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RESEARCH ARTICLE

Avoiding transthoracic echocardiography and transesophageal echocardiography for patients with variable body mass indexes in infective endocarditis

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Background: Echocardiography has been a popular modality used to aid in the diagnosis of infective endocarditis (IE) with the modified Duke criteria. We evaluated the necessity between the uses of either a transthoracic echocardiography (TTE) or transesophageal echocardiography (TEE) in patients with a body mass index (BMI) greater than or equal to 25 kg/m^2 and less than 25 kg/m^2.

Methods: A single-centered, retrospective study of 198 patients between 2005 and 2012 diagnosed with IE based on modified Duke criteria. Patients, required to be above age 18, had undergone an echocardiogram study and had blood cultures to be included in the study.

Results: Among 198 patients, two echocardiographic groups were evaluated as 158 patients obtained a TTE, 143 obtained a TEE, and 103 overlapped with TEE and TTE. Out of these patients, 167 patients were included in the study as 109 (65%) were discovered to have native valve vegetations on TEE and 58 (35%) with TTE. TTE findings were compared with TEE results for true negatives and positives to isolate valvular vegetations. Overall sensitivity of TTE was calculated to be 67% with a specificity of 93%. Patients were further divided into two groups with the first group having a BMI $\geq$25 kg/m^2 and the subsequent group with a BMI $<$25 kg/m^2. Patients with a BMI $\geq$25 kg/m^2 who underwent a TTE study had a sensitivity and specificity of 54 and 92%, respectively. On the contrary, patients with a BMI $<$ 25 kg/m^2 had a TTE sensitivity and specificity of 78 and 95%, respectively.

Conclusions: Patients with a BMI $<$25 kg/m^2 and a negative TTE should refrain from further diagnostic studies, with TEE strong clinical judgment is warranted. Patients with a BMI $\geq$ 25 kg/m^2 may proceed directly to TEE as the initial study, possibly avoiding an additional study with a TTE.

Keywords: *Infective endocarditis*; *Echocardiogram*; *Transesophageal echocardiogram*; *Transthoracic echocardiogram*; *Body Mass index*

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Given the high complications and mortality rates of infective endocarditis (IE), early identification and appropriate management of the infection remains essential. Over the decades, our echocardiographic capabilities have advanced, providing an important non-invasive modality with transthoracic echocardiography (TTE) for assessing valvular vegetations in IE. The importance of echocardiography has surpassed the expectations by not only providing the presence or absence of a vegetation but also demonstrating its characteristics of size, extent, and dynamics thereby further enhancing prognostication (1). Although invasive, transesophageal echocardiography (TEE) has been shown to be a highly sensitive study when compared to TTE with relatively similar specificities (2). Given the dismal sensitivities of TTE for identifying valvular vegetations, we further evaluated patients according to their body mass index (BMI), calculated as kg/m^2 to assess the possible effect of body habitus on TTE quality. Identification of a possible factor may provide evidence to avoid the need of a TTE as

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the initial study and proceed directly to TEE, while patients with normal weights defined as BMI < 25 kg/m^2 will suffice with TTE findings and avoid an additional TEE study.

Methods

A single-centered, retrospective study of 198 patients between 2005 and 2012 diagnosed with IE based on modified Duke criteria. Patients, required to be above age 18, undergone an echocardiogram study and had blood cultures to be included in the study. Then we divided the patients into two groups: patients with BMI ≥ 25 kg/m^2 and patients with BMI < 25 kg/m^2. The BMI or Quetelet index is a value derived from the mass (weight) and height of an individual. The BMI is defined as the body mass divided by the square of the body height and is universally expressed in kg/m^2, resulting from mass in kilograms and height in meters. According to BMI scale, the optimal weight is below 25 kg/m^2 and in our study the cutoff number is 25 kg/m^2.

This study was conducted in a major hospital in one of the most diverse communities in the United States, providing a cultural and epidemiologically significant advantage. An approved chart analysis using QuadraMed Computerized Patient Record (QCPR) was retrospectively accessed with data input and calculations formulated in computerized software.

Results

Among 198 patients, two echocardiographic groups were evaluated as 158 patients obtained a TTE, 143 obtained a TEE, and 103 overlapped with TEE and TTE; 167 patients were included in the study as 109 (65%) were discovered to have native valve vegetations on TEE and 58 (35%) with TTE. TTE findings were compared with TEE results for true negatives and positives to isolate valvular vegetations. Overall sensitivity of TTE was calculated to be 67% with a specificity of 93%. Patients were further divided into two groups with the first group having a BMI ≥ 25 kg/m^2 and the subsequent group with a BMI < 25 kg/m^2. Patients with a BMI ≥ 25 kg/m^2 that underwent a TTE study had a sensitivity and specificity of 54 and 92%, respectively. On the contrary, patients with a BMI < 25 kg/m^2 had a TTE sensitivity and specificity of 78 and 95%, respectively. Furthermore, we obtained the sensitivities of specific valves diseased from vegetations, visualized by TTE (Fig. 1). Finally, we were able to demonstrate a correlation between the different modalities of echocardiography used in the specific organism identified on blood cultures (Fig. 2).

No gender difference is considered when correlated to BMI and imaging modalities.

Discussion

With an alarmingly high mortality rates of 15–20% in hospitalized patients and a 1-year mortality rate of

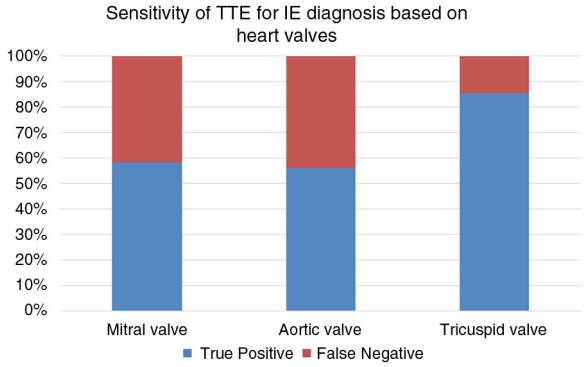

Fig. 1. Sensitivity of TTE for diagnosis based on heart valves.

40% (3), IE has become a life-threatening infection requiring prompt identification and management. The constant rising rates of IE in the United States have been determined between 2000 and 2011 with an incidence rate of 11 per 100,000 to 15 per 100,000 persons. It is speculated by Sadip et al. that these rising rates may be partly due to the increasing number of invasive instrumentations and procedures performed (4). The combination of rising incidence and high mortality rates of IE postulates a concerning and devastating dilemma to health care. Timely identification and diagnosis of IE is imperative to possibly reduce mortality rates and provide appropriate management. Delay in diagnosis may possibly cause progressive and irreversible structural heart damage along with compromise to other organs. Common complications, such as stroke, embolization, heart failure (HF), the need for surgery, and intracardiac abscess, pose possible debilitating outcomes for patients (3). In 2000, the modified Duke criteria provided an important tool to help clinicians better guide the diagnosis of IE. A noteworthy modification to the Duke criteria was eliminating echocardiographic findings from minor criteria and proposing it as major criteria with further detail to initial approach between TTE and TEE studies (5). TEE has been well studied to be a highly specific and sensitive study for detection of valvular vegetations.

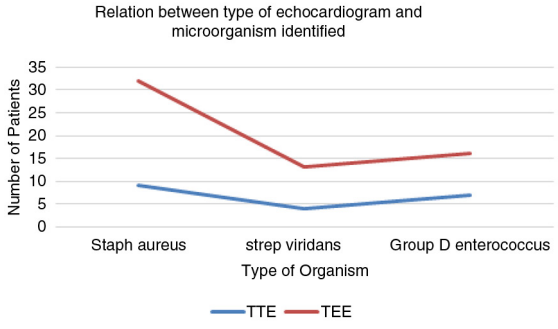

Fig. 2. Relationship between types of echocardiogram and microorganism identified.

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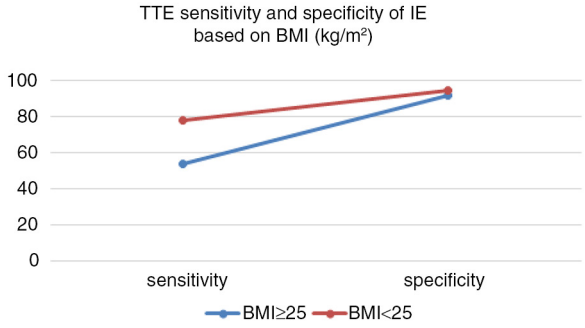

Fig. 3. TTE sensitivity and specificity of IE based on BMI (kg/m^2).

Microbiological identification in IE is imperative to identify and isolate the commonality of the organisms as it helps dictate broad spectrum treatment regimens. *Staphylococcus aureus* has been the most common organism identified, among which approximately 30% of the patients had MRSA (methicillin resistant staphylococcus aureus). Fowler et al. identified health care–associated IE as the most common form of *S. aureus* with the highest in-hospital mortality rates (6, 7). Similarly, we were able to demonstrate *S. aureus* as the most common causative organism of IE followed by group D streptococcus and streptococcus viridans. In addition, we illustrated echocardiographic correlation with microorganisms by identifying high rates of *S. aureus* bacteremia and positive echocardiographic findings when compared to other organisms (Fig. 2).

Guidelines and recommendations have been well proposed for the role of echocardiography in IE (3, 5). Echocardiographic findings have been modified in Duke criteria to be part of major criteria for the diagnosis of IE, making the study a significant influence (5). TTE has been studied to result in a significantly lower sensitivity rates compared to TEE with similarly high specificities. Variable low results have been concluded for the percentages of the sensitivities of TTE and TEE; however, similar specificities above 90% have been described for both. Sensitivities for TTE and TEE have been shown to range from 44–60% to 87–100%, respectively. Specificities for TTE and TEE were described to range from 91 to 100% in both imaging modalities (2, 8, 9). In 1984, O'Brien and Geiser described two-dimensional use of TTE in IE for valvular vegetations identified in 80% of patients (10). Flachskampf et al. approximated the sensitivity of TTE to be 70% and an increase with TEE to approximately 85–90% (11). The initial and original Duke criteria relied heavily on TTE as TEE was not systemically evaluated at the time. Recommendations have been proposed for the definition of the modified Duke criteria with TEE as the initial echocardiographic study to be performed in patients with prosthetic valves, 'possible IE', or complicated IE (paravalvular abscess). In all other cases, TTE is recommended as the initial echocardiographic study (5). Although the best method for detection of early abscess formation, TEE was found to be a limited study and an underestimation with an abscess detection rate of 48% (12) Limitations of TTE exist, decreasing the sensitivity as detection of vegetations less than 3 mm were found to be missed. We established similar sensitivities and specificities for TTE and proposed to identify a possible limitation to the quality of the study by factoring in patients body habitus, calculated by their BMI. Patients with BMIs less than 25 kg/m^2 were found to have a higher valvular vegetation detection rates and lower false negatives resulting in a sensitivity of 78%. Furthermore, patients with BMIs greater than or equal to 25 kg/m^2 were found to have sensitivities of 54% and similar specificities above 90% in both groups (Fig. 3). Body habitus appeared to have an impact on the detection rates between the two groups with an increased sensitivity difference of 24% in patients with BMI <25 kg/m^2. Although our study is limited to a small population, we suggest body habitus as a possible factor in the decreased sensitivities of TTE. TTE provides better detection rates in patients with a BMI <25 kg/m^2. We propose using strong clinical judgment before proceeding with an additional, possibly unnecessary TEE study. We further suggest proceeding directly to TEE as the initial study for IE in patients with a BMI greater than or equal to 25 kg/m^2, unless a TTE is clinically warranted.

Conclusion

Calculating a BMI in patients with suspicion for IE may provide benefit in reducing further diagnostic imaging. Our study demonstrated that patients having a BMI <25 kg/m^2 with a negative TTE should refrain from further diagnostic studies with TEE, given the findings of increased sensitivities. Patients with a BMI ≥ 25 kg/m^2 may proceed directly to a TEE, possibly avoiding an additional study with a TTE given the low sensitivities identified in this population. However, clinician judgment is important in deciding the imaging modalities in patients suspected of IE.

Conflict of interest and funding

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