

UPDATES TO THE DUKE CRITERIA FOR THE DIAGNOSIS OF INFECTIOUS ENDOCARDITIS: A REVIEW OF THE LITERATURE

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Abstract: Goal: To investigate updates to the Duke Criteria for diagnosing infective endocarditis (EI). **Methods:** Bibliographic review conducted in the PubMed database using the specific search strategy ((duke criteria) AND (endocarditis)) AND ((diagnosis) OR (update) OR (management)). 18 articles selected from an initial total of 197 were analyzed. **Discussion:** The findings reveal an advance in the identification of IE, incorporating diverse populations, new microorganisms and imaging technologies. Methods such as cardiac PET-CT and three-dimensional transesophageal echocardiography have proven effective, highlighting persistent challenges, especially in patients with clinical suspicion of IE. **Final considerations:** Interdisciplinary collaborations are crucial to advance diagnostic accuracy, highlighting the importance of continuous research to improve diagnostic strategies and positively impact clinical practice and patients' lives. **Keywords:** Duke Criteria, Infective Endocarditis, Diagnosis.

INTRODUCTION

Infectious Endocarditis (IE) is a serious pathology whose accurate and timely diagnosis is imperative for effective management. The Duke criteria, established in 1994 and published in 2000, serve as a standard for evaluating the presence of IE in patients (DAHL A. et al., 2022; MAHABADI A. A. et al., 2021). Duke, the demographics of patients evaluated by EI have changed substantially. A high proportion of immunodeficient, seriously ill patients with prosthetic valves or undergoing prolonged intensive treatment was observed.

These new conditions present challenges for the application of the Duke criteria, due to their lower sensitivity in these populations. The resulting diagnostic uncertainty often

leads to dependence on advanced imaging modalities (MAHABADI A. A. et al., 2021). Recent studies suggest the need to review the Duke criteria. Mahabadi A. A. et al. (2021) highlighted the superiority of transesophageal echocardiography, while El-Dalati S. et al. (2020) demonstrated its high sensitivity. Furthermore, new imaging modalities, such as cardiac computed tomography and 18F-FDG PET/CT, have shown promise in evaluating patients with IE, albeit with challenges related to false-positives (FOWLER JR.; VANCE G., 2023; PHILIP M. et al., 2020). The detection of new etiological agents and the increasing incidence of IE caused by *Enterococcus faecalis* also emphasize the need to review and adjust the Duke criteria (DAHL A. et al., 2022; FOWLER JR.; VANCE G., 2023).

This review seeks to evaluate the applicability of the Duke criteria in the modern era, explore new diagnostic modalities, and suggest potential modifications to existing criteria to better reflect demographic and technological changes. Furthermore, we intend to discuss developments in diagnostic and therapeutic tools, and how the multidisciplinary approach has contributed to more adequate management of patients with IE, especially those with complex clinical conditions.

METHODOLOGY

This is a narrative bibliographic review developed according to the criteria of the PVO strategy, an acronym that represents: population or research problem, variables and outcome. Used to prepare the research through its guiding question: “How do the most recent updates to the Duke Criteria affect the diagnostic accuracy of infective endocarditis in patients with clinical suspicion of the disease?” In this sense, according to the parameters mentioned above, the population or problem of this research refers

to patients with clinical suspicion of infective endocarditis who underwent diagnosis based on the Duke Criteria with the aim of evaluating the effectiveness and precision of the Criteria. of Duke updated in the diagnosis of such pathology. The searches were carried out by searching the PubMed Central (PMC) database. The search terms were used in combination with the Boolean term “AND” through the following search strategy: ((“duke criteria”) AND (endocarditis)) AND ((diagnosis) OR (update) OR (management)). From this search, 197 articles were found, subsequently submitted to the selection criteria. The inclusion criteria were: articles published between 2018 and 2023 that addressed the themes proposed for this research, meta-analysis studies, observational studies, clinical trials and original articles available in full. The exclusion criteria were: duplicate articles, available in abstract form, which did not directly address the proposal studied and which did not meet the other inclusion criteria. A total of 18 articles were selected to compose the present study.

DISCUSSION

A late or missing diagnosis of infective endocarditis (IE) can lead to significant morbidity and mortality. The mortality rate from untreated IE can reach 50% (YANG Y.C. et al., 2019). Initially proposed in 1994, the Duke criteria for the diagnosis of Infectious Endocarditis (IE) represent a significant milestone for the management and follow-up of this condition. They have evolved over the decades, due to the need for a more targeted approach as the characteristics of patients with Infective Endocarditis changed (MAHABADI A. A. et al., 2021).

The criteria were revised in 2000, incorporating new findings and adjusting sensitivity and specificity for a more accurate diagnosis. This update also highlighted the

importance of clinical assessment and the use of imaging tests, such as echocardiography, in confirming the diagnosis. This refined the diagnostic approach, increasing the accuracy and reliability of the process (EL-DALATI S. et al., 2020). In 2015, they became known as the Modified Duke Criteria. This version emphasizes the importance of detailed clinical assessment, the integration of laboratory and imaging tests, and a multidisciplinary approach. The inclusion of criteria such as the detection of microorganisms by molecular methods and serology also reflects advances in diagnostic microbiology (PECORARO A.J.K. et al., 2022). However, for Martínez-Sellés M. and Muñoz P. (2023), despite the changes, the approach and treatment of IE continue to be difficult, and new research is needed to include groups that are difficult to manage in the diagnosis. In this sense, in 2023 the European Society of Cardiology published new modifications to the Duke Criteria (DELGADO V. et al., 2023), which can facilitate diagnosis and decision-making more effectively (MARTÍNEZ-SELLÉS M.; MUÑOZ P., 2023).

Transthoracic Echocardiography (TTE) and Transesophageal Echocardiography (TEE) are the main imaging modalities used. The sensitivity and specificity of TTE in detecting valve vegetations or perivalvular abscesses associated with native valve endocarditis range from 28% to 63% and from 91% to 99%, respectively, while for TEE, these ranges are from 87% to 94%. and 91% to 100%, respectively (YANG Y.C. et al., 2019). TEE demonstrates greater sensitivity when compared to TTE in diagnosing IE (MARTÍNEZ-SELLÉS M.; MUÑOZ P., 2023).

ETT demonstrates greater sensitivity in detecting valve vegetation that is larger than 6 mm, however, sensitivity decreases to 25% when the vegetation size is smaller than 5 mm. TEE, on the other hand, offers a closer

view of the heart through the esophageal axis and can detect vegetations 1 mm in size or larger. However, the role of TEE is limited in patients with certain comorbidities, such as esophageal cancer, extensive esophageal ulceration, Zenker's diverticulum, or anatomical anomalies of the esophagus, since the probe may not be able to pass or the risk of esophageal perforation iatrogenic risk is high (YANG Y.C. et al., 2019).

TEE is useful in a wide variety of clinical scenarios due to the limitations of TTE in diagnosing perivalvular complications, small vegetations, PVE, and vegetations associated with CIED. TEE is strongly recommended in patients with an inconclusive TTE, in patients with a negative TTE and a high suspicion of IE, as well as in patients with a positive TTE, to document local complications. Repeat TTE and/or TEE must be considered during follow-up of uncomplicated IE in order to detect new silent complications and monitor vegetation size. The timing and modality (ETT or TEE) of the repeated examination depend on the initial findings, the type of microorganism and the initial response to therapy (FOWLER JR.; VANCE G., 2023).

According to Fowler Jr and Vance G. et al (2023), the combination of microbiological parameters (type of microorganism and number of positive blood culture bottles) and cardiac risk factors (native valve disease, previous IE, prosthetic valve and cardiac devices) can help identify patients in whom echocardiography (TTE+TEE) is necessary.

The Modified Duke Criteria (CDM) offer high diagnostic value in suspected infective endocarditis (MAHABADI A. A. et al., 2021). Initially, they consisted of clinical, echocardiographic and biological findings, such as blood cultures and serology, which were part of the diagnostic evaluation of infective endocarditis (IE).

However, due to the increase in IE cases

associated with cardiac prostheses and devices, it became necessary to make changes to the IE diagnostic criteria (MAHABADI A. A. et al., 2021). Several studies have highlighted diagnostic failures of infectious endocarditis when using CDMs, especially related to the ineffectiveness of echocardiography in cases of endocarditis of prosthetic valves, pacemaker electrodes or defibrillators, given their low sensitivity (PRETET V. et al., 2021). This update incorporates different causative agents and introduces new, more specific and sensitive diagnostic methods, such as cardiac PET-CT and polymerase chain reaction (PCR) methods. As a result, new criteria were added with the aim of expanding the identification of endocarditis cases in different populations (PRETET V. et al., 2021).

New laboratory diagnostic methods were added to the criteria, such as the use of the polymerase chain reaction (PCR) technique for the 16S/18S rRNA gene, new sequencing approaches and the fluorescence in situ hybridization technique (FOWLER JR.; VANCE G., 2023). The combination of the fluorescence in situ hybridization technique with PCR/sequencing (FISHseq), for example, resulted in a 30% increase in the detection and identification of microorganisms causing IE in prosthetic heart valves, when compared to other culture methods commonly used (FOWLER JR.; VANCE G., 2023). Furthermore, it was noted that bacteremia, while meeting the major criteria according to the Duke criteria, did not provide a greater positive predictive value nor stronger associations with IE compared to pathogen detection, considered minor criteria according to Duke (PHILIP M. et al., 2020). Consequently, new topics were added to the existing criteria, such as the inclusion of new typical microorganisms, adjusting the Duke criteria for enterococci and adding *Enterococcus faecalis* as a typical bacterium

(DAHL A. et al., 2022).

Intraoperative evidence of IE, such as vegetations, abscesses, dehiscence, and valve destruction, has also been incorporated as a new Major Criteria in the 2023 Duke IE Criteria when other criteria are unavailable. Additional clinical features have been included as Minor Criteria, such as specific types of cardiac prosthetic materials and updated congenital heart conditions. Vascular phenomena such as brain abscess and splenic abscess have been recognized, and a practical definition of immune complex-mediated glomerulonephritis has been developed under the category of immunological phenomena (FOWLER JR.; VANCE G., 2023)

It is worth mentioning that, although the modifications in the CDM included transesophageal and transthoracic echocardiography in conjunction with clinical suspicion, significantly improving the diagnostic confirmation of IE, these were not sufficient to encompass changes in the current epidemiological profile of patients suspected of having IE (PRETET V. et al., 2021).

Echocardiography remains the primary method for identifying anatomical signs of Infective Endocarditis (IE) and remains a fundamental criterion in the 2023 Duke Criteria (FOWLER JR.; VANCE G., 2023). Compared to transthoracic echocardiography, transesophageal echocardiography (TEE) has greater sensitivity in diagnosing IE. Therefore, TEE is generally indispensable in cases of suspected IE, especially when involving prosthetic valves, cardiac devices or complications such as perforations, paravalvular lesions, fistulas or prosthetic valve dehiscence. TEE imaging technology has been improved with higher frame rates and three-dimensional (3D) images, improving visualization of heart chambers and valve anatomy (FOWLER JR.; VANCE G., 2023). Several studies have shown that TEE

is superior to cardiac computed tomography (CCT) in diagnosing IE-related valve lesions (Montané B. et al., 2023).

Several studies demonstrate how intracardiac echocardiography (ICE) can be a diagnostic tool in patients with valve prostheses and inconclusive results from transthoracic echocardiography (TTE) and TEE. In complex cases, ICE can help make medical decisions about the duration of antibiotic treatment and the need for surgical intervention. However, due to the invasive nature of ICE, potential complications need to be considered in relation to diagnostic benefits. Therefore, ICE must only be used when TTE and TEE results do not provide clear conclusions (ØSTERGAARD L. et al., 2019).

Additionally, cardiac computed tomography (CCT) was included as an additional imaging modality in the 2023 Duke Criteria along with 18F-fluorodeoxyglucose positron emission tomography ([18F] FDG PET/CT) (FOWLER JR.; VANCE G., 2023). In view of the above, some studies have demonstrated that 18 F-FDG positron emission tomography, when associated with computed tomography, improves the sensitivity of the diagnostic criteria as it is a proficient instrument in the suspicion of IE. However, it may present insignificant results when disregarding the operational receiver (MAHABADI A. A. et al., 2021).

Therefore, according to Mahabadi A. A. et al. (2021) the use of contemporary ultrasound devices to perform three-dimensional transesophageal echocardiography (TEE) achieves high diagnostic accuracy, concluding that the latest updates in the quality of imaging exams are extremely important in the analysis of patients suspected of HEY. Sifaoui I. et al. (2020) compared TEE with CT for the diagnosis of IE complications, showing that TEE has a better result in detecting

valve lesions related to IE, compared to CT. Ultimately, this addition was supported by studies that highlighted its usefulness in the evaluation of patients with suspected infectious endocarditis in valve prostheses, increasing diagnostic accuracy, especially in possible cases of IE (FERNÁNDEZ D.P. et al., 2023).

Cardiac magnetic resonance (MRI), cardiac computed tomography (CT), cardiac tomography angiography (CTA), and fluorodeoxyglucose positron emission tomography (PET) with CT or CTA (FDG PET/CT or FDG PET/CTA) are alternative diagnostic tools in patients who have contraindications to TEE. However, the role of these imaging modalities may be limited as they often depend on other factors such as the local availability of imaging equipment or the experience of interpreters, the presence of implants not compatible with MRI, or impaired renal function (YANG Y.C. et al., 2019).

FINAL CONSIDERATIONS

This review addressed advances in the Duke criteria for diagnosing infective endocarditis (IE), a crucial development in identifying this condition in diverse populations. The updates consider new microorganisms and technological advances in imaging methods, such as cardiac PET-CT and three-dimensional transesophageal echocardiography (TEE), which have proven effective in diagnosing and evaluating patients with suspected IE. A broad overview of the current state of knowledge about IE was provided, highlighting improvements in the Duke criteria and focusing on areas that still require research, particularly the diagnostic challenges in patients with clinical suspicion of the disease. Interdisciplinary collaboration between cardiologists, microbiologists, and medical imaging specialists is critical to

improving diagnostic accuracy. IE is a serious condition that demands early and accurate diagnosis to guide appropriate therapy, thus improving patients' prognosis. Continuous

research is essential to develop more effective diagnostic strategies, significantly impacting clinical practice and patients' quality of life.

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