opin Cardiol* 2002;17:478-485.
57. Lindner JR. Role of echocardiographic imaging in infective endocarditis. *ACC Current Journal Review* 2002;Mar/Apr:40-43.
58. Greaves K, Mae D, Patel A, Celermajer DS. Clinical criteria and the appropriate use of transthoracic echocardiography for the exclusion of infective endocarditis. *Heart* 2003;89:273-275.
59. Delahaye F, Celard M, Roth O, de Gevigney G. Indications and optimal timing for surgery in infective endocarditis. *Heart* 2004;9:618-620.

60. Eicher J-C, De Nadai L, Soto F-X, Falcon-Erchier S, et al. Bacterial endocarditis complicating mitral annular calcification: A clinical and echocardiographic study. *J Heart Valve Dis* 2004;13:217-227.
61. Law A, Honos G, Huynh T. Negative predictive value of multiplane transesophageal echocardiography in the diagnosis of infective endocarditis. *Eur J Echocardiogr* 2004;5:416-421.
62. Anguera J, Miro JM, Vilacosta I, et al. Aorto-cavitary fistulous tract formation in infective endocarditis: clinical and echocardiographic features of 76 cases and risk factors for mortality. *Eur Heart J* 2005;26:288-297.
63. Thangaroopan M, Choy JB. Is transesophageal echocardiography over used in the diagnosis of infective endocarditis? *Am J Cardiol* 2005;95:295-297.