The Preoperative Evaluation of Infective Endocarditis

via 3-Dimensional Transesophageal Echocardiography

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Transesophageal echocardiography continues to have a central role in the diagnosis of infective endocarditis and its sequelae. Recent technological advances offer the option of 3-dimensional imaging in the evaluation of patients with infective endocarditis. We present an illustrative case and review the literature regarding the potential advantages and limitations of 3-dimensional transesophageal echocardiography in the diagnosis of complicated infective endocarditis.

A 51-year-old man, an intravenous drug user who had undergone bioprosthetic aortic valve replacement 5 months earlier, presented with prosthetic valve endocarditis. Preoperative transesophageal echocardiography with 3D rendition revealed a large abscess involving the mitral aortic intervalvular fibrosa, together with a mycotic aneurysm that had ruptured into the left atrium, resulting in a left ventricle-to-left atrium fistula. Three-dimensional transesophageal echocardiography enabled superior preoperative anatomic delineation and surgical planning. We conclude that 3-dimensional transesophageal echocardiography can be a useful adjunct to traditional 2-dimensional transesophageal echocardiography as a tool in the diagnosis of infective endocarditis. (*Tex Heart Inst J* 2015;42(4):372-6)

Transesophageal echocardiography (TEE) plays a key role in diagnosing infective endocarditis (IE), in identifying its sequelae, and in guiding its management. Recent technologic advances offer the option of 3-dimensional (3D) imaging in the evaluation of IE patients. We present an illustrative case wherein 3D TEE provided accurate evaluation of IE sequelae before surgery, and we review the usefulness of 3D TEE in the management of IE.

Case Report

A 51-year-old man presented with fever and dyspnea. He had a history of intravenous drug use and of *Corynebacterium* endocarditis that had affected his native bicuspid aortic valve (replaced, 5 months earlier, with a bioprosthesis). His vital signs were normal; auscultation revealed a widely radiating grade 3/6 pansystolic apical murmur. The patient's comorbidities included type 1 diabetes mellitus, hepatitis C, dyslipidemia, hypertension, and bipolar disorder. Preoperative TEE with 3D rendition revealed a large abscess involving the mitral aortic intervalvular fibrosa, together with a mycotic aneurysm that had ruptured into the left atrium, resulting in a left ventricle-to-left atrium fistula (Fig. 1 and Figs. 2A–C). Blood cultures grew *Haemophilus parainfluenzae*. In addition, the patient had sustained multifocal acute and subacute small-vessel cerebral infarcts secondary to septic emboli. He proceeded to surgery, where the TEE findings were confirmed intraoperatively (Figs. 2D and E). He underwent concomitant valve replacement: the mitral valve with a 29-mm Hancock® porcine tissue valve (Medtronic, Inc.; Minneapolis, Minn) and the aortic valve with a 27-mm Carpentier-Edwards PERIMOUNT pericardial tissue valve (Edwards Lifesciences Corporation; Irvine, Calif). He also underwent reconstruction of the left ventricular outflow tract and intervalvular fibrosa by means of bovine pericardial patches. A postoperative transthoracic echocardiogram revealed satisfactory prosthetic valve function. The patient was discharged to the referring medical center on postoperative day 9. He received a 6-week course of intravenous antibiotics

Fig. 1 Transesophageal echocardiograms show prosthetic aortic valve endocarditis with native mitral valve involvement **A)** from the surgeon's view (left atrial perspective) of the mitral valve (note prominent mycotic aneurysm of the intervalvular fibrosa), and **B)** from the opening of the mycotic aneurysm above the mitral valve (arrowheads). ©2015 Mayo Foundation for Medical Education and Research. All rights reserved.

AML = anterior mitral leaflet

(ceftriaxone and vancomycin), followed by chronic suppression with oral amoxicillin.

Discussion

In 1994, Durack and colleagues¹ proposed for the diagnosis of infective endocarditis the addition of 1 to 3 major criteria—vegetation, abscess formation, or new prosthetic valve dehiscence—all of which include echocardiographic features as a major component. Currently, the European Association of Echocardiography² recommends that transthoracic echocardiography be used first, because of its noninvasive nature. However, TEE remains the gold-standard investigative tool and is to be applied in most suspected cases of IE.² Echocardiography is valuable in identifying patients who are likely to fail medical therapy, and who therefore will need surgical intervention. The echocardiographic features of severe valvular insufficiency—in combination with heart failure, perivalvular infective extension, or large mobile vegetations (increased risk of embolic phenomena)—are the main indications for surgical intervention.³

Since its emergence, 3D echocardiography has gained popularity as a diagnostic tool in cardiac surgery for patients who present with IE. Whereas 2D echocardiography amounts to a single tomographic slice through a region of interest, 3D echocardiography can provide visual information about the entire region. The 3D data set is constructed by simultaneously acquiring multiple 2D sectors to form a pyramidal 3D volume, which can then be adjusted both automatically and manually for easier interpretation. When the entire volume is acquired in a single beat, it is viewed live and is described as “real-time”—although this necessarily gives

lower temporal image resolution than do volumes acquired over several heartbeats. Superior guidance during catheter-based procedures has led to the widespread use of live 3D TEE—a technology that can also be applied in diagnosing IE when cases involve either native valves or prosthetic devices, as our clinical case shows.

The sensitivity of 2D TEE for the detection of vegetations is 85% to 90%, with a specificity of approximately 90% to 100%.⁴ Furthermore, 2D TEE is particularly useful in the evaluation of sequelae, such as abscesses (sensitivity 90% and specificity 90%),⁵ fistulae, pseudoaneurysms, and perforated leaflets. Given this excellent sensitivity and specificity, what is the added value of 3D TEE? The true strength of 3D echocardiography lies in its role as a complement to 2D echocardiography, in providing additional information that improves diagnostic accuracy. Especially when large vegetations are present, 2D TEE fails to provide sufficient information regarding the relationship between vegetations, prosthesis, and adjacent structures. Furthermore, the investigators in one case series⁶ noted that only 48% of abscesses detected intraoperatively correlated with preoperative 2D TEE findings. Because abscesses typically are not limited to specific tissue planes, they can extend in directions beyond the planes that routinely are acquired in 2D viewing. Conversely, the improved spatial orientation of 3D TEE enables more precise and complete examination of intracardiac anatomy.^{7,8} Furthermore, 3D TEE is superior in identifying the sequelae of IE—in particular, in locating and evaluating prosthetic dehiscence, perivalvular abscesses, and valvular perforation.⁹⁻¹³ Hansalia and colleagues¹⁰ compared 3D TEE and 2D TEE in 13 patients with valvular vegetations and concluded that 3D TEE was superior in determin-

Fig. 2 Transesophageal echocardiograms in our patient reveal prosthetic aortic valve endocarditis: **A)** a large periprosthetic aortic valve vegetation/abscess, **B)** the destruction of the aorto-mitral intervalvular fibrosa, abscess of the aortic root, and **C)** the resultant left ventricle–left atrium (LV–LA) fistula. Intraoperative images depict the **D)** abscess and **E)** fistula. ©2015 Mayo Foundation for Medical Education and Research. All rights reserved. AML = anterior mitral leaflet; Ao = aorta; AV = aortic valve

ing, during surgery, the overall presence and exact site of valvular vegetations. These authors further ventured the possibility that 3D TEE can measure the volume of vegetations, and they showed low interobserver variability between measurements performed by means of 3D echocardiography.¹⁰ The accuracy and reproducibility of vegetation measurements has become particularly important after a 2012 study showed the effectiveness of early operation in patients with large vegetations.¹⁴

Our experience at the Mayo Clinic has shown that 3D TEE can be used to identify abscess-related sequelae and the extent of IE (Figs. 1–3*), which might enable better risk stratification, surgical decision-making, and operative planning. In addition, 3D TEE can be useful when there is right-sided valvular involvement (Fig. 4*).

*Note that Figures 3 and 4 do not belong to the patient in this report.

Fig. 3* Transesophageal echocardiograms show **A)** infective endocarditis involving both atria and the internal crux of the heart and **B)** the large vegetation (arrows) in both atria (magnified view). The left atrial and right atrial vegetation are in continuity with the internal crux (black arrow). ©2015 Mayo Foundation for Medical Education and Research. All rights reserved.

Fig. 4* Transesophageal echocardiogram shows extensive tricuspid valve endocarditis. This global view of the heart reveals a large vegetation on the tricuspid valve with involvement of the aortic valve (arrowhead). ©2015 Mayo Foundation for Medical Education and Research. All rights reserved.

ATL = anterior tricuspid leaflet

*Note that Figures 3 and 4 do not belong to the patient in this report.

The acquisition of 3D information enables surgeons to anticipate operative findings and to plan appropriate repair.¹⁵ The availability of information on such matters as fistula formation, valvular perforation, concomitant leaflet clefts, and commissural mitral regurgitation is crucial to operative planning. In our patient, the accuracy of the images provided by 3D TEE was confirmed intraoperatively (Fig. 2). This has been similarly described in other case reports.¹⁰⁻¹⁶ A particular strength of 3D TEE is its ability to accurately portray the mitral valve from the perspective of the left atrium (the “surgeon’s view”). The mitral valve can be seen from a single 3D echocardiographic view, in contrast to the extensive manipulation frequently imposed by 2D imaging. The 3D image improves communication within the operative team by greatly reducing the need for “mental reconstruction.”

Because of the large amount of imaging data acquired, low temporal resolution remains a fundamental limitation of real-time 3D TEE. This can be overcome by multi-beat acquisition, a technique by which the 3D volume of interest is divided into subvolumes and data are acquired for each subvolume at separate time points. The subvolumes are then electronically “stitched together” to form the complete 3D data set.

Another limitation is the presence of dropout artifacts that can mimic a periprosthetic leak or leaflet perforation.¹⁷ To establish the diagnosis of a true defect, color-flow Doppler mode is used to document the presence or absence of flow through the defect.

In addition, the use of 3D TEE has focused predominantly on the aortic and mitral valves, because the distance from the transducer limits the role of that technique in examining the tricuspid valve.

Finally, Hansalia and colleagues¹⁰ have observed that the posterior mitral valve leaflet is not well viewed in 3D TEE, which results in missed diagnoses when perforation is present. Although this problem might be operator dependent, they emphasized the need, in the evaluation of IE, for combined 2D TEE and 3D TEE.

Conclusion

Three-dimensional TEE is a useful adjunct to traditional 2D TEE as a diagnostic tool in IE. Whereas 2D TEE effectively reveals signs of endocarditis on native and prosthetic valves, the advent of 3D TEE enables superior preoperative anatomic delineation and evaluation for complications of IE, with consequent improvement in surgical planning.

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References

1. Durack DT, Lukes AS, Bright DK. New criteria for diagnosis of infective endocarditis: utilization of specific echocardiographic findings. Duke Endocarditis Service. *Am J Med* 1994;96(3):200-9.
2. Habib G, Badano L, Tribouilloy C, Vilacosta I, Zamorano JL, Galderisi M, et al. Recommendations for the practice of echocardiography in infective endocarditis. *Eur J Echocardiogr* 2010;11(2):202-19.
3. Habib G, Hoen B, Tornos P, Thuny F, Prendergast B, Vilacosta I, et al. Guidelines on the prevention, diagnosis, and treatment of infective endocarditis (new version 2009): the Task Force on the Prevention, Diagnosis, and Treatment of Infective Endocarditis of the European Society of Cardiology (ESC). Endorsed by the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) and the International Society of Chemotherapy (ISC) for Infection and Cancer. *Eur Heart J* 2009;30(19):2369-413.
4. Evangelista A, Gonzalez-Alujas MT. Echocardiography in infective endocarditis. *Heart* 2004;90(6):614-7.
5. Daniel WG, Mugge A, Martin RP, Lindert O, Hansmann D, Nonnast-Daniel B, et al. Improvement in the diagnosis of abscesses associated with endocarditis by transesophageal echocardiography. *N Engl J Med* 1991;324(12):795-800.
6. Hill EE, Herijgers P, Claus P, Vanderschueren S, Peetermans WE, Herregods MC. Abscess in infective endocarditis: the value of transesophageal echocardiography and outcome: a 5-year study. *Am Heart J* 2007;154(5):923-8.
7. Vrettou AR, Zacharoulis A, Lerakis S, Kremastinos DT. Revealing infective endocarditis complications by echocardiography: the value of real-time 3D transesophageal echocardiography. *Hellenic J Cardiol* 2013;54(2):147-9.
8. Salcedo EE, Quaipe RA, Seres T, Carroll JD. A framework for systematic characterization of the mitral valve by real-time three-dimensional transesophageal echocardiography. *J Am Soc Echocardiogr* 2009;22(10):1087-99.
9. Walker N, Bhan A, Desai J, Monaghan MJ. Myocardial abscess: a rare complication of valvular endocarditis demonstrated by 3D contrast echocardiography. *Eur J Echocardiogr* 2010;11(10):E37.
10. Hansalia S, Biswas M, Dutta R, Hage FG, Hsuing MC, Nanda NC, et al. The value of live/real time three-dimensional transesophageal echocardiography in the assessment of valvular vegetations. *Echocardiography* 2009;26(10):1264-73.
11. Mukhtari O, Horton CJ Jr, Nanda NC, Aaluri SR, Pacifico A. Transesophageal color Doppler three-dimensional echocardiographic detection of prosthetic aortic valve dehiscence: correlation with surgical findings. *Echocardiography* 2001;18(5):393-7.
12. Thompson KA, Shiota T, Tolstrup K, Gurudevan SV, Siegel RJ. Utility of three-dimensional transesophageal echocardiography in the diagnosis of valvular perforations. *Am J Cardiol* 2011;107(1):100-2.
13. Chandra S, Vijay SK, Dwivedi SK, Saran RK. Delineation of anatomy of the ruptured sinus of Valsalva with three-dimensional echocardiography: the advantage of the added dimension. *Echocardiography* 2012;29(6):E148-51.
14. Kang DH, Kim YJ, Kim SH, Sun BJ, Kim DH, Yun SC, et al. Early surgery versus conventional treatment for infective endocarditis. *N Engl J Med* 2012;366(26):2466-73.
15. Caselli S, Mazzesi G, Tritapepe L, Barretta A, Pandian NG, Agati L, Fedele F. 3D echocardiographic delineation of mitral-aortic intervalvular fibrosa pseudoaneurysm caused by bicuspid aortic valve endocarditis. *Echocardiography* 2011;28(1):E1-4.
16. Perez de Isla L, Zamorano J, Malangatana G, Almeria C, Rodrigo JL, Cordeiro P, Macaya C. Usefulness of real-time 3-dimensional echocardiography in the assessment of infective endocarditis: initial experience. *J Ultrasound Med* 2005;24(2):231-3.
17. Saxena P, Malouf JF, Click R, Suri RM. 3D echocardiography in cardiac surgery. *J Card Surg* 2014;29(1):51-4.