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Literature Review

The In-Depth Analysis of Trans-Esophageal Echocardiography (TEE), Trans -Thoracic Echocardiography (TTE) and Multidetector Cardiac Computed Tomographic Angiography

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ABSTRACT

Imaging is essential for the diagnosis, treatment, and intervention of infective endocarditis (IE) nowadays. Echocardiography, with its most standard form being trans-esophageal echocardiography (TEE), is essential for diagnosing native valve endocarditis (NVE). It can also be used for numerous other heart related pathologies as it gives us a clear view of the cardiac anatomy; however its accuracy is somewhat lower for prosthetic valve endocarditis (PVE). Even though transthoracic echocardiography (TTE) is less reliable than TEE, PVE cannot be ruled out by a negative TEE test. In about thirty percent of instances, both TTE and TEE imaging techniques may yield normal or unreliable results, particularly in patients who use prosthetic devices. Recent advancements in nuclear medicine imaging have demonstrated better-quality investigative performance to TEE for PVE and infective endocarditis related to cardiac implantable electronic devices (CIED-IE). Cardiac computed tomography angiography is advantageous when TTE and TEE findings are uncertain, particularly for evaluating para-valvular complications in PVE. This article explores the strengths and restrictions of multiple different imaging techniques in diagnosing NVE, PVE, and CIED-IE, as well as the use of multimodality imaging and methods for assessing local and distant IE complications. It also proposes a possible diagnostic approach for a variety of clinical scenarios.

Keywords: Trans-esophageal echocardiography (TEE); Infective endocarditis; Prosthetic valve endocarditis; Cardiac computed tomography

Introduction

Cardiovascular diseases have a significant financial burden on both community health and the worldwide financial system. Extensive scientific research has definitively linked cardiovascular risk factors to a range of presymptomatic and symptomatic conditions such as congestive heart failure, cerebrovascular accident (CVA), arteriosclerosis and atheromatosis, and infective endocarditis (IE)[1].

An infection of the innermost lining of the tissue covering the heart cavities which can cause damage to implanted prosthetic valves, natural heart valves, or other heart implants is known as Infective Endocarditis (IE)[2]. The prevalence of IE is estimated at around 15 persons per 100,000 population, showing a gradual increase in recent years. In-hospital mortality varies between 14% to 22%, and death rate per year may exceed 40%, indicating that significant mortality rates persist regardless of advancements in diagnosis and treatment[3,4]. The prevalence of prosthetic valve endocarditis (PVE) has also been on the rise, now representing 20-30% of all IE cases[5-7]. IE is linked to oxidative stress in the heart which is associated with elevated cardiac formation of hydrogen peroxide (H2O2) and the synthesis of thiobarbituric acid reactive compounds[8,9].

People who have suffered from infective endocarditis in the past, have surgically or catheter-implanted artificial valves, incorrected or inadequately taken care of cyanotic congenital heart disease (CCHD), have surgically placed artificial devices, or have left ventricular aid devices are prone to contract the disease[6].

Prompt and precise identification of IE is essential and has a substantial impact on the management of patients. A late or inaccurate interpretation can give rise to potential risks including congestive heart failure, abscess growth, arrhythmias, vascular obstruction and faulty prosthetic valves. The modified Duke criteria are utilized to categorize patients into definite, possible, or rejected IE classifications. Radiological findings are crucial for the diagnosis of IE, with various radiological modalities providing essential diagnostic criteria[10-12]. For the most effective treatment and results in IE, a collaborative approach comprising heart specialists, cardiac surgeons, infectious disease experts, microbiologists, and radiologists, is advised[13].

The primary imaging modality for IE is echocardiography, which can give precise or ambiguous results in as many as one-third of patients. This is especially true for cases of PVE, or CIED-related infective endocarditis (IE). Transesophageal echocardiography (TEE) and transthoracic echocardiography (TTE) are important methods for the diagnosis of IE. They can detect significant imaging criteria such as prosthetic valve breakdown, vegetations, abscesses, pseudoaneurysms, and valvular perforations[14].

For native valve IE (NVE), the modified Duke criteria show exceptional sensitivity and specificity but they are insufficiently reliable for IE using prosthetic materials. New radiological modalities are required to improve treatment results and diagnosis[7,15-20]. Advanced radiological modalities such as cardiac computed tomography angiography (CTA), 18-fluorodeoxyglucose positron emission tomography/ computed tomography (18 F-FDG PET-CT), and radiolabeled white-blood-cell single-photon emission tomography along with computed tomography (WBC SPECT/CT) can provide further diagnostic standards[21].

These novel tests can enhance echocardiography, improving diagnostic precision and enabling assessment of infection severity and extent for preoperative assessment In instances where TTE and TEE yield inconclusive results, multislice CTA and nuclear imaging methods like 18 F FDG PET/CT or WBC SPECT/CT help decrease the incidence of misinterpreted IE. This is especially true for PVE, paravalvular extension of infection, and CIED-IE cases. ECG-gated CTA allows visualization of heart valves and perivalvular tissue in 3D or 4D, accurately identifying pseudoaneurysm, abscess, and paravalvular spread of infection[22]. Additionally, cardiac CTA can evaluate the aortic valve and root as well as detect coronary artery embolic problems. This information is vital for surgical preparation, especially when prosthetic valves are involved, regardless of the aortic duct prosthesis[23].

18 F-FDG-PET/CT has shown added diagnostic accuracy in individuals with pacemakers, left ventricular assist devices (LVADs), prosthetic valve endocarditis (PVE), and internal cardioverter defibrillators (ICDs) for early identification of cardiac infections and extracardiac infectious foci (PVE) in native valve endocarditis (NVE) as well as prosthetic valve endocarditis (PVE)[24]. WBC SPECT/CT offers increased specificity but lower sensitivity and is associated with several drawbacks related to patient preparation and comfort. In individuals who have ambiguous echocardiography and are at risk of PVE, it may be taken into consideration. However, 18 F-FDG-PET/CT is often the initial diagnostic assessment because of its exceptional sensitivity for identifying active infection. WBC SPECT/CT is recommended when 18 F-FDG-PET/CT results are ambiguous, as it has significant specificity. Both 18 F-FDG-PET/CT and WBC SPECT/CT can be effective for determining the CIED-related infective endocarditis (IE). While FDG-PET/CT has a lesser sensitivity for lead infections, it is extremely sensitive for pocket infections[25].

With an emphasis on native valve endocarditis (NVE), prosthetic valve endocarditis (PVE), and CIED-related infective endocarditis (IE), this research attempts to evaluate the application of hybrid imaging in the interpretation of IE. It offers a critique of the benefits and drawbacks of several imaging modalities, emphasizing on the judicious application of these techniques in healthcare settings. The review offers contemporary insights into a hybrid imaging approach, presenting effective diagnostic techniques in multiple clinical scenarios. It also looks at novel angles, like the diagnostic performance of sophisticated imaging strategies in problematic cases like PVE and CIED-IE when echocardiography results are equivocal.

Trans-Thoracic and Trans-Esophageal Echocardiograph

Echocardiography is the preferred imaging method and is promptly conducted when IE is suspected[26]. Major echocardiographic findings serving as diagnostic criteria include pseudoaneurysm, abscess, new prosthetic valve breakdown, aneurysm, valvular perforation, vegetations, intracardiac fistulas,. Vegetations are seen as intracardiac masses attached to valves or intracardiac devices, often with oscillating motion. Abscesses present as irregular, non-homogeneous paravalvular masses, while pseudoaneurysms are pulsatile areas near valves communicating with cavities of the heart[27]. In contrast to aneurysms, which appear as the leaflet outpouching, leaflet perforations are characterized by anomalies in the leaflet tissue with obvious color flow across the defect. A fistula indicates communication between two cavities of heart. Paravalvular leak with potentially anomalous prosthetic valve motion is known as prosthetic valve breakdown[30].

Initially, transthoracic echocardiography (TTE) is conducted, followed by transesophageal echocardiography (TEE) for additional lesion characterization or complication identification, except in right-sided IE cases with clear transthoracic images[6]. In the majority of patients, TTE results are insufficient to rule out IE. For all patients excluding those with no prosthetic valves and those with significantly negative optimum TTE pictures, further TEE assessment is required[31].

TEE is required when there is indication of IE but the results of TTE are ambiguous, or when the patient has intracardiac devices or prosthetic heart valves[28]. To identify which cases of IE necessitate echocardiographic evaluation for individuals with various forms of bacteremia, risk scores have been developed [6]. A second echocardiogram may be required if the primary test is negative but concern of infective endocarditis persists, with the best timing suggested at 3-5 and 5-7 days according to the criteria set by AHA and ESC respectively, especially in high-risk patients with a confirmed IE diagnosis[6,7,32]. Repeat echocardiography is also indicated in cases of new problems such as embolism, congestive heart failure, murmurs, atrioventricular block (AV Block), abscesses, and persistent pyrexia[33]. Repeat echocardiography may be necessary in instances of mild IE in order to observe the variations in vegetation size and asymptomatic problems. TEE is suggested prior to shifting from parenteral to oral treatment, and at the end of antibiotic treatment, TEE and TTE are crucial for assessing structure and activity of the valve[6].

Transthoracic echocardiography (TTE) is capable of evaluating native left-sided valve IE, tricuspid valve IE, and anterior aortic abscesses. Nonetheless, its sensitivity for detecting vegetations is 65%, and it is less effective at identifying paravalvular complications like perforation, abscess, and fistulas[12,34,35].

Transesophageal echocardiography (TEE) surpasses other imaging modalities in detecting and quantifying vegetations, crucial for determining the likelihood of embolic incidents and the necessity for swift surgical intervention. It is widely regarded as the most accurate imaging technique in infective endocarditis (IE), exhibiting a sensitivity ranging from ninety percent to hundred percent and a specificity of ninety percent for native valve IE (NVE), although its specificity is lower for prosthetic valve endocarditis (PVE) and CIED-related infective endocarditis (IE). Despite these strengths, distinguishing vegetations from other intracardiac growths or artifacts on echocardiography is still a concern. Conditions such as papillary fibroelastoma, nonbacterial thrombotic endocarditis, thrombus, myxomatous mitral valve, and Lambl excrescences can be mistaken for vegetations. Moreover, a simple echocardiogram is unable to rule out IE, especially in cases involving degenerative valvular changes, a cardiac device, or prosthetic material, which can hinder lesion visualization[36,37].

Transthoracic echocardiography (TTE) is the principal diagnostic modality for right-heart infective endocarditis (IE), while transesophageal echocardiography (TEE) is limited to specific circumstances, such as unclear TTE results or the presence of an intracardiac device or prosthetic valve. TTE is generally effective in identifying vegetations on the tricuspid valve, which is positioned anteriorly and typically harbors larger vegetations in right-sided infections. However, distinguishing between different types of vegetations in the right heart can be challenging[39]. While TEE is more adept at detecting vegetations on the pulmonary valves and identifying coexisting left-heart IE, imaging right-ventricle-outflow-tract and pulmonic-valve IE poses difficulties for both TTE and TEE. Additionally, TEE exhibits greater sensitivity in evaluating devices, prosthetic valves, intravenous catheters, and IE-related issues like paravalvular abscess[38]. Tricuspid valve IE can be visualized using TTE, although multiple views are typically essential to assess the tricuspid ring and all three leaflets adequately. Compared to two-dimensional TEE, three-dimensional TEE provides better imaging of the tricuspid valve apparatus and adjacent tissue. This enhanced capability is particularly beneficial in identifying and quantifying vegetations on the tricuspid valve. In individuals having intracardiac devices, valve prosthesis, tricuspid ring, 3D echocardiography outperforms two-dimensional TEE in detecting vegetations and guiding therapeutic interventions, such as removal of device[40].

The assessment of prosthetic valve endocarditis (PVE) poses several challenges due to acoustic shadowing artifacts, which can hinder the visualization of vegetations and paravalvular extensions. Additionally, postoperative changes like edema or hematoma may obscure imaging, particularly in the early postoperative period. Despite being crucial for diagnosis, both echocardiography and blood cultures often yield negative results in PVE.

Transthoracic echocardiography (TTE) exhibits reduced sensitivity (36-69%) in detecting vegetations in PVE and lower precision in identifying paravalvular issues. In contrast, transesophageal echocardiography (TEE) proves more effective, with a sensitivity of 86-94% and a specificity of 88-100% for finding vegetations in PVE.

When paravalvular leak around the prosthetic valve is suspected of causing PVE, valve breakdown, valve instability, and perivalvular growth of infection should be the main targets of echocardiography. Off-axis imaging planes, multidimensional imaging, and the use of three-dimensional echocardiography if accessible may be necessary to achieve this. When aortic PVE occurs, acoustic shadowing makes it difficult to identify anterior abscesses with TEE, and evaluation of posterior abscesses with TTE may be problematic. As a result, it is preferable to combine the two approaches.

When endocarditis occurs in unusual places, such as the suture site, aortotomy, or atrial septal closure, unconventional echocardiographic techniques may be required[6]. Paravalvular problems are more common in PVE compared to NVE, especially in aortic-valve IE compared to mitral-valve IE. In aortic-valve IE, the spread of infection frequently involves the mitral-aortic intervalvular fibrosa, while in mitral-valve IE, extension tends to be more posterior and lateral. Clinical indicators of paravalvular spread include continuous pyrexia,heart block, and new murmurs.

Transesophageal echocardiography (TEE) outperforms transthoracic echocardiography (TTE) in evaluating perivalvular complications, although its diagnostic accuracy is diminished for PVE. Therefore, when there is a significant risk of PVE and results of TTE/TEE are negative or unclear, other imaging techniques such as computed tomography angiography (CTA) and nuclear techniques are required. These advanced imaging tests can aid in detecting paravalvular extension, a feature present in 50% of PVE cases. Paravalvular leak, continuous pyrexia, or heart block are the factors that call for CTA or nuclear imaging[6,32].

CIED-related infective endocarditis (IE) is linked to a high mortality rate, prompting the recommendation for device removal in all confirmed cases. For CIED infections, the diagnostic strategy depending on the modified Duke criteria is regarded as unsatisfactory. Implantable defibrillators, pacemakers, septal defect closure devices, left atrial appendage occluders, and devices used in non-valvular heart procedures are among the devices that are most commonly affected by CIED infections. These devices offer issues for imaging due to acoustic shadowing and the limitations of typical echocardiography images, often requiring unconventional views for optimal imaging. Thrombi adhering to right-heart devices, caused by low pressure, can be challenging to differentiate from vegetations. Transthoracic echocardiography (TTE) is less precise than the transesophageal echocardiography (TEE) is in assessing the intra and extra cardiac leads, as well as in identifying issues including perforations, abscesses, and fistulas[36,41].

When it comes to identifying CIED infections, transesophageal echocardiography (TEE) has a far greater sensitivity than transthoracic echocardiography (TTE) (90% vs. 22-43%). TEE is recommended for a more careful assessment of the superior vena cava and right atrium parts of the leads, whereas TTE may indicate symptoms of device-related infection on leads from the right atrium or right ventricle. While TTE has lower accuracy in comparison to TEE and three-dimensional echocardiography, and the two tests are complementary in their ability to provide information about CIED infections.

While both TTE and TEE are helpful in recognizing prognostic parameters such as pericardial effusion, ventricular failure, and elevated pulmonary arterial pressure, TEE is superior in identifying and measuring vegetations[42].

Limitations of transesophageal echocardiography (TEE) include challenges in distinguishing between active infection and postsurgical alterations in individuals who have just undergone surgery, as well as in differentiating between vegetations and thrombi or fibrous strands[44]. 3D echocardiography and intracardiac echocardiography are increasingly important in such scenarios[29,45,46].

3D echocardiography offers a multiplanar view that allows assessment of vegetations and valves from angles not accessible with 2D TEE. It is particularly beneficial for evaluating paravalvular abscesses, regurgitation, and perforations. While three-dimensional echocardiography can exclude infective endocarditis with as much as one hundred percent higher specificity, it is not as sensitive as TEE[47-50].

As much as thirty percent of operative choices might be influenced by intraoperative TEE, which is often used in operation theaters[51,52]. Nevertheless, there is little data on 3D TEE's efficacy. Because of its low frame rate, the approach should be viewed as an extra tool to TTE/ two-dimensional TEE as it may overlook tiny, actively moving vegetation[14].

Diagnosing CIED infections remains challenging despite utilizing both TTE and TEE, particularly in distinguishing it from a thrombus[4,7,37,43]. Up to 30% of infective endocarditis (IE) cases might be overlooked with TTE and TEE, particularly in individuals with already existing severe valvular disease, prosthetic valves, CIED, small vegetation, abscess, or embolized vegetation. A negative test result is unable to exclude the probability of infection involving the extracardiac part of a CIED. Intracardiac echocardiography utilizes a catheter with a transducer that is passed through the femoral vein to visualize structures within the heart. It has shown high sensitivity in identifying vegetations on cardiac devices[38,53].

In conclusion, TTE serves as the primary imaging technique for identifying vegetations and associated valve lesions, with TEE recommended when TTE results are unclear or negative. TEE offers enhanced accuracy in assessing vegetations and problems of infective endocarditis (IE). Although false-negative results are more prevalent, both TEE and TTE are suggested in PVE. TEE may be the initial investigative step in PVE and is also useful when TTE yields negative results in PVE or for identifying periprosthetic abscesses and leaks. Regarding infections related to CIED, TTE and TEE are crucial for the initial assessment of vegetations involving the superior vena cava and intracardiac portions of the leads, but they have a limited application in infections associated with the device pocket. Notably, a negative result from both TTE and TEE does not completely rule out the possibility of infection in CIED cases[54].

Multidetector Cardiac Computed Tomographic Angiography

In cases where echocardiography results are ambiguous, the European Society of Cardiology (ESC) guidelines strongly advocate cardiac computed tomography angiography (CTA) for the identification of valvular lesions, confirmation of diagnoses, and detection of perivalvular and periprosthetic problems. When assessing paravalvular and periprosthetic problems such as abscesses and pseudoaneurysms, its precision exceeds that of TEE. However, TEE continues to be the best method for identifying vegetation, fistulas, and leaflet perforations[6].

Numerous studies have investigated the effectiveness of cardiac CTA in detecting vegetations. Vegetations can be seen as localized dilatation of the valve leaflets or as growths with low-to-intermediate opacity on cardiac CTA images[55]. A comparative study between multislice cardiac CTA, TEE, and intraoperative findings demonstrated that CTA correctly identified valve abnormalities in ninety seven percent of cases identified by TEE and accurately detected vegetations in ninety six percent of cases verified intraoperatively. Moreover, multislice cardiac CTA distinguished between valve calcifications and vegetations, and it was successful in identifying a vegetation linked to a mechanical valve that TEE had overlooked[22].

In a research involving forty nine patients, including twelve having PVE, four-dimensional cardiac CTA identified vegetations with a sensitivity of ninety one percent[56]. Another study found that the detection of aortic valve vegetations had a lower sensitivity of seventy-one percent and a higher specificity of hundred percent when comparing four-dimensional cardiac CTA with intraoperative observations in nineteen patients with aortic-valve IE (reaching 100% sensitivity for vegetations bigger than 10 mm)[23]. According to a retrospective study, one hundred and thirty seven individuals who had cardiac CTA prior to operation had a seventy percent sensitivity in identifying vegetations[57]. In a different retrospective investigation, TEE detected vegetations at a higher rate than cardiac CTA (97% vs. 72%) in seventy five individuals who had undergone both procedures. Furthermore, cardiac CTA commonly overlooked tiny vegetations (<10 mm) (53% vs 94%)[58]. Eight research studies comparing TEE with cardiac CTA were reviewed in a systematic manner, and the results showed that TEE had a much greater sensitivity for vegetation identification (94% vs. 64%, $p < 0.001$)[59]. The combined sensitivity for vegetation detection was shown to be eighty two percent for TEE, eighty eight percent for TEE paired with multislice cardiac CTA, and twenty nine percent for TTE alone, according to a meta-analysis of twenty investigations involving four hundred ninety six patients. For periannular complications (abscesses, mycotic aneurysms), the combined sensitivity was eighty six percent for TEE, hundred percent when TEE was paired with multislice cardiac CTA, and thirty six percent when TTE was used alone. The sensitivity of vegetation detection in PVE increased remarkably (from 63% to 100%) with the addition of ECG-gated CTA to TTE or TEE[60].

The occurrence of vegetations on heart valves may be mistaken for nonbacterial thrombotic endocarditis, fibroelastomas, and blood clots[61,62]. Small lesions known as fibroelastomas have low attenuation and are often not associated with valve malfunction or impairment. They are connected to valves by a slender stalk. Their tiny dimensions and movement make them easier to be visualized with TEE[63]. Small, atypical aggregates on heart valves are indicative of nonbacterial thrombotic endocarditis, which is frequently linked to pre-existing cancer or autoimmune diseases[62].

Cardiac CTA provides enhanced detection of perivalvular complications compared to echocardiography. Abscesses typically present as irregular, non-homogeneous paravalvular masses with high echogenicity on ECG[6]. In contrast, cardiac CTA reveals a central ischemic portion having low attenuation surrounded by a peripheral enhancing rim[64,65]. Pseudoaneurysms are visualized as pulsatile, anechoic spaces adjacent to the valve with flow demonstrated on color Doppler[55]. A pseudoaneurysm is indicated by a contrast-filled hollow space next to the valve in cardiac CTA that can be seen to be connected to the aortic root or cardiovascular lumen. As the contrast agent fills the pseudoaneurysm hollow space, using contrast aids in separating a pseudoaneurysm from an abscess[66].

According to a latest investigation evaluating the effectiveness of cardiac CTA in identifying paravalvular problems, the sensitivity of TEE and TTE in identifying abscesses or pseudoaneurysms was ninety percent and sixty-three percent, respectively, and hundred percent for the two procedures when cardiac CTA was incorporated into the investigative procedure[66]. Sims et al. reported a sensitivity of ninety-one percent in identifying abscesses or pseudoaneurysms in one hundred thirty seven individuals who underwent cardiac CTA prior to operation[57]. Furthermore, in individuals with aortic-valve IE, four-dimensional cardiac CTA showed hundred percent sensitivity and eighty-seven and half percent specificity in identifying pseudoaneurysms[23]. When it comes to identifying abscesses and pseudoaneurysms, cardiac CTA has a higher sensitivity than TEE (78% vs. 69%, $p = 0.052$), according to a systematic review and meta-analysis[59]. Multiphase cardiac CTA studies also increase the sensitivity to eighty-seven percent ($p = 0.04$)[59].

Paravalvular spread of infective endocarditis (IE) is more prevalent in prosthetic valve endocarditis (PVE) and is linked to poor outcome, often leading to valve annulus destruction, valvular breakdown, and paravalvular leaks. While transesophageal echocardiography (TEE) is typically the preferred imaging technique for evaluating PVE, cardiac computed tomography angiography (CTA) offers additional insights when acoustic shadowing from prosthetic material complicates visualization. Breakdown of prosthetic valve can be identified on cardiac CTA by observing misalignment between the annulus and the prosthesis, as well as by noting rocking motion on cine images[55,64,65]. Both cardiac CTA and TEE demonstrate comparable capabilities in detecting valve breakdown, with TEE being slightly more effective due to its use of color Doppler, which enhances visualization of paravalvular leaks and facilitates better depiction of valve rocking[6]. When it comes to identifying breakdown, SP-CTA and TEE have almost the same specificity (97% vs. 99%) but less sensitivity(46% vs. 15%)[65].

Fistulas, abnormal communications between neighboring cavities, typically arise from abscesses or pseudoaneurysms. Color Doppler imaging reveals a tract connecting the 2 hollow chambers[6]. On the other hand, cardiac CTA shows a tract filled with a contrast material that connects the hollow chambers. Fistulas are more accurately detected by TEE, yet this problem is frequently linked to a poor result[67]. Significant valvular regurgitation can result from leaflet perforation; this can be seen on echocardiography when color Doppler displays flow through the gap. A hole in cardiac CTA is indicated by a discontinuity in the valve leaflet[65,66]. When it comes to identifying leaflet perforation, cardiac CTA is more specific (89% vs. 79%) but less sensitive (43% vs. 75%) than TEE. All four of the individuals with leaflet perforations were not identified with cardiac CTA in a study with twenty nine surgical patients[22]. Additionally, Oliveira et al. found that TEE was more sensitive than cardiac CTA at identifying valve perforations (81% vs. 41%, $p = 0.02$)[59]. Aneurysms in the valve leaflets manifest as deformed saccular protrusions that have lost their typical curvature[6,66]. When it came to identifying valve aneurysms, TEE and cardiac CTA agreed 100% of the time[58].

Multislice cardiac CTA is more accurate than TEE in the identification of prosthetic valve endocarditis (PVE) and associated consequences, such as abscesses and pseudoaneurysms, according to a recent meta-analysis[68,69]. Research on the use of multislice cardiac CTA in the interpretation of PVE indicated ninety-three percent sensitivity. Multislice cardiac CTA raised sensitivity to hundred percent and specificity to eighty-three percent when combined with conventional diagnostic techniques, potentially changing treatment plans in a considerable number of cases[60]. Since it is less impacted by artifacts from prosthetic valves, it is a useful addition to TEE in PVE evaluation[70]. While ECG-gated CTA is better at assessing paravalvular problems in PVE, overall diagnostic value is comparable to TEE[22,23].

Cardiac CTA can also detect extracardiac findings such as embolic events, which are less significant indicators for IE diagnosis[12]. These peripheral lesions include infarctions or abscesses related to kidney, spleen, lungs and mesentery[71], lesions of the cerebral cortex, osteoarticular infections, pulmonary septic embolism and mycotic aneurysms associated with right heart IE[72].

Due to blooming and beam-hardening artifacts, cardiac CTA in CIED-IE has a lower sensitivity than TTE or TEE for detecting pacemaker lead vegetations[38]. While localized peri-device inflammation or abscess collection can be identified using contrast-enhanced CTA to assess pacemaker pocket infections[71], the difficulty of differentiating pacemaker pocket infections from recent implantation inflammatory changes limits the application of this technique[6]. In CIED-IE, the tricuspid valve is frequently damaged[73]. Valvular intervention and device extraction may be necessary for management[74]. Because cardiac CTA visualizes lead adhesion to surrounding vasculature, it can help with pre-procedural assessment. Furthermore, extracardiac septic emboli and mycotic aneurysms are detectable by contrast-enhanced CTA, which are other diagnostic standards[75].

Cardiac CTA is being utilized more often prior to surgery for assessment of the thoracic aorta and coronary arteries, as well as for the identification of IE and its local consequences. TEE is less effective than ECG-gated cardiac CTA with thin-section reconstruction in identifying abscesses and pseudoaneurysms. Using both techniques elevates the sensitivity of the interpretation. Cardiac CTA is inferior to TEE, despite having good spatial and temporal resolution. Cardiac CTA is a useful supplement to TEE in the detection of tiny, active vegetations (<10 mm), leaflet perforations, and paravalvular regurgitation[38]. The tricuspid valves and annulus can be seen with cardiac CTA[76], which can be difficult to see with TEE because of its anterior placement and because of the thinness of the tricuspid leaflet and the saddle-shaped annulus[77]. Furthermore, TTE and TEE are not very sensitive in identifying abscesses, particularly in patients who have intracardiac implants or prosthetic valves[78]. Multislice cardiac CTA's predictive relevance in IE was documented by Wang et al[79], who emphasized the technique's significance for surgical planning and mortality prediction. When TEE results are unclear or contraindicated in cases with both NVE and PVE, cardiac CTA is advised. It can improve the precision of diagnosis, especially in identifying paravalvular and periprosthetic problems. Using whole-body and brain imaging, CTA also has the advantage of detecting remote lesions and portals of entry, as well as revealing other possible diagnoses. PET/CT, however, is the recommended imaging technique in these circumstances. CTA can be used to detect mycotic artery aneurysms anywhere along the vascular tree, including the CNS. Magnetic resonance imaging provides a more precise assessment of neurological problems, spondylodiscitis, and vertebral osteomyelitis[80].

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