

Fungal infections associated with intracardiac devices: diagnosis and treatment

Infecciones fúngicas asociadas a dispositivos intracardiacos, diagnóstico y tratamiento

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Abstract: Invasive fungal infections associated with intracardiac devices, such as prosthetic heart valves, pacemakers, and other devices, are uncommon but severe and associated with high mortality. A narrative review of the scientific literature was conducted to identify the theoretical foundations of invasive fungal infections associated with intravascular devices, including their etiology, pathogenesis, diagnosis, and treatment. *Candida* spp. and *Aspergillus* spp. are the main etiological agents, with biofilm formation, adhesins, and host-related factors contributing to infection. Mycological diagnosis is based on blood cultures (the gold standard) as well as cultures of valves, vegetations, adherent tissue, and purulent material from pacemaker pockets, alongside serological and molecular tests. Treatment requires a combination of surgery (valve replacement and device removal) and prolonged antifungal therapy (amphotericin B, flucytosine, echinocandins, and voriconazole). Suppressive therapy with azoles is often required after the acute phase.

Key words: Invasive fungal infections; Intracardiac devices; Blood cultures; Antifungal agents; Suppressive therapy

Resumen: Las infecciones fúngicas invasivas asociadas a dispositivos intracardiacos, como válvulas cardíacas protésicas, marcapasos y otros, son poco frecuentes, pero graves y de elevada mortalidad. Se realizó un análisis, mediante una revisión narrativa de la literatura científica, para obtener los referentes teóricos sobre las infecciones fúngicas invasivas asociadas a dispositivos intravasculares, su etiología, patogenia, diagnóstico y tratamiento. *Candida* spp. y *Aspergillus* spp. son los principales agentes etiológicos, favorecidos por la formación de biopelículas, adhesinas y factores del huésped. El diagnóstico micológico se basa en hemocultivos (estándar de oro), cultivos de válvulas, vegetaciones, tejidos adheridos y material purulento de las bolsas de marcapasos, además de pruebas serológicas y moleculares. El tratamiento requiere combinación de cirugía (recambio valvular, retirada del dispositivo) y antifúngicos prolongados (anfotericina B, flucitosina, equinocandinas, voriconazol). La terapia supresora con azoles suele ser necesaria tras la fase aguda.

Palabras clave: Infecciones fúngicas invasivas; Dispositivos intracardiacos; Hemocultivos; Antifúngicos; Terapia supresora

Introduction

Fungal infections in general, and invasive forms in particular, are recognized as a leading and significant cause of morbidity and mortality worldwide. The incidence of these conditions has increased over the past decades, and their impact on human health is now considered comparable to that caused by other microorganisms, such as bacteria, viruses, and parasites.¹

Currently, two factors contribute to the sustained increase in the incidence of invasive fungal infections (IFIs). First, the two pandemics, AIDS and COVID-19, in which five opportunistic fungal infections—pneumocystosis, cryptococcosis, histoplasmosis, talaromycosis, and mucormycosis—have become leading causes of death in these populations^{1,2} Second, major advances in medicine aimed at prolonging the lives of patients with chronic noncommunicable diseases, particularly cardiovascular diseases, have led to the increasing use of biomedical devices implanted through surgical or percutaneous procedures. These devices have improved patients' quality of life and survival rates while also contributing to a considerable increase in IFIs.

The complexity and severity of these infections have driven the development and consolidation of new microbiological techniques, which are now considered the diagnostic standard. From a clinical perspective, various diagnostic and treatment guidelines have also been established through consensus among the medical specialties involved. This process has been supported by the modified Duke criteria, which integrate Microbiology, Cardiac Imaging, Cardiology, and Cardiovascular Surgery.^{3,4}

Nevertheless, overall rates of device-associated IFIs are low, although they vary according to the type of implanted device, surgical technique, and the presence of comorbidities. These infections also involve highly complex interactions among the fungus, the surface of the implant itself, and the host. Consequently, mycological diagnosis is challenging and can often only be established after device removal. The aim of this article is to analyze, through a narrative review of the scientific literature, the theoretical foundations of invasive fungal infections associated with intravascular devices, including their etiology, pathogenesis, diagnosis, and treatment.

Method: A narrative review of the scientific literature was conducted based on a targeted search for articles, guidelines, books, and official documents from scientific societies published in databases such as PubMed and Scielo. According to expert judgment, 23 articles addressing the etiology, pathogenesis, diagno-

sis, and treatment of IFIs associated with intravascular devices were selected. In addition, data from two provincial hospitals were incorporated.

Development

Fungal Infections Associated with Prosthetic Heart Valves

Cardiac valves may be biological or mechanical. Their replacement with prosthetic material has represented a major advance in the treatment of various valvular diseases since the 1960s³. According to historical data from the *Hospital Provincial Universitario Cardiocentro Ernesto Guevara* in Santa Clara, Villa Clara, approximately 1,370 valve surgeries were performed between 2002 and 2025 (Source: Department of Medical Records and Statistics of the *Hospital Provincial Universitario Cardiocentro «Ernesto Guevara»*, 2026). Fungal infection of these valves is uncommon but represents one of the most serious complications that patients may experience during the postoperative period and may lead to prosthetic valve endocarditis.

Worldwide, the incidence of fungal endocarditis ranges from 1% to 3% of all cases of bacterial endocarditis. It affects 0.1% of all prosthetic valves and is associated with a mortality rate exceeding 70%⁵. The most frequently isolated species are *Candida* spp. (predominantly *Candida albicans*), *Aspergillus* spp. (particularly *Aspergillus fumigatus*), and *Histoplasma* spp., although the latter two are less common.^{3,5,6} The pathogenesis of this infection involves contributing factors: preexisting tissue damage to the cardiac endothelium, the virulence of the causative fungus, and the patient's immune status. Arnaiz-García et al.⁷ describe a patient with infection involving the mitral and aortic valves, associated with age-related immunodeficiency and a history of a four-month febrile syndrome.

Regarding the route of transmission, fungi may contaminate the valve during surgery or postoperatively through hematogenous dissemination from a damaged gastrointestinal epithelium or from the skin and soft tissues.⁵ According to Bonifaz-Trujillo,⁸ *Candida* spp. forms extracellular biofilms, as do the bacteria *Staphylococcus aureus* and *Pseudomonas* spp., as well as adhesins that promote attachment to surfaces through polymeric substances secreted by the microorganisms themselves. This results in a high capacity for defense and persistence, as well as increased resistance to antifungal therapy.⁶

As previously mentioned, *Candida albicans*, accounting for 50% of cases, is the main species responsible for prosthetic valve endocarditis.

This is attributed to its morphological transition, which represents a third virulence factor and

consists of a morphological shift from yeast-like blastospores to pseudohyphae and true hyphae. It is followed by the *Candida parapsilosis* complex (15-41%), *Candida tropicalis* (10-13%), *Candida glabrata* (4-9%), *Meyeromyces guilliermondii* (4%), and *Pichia kudriavzevii* (1%).^{5,9} Other species, such as *Candida auris*, are uncommon.¹⁰

In the particular case of *Aspergillus* spp., its spores may contaminate the air, and infection can therefore occur during the surgical procedure. Its virulence is multifactorial. It has been described as having resistance to oxidative stress and adhesins or surface proteins involved in interactions with receptor cells, as well as a variety of enzymes, including proteases, peptidases, catalases, elastases (serine proteases and metalloproteases), phospholipases, and superoxide dismutase.⁸ This fungus is the leading cause of fungal endocarditis with negative blood cultures.^{5,11}

In general, as the infection progresses, prosthetic vegetations may develop. These consist of large amounts of microorganisms and fibrin-platelet aggregates. They are larger than those formed by bacteria and are associated with high mortality.³ When *Aspergillus* spp. is the etiological agent, vegetations are the first warning sign.^{12,13}

Fungal Infections Associated with Cardiac Implantable Electronic Devices

Fungal infections associated with these devices are currently a concern that requires healthcare professionals to be familiar with their potential complications. The absolute number of these infections has increased considerably as the number of implanted devices has risen. At *Hospital Provincial Universitario, Cardiocentro «Ernesto Guevara»*, pacemaker implantation rates have varied over time, with an average of 470 procedures per year from 2000 to 2015, followed by 350 per year from 2016 to 2019 (Source: Department of Medical Records and Statistics of the *Hospital Provincial Universitario Cardiocentro «Ernesto Guevara»*, 2020). According to the literature, infection involving the generator alone is the most common type.¹³ Nevertheless, this review will address aspects of fungal infections involving the generator and its leads.

Infection of a cardiac implantable electronic device is a process with serious consequences. In Spain, its incidence is estimated at 1-6%, corresponding to 1.9 infections per 1,000 device-years, and is higher among patients who have required system reimplantation³. Regarding the microorganisms responsible for these IFIs, *Candida albicans* accounts for 1-2% and *Aspergillus* spp. for up to 1%.¹⁴ As with prosthetic heart valves, infection results from the interaction between the fungus and the material

from which the device is made, together with patient-related factors such as immune status and the presence of other comorbidities.^{3,13}

Contamination of the device or the pocket in which it is implanted, as well as its leads, may occur during implantation, following manipulation of the system, or as a result of skin erosion. In this regard, the microorganisms that reach the device material are generally those present on the surrounding skin. This may explain *Candida* infections, as several *Candida* species are components of the body's normal microbiota; they are present from the first days of life and have a strong predilection for mucosal surfaces rather than healthy skin.⁸ Pocket infections may also occur through contiguous spread from the generator to the leads, whereas hematogenous infection is the least common route.³

It is important to emphasize that these yeasts have the ability to form biofilms and express adhesins, a characteristic shared with Gram-positive cocci that plays a critical role in the pathogenesis of these infections. *Aspergillus* spp. can also cause infection, although less frequently. Clinical manifestations depend on the type of infection, the implantation site, the fungal species involved, and the complications that may arise¹³. These manifestations range from a localized infection to an IFI.¹⁴

Mycological Diagnosis

Native and prosthetic heart valves, leads from cardiac implantable electronic devices, purulent material from the pocket of the implanted device, periprosthetic or perianular abscesses, and, in all cases, blood cultures are appropriate specimens for the mycological diagnosis of these infections. All specimens should be collected under strict aseptic conditions, following proper skin disinfection and with minimal manipulation. In general, exudates obtained from fistulas or collected with swabs are not considered valid specimens.³

Valves, vegetations, and adherent tissue should be placed in sterile containers containing sterile distilled water and sealed hermetically in containers of an appropriate size, without adding formalin, viral transport medium, or other preservatives. For the latter specimen, two or more pieces measuring at least 5-10 mm are preferred because of the possibility of contamination by environmental *Aspergillus* spp.³ Purulent material should preferably be obtained by aspiration with a syringe and needle, with a volume of 1-5 mL, and transported in the same device. Hariri *et al.*¹⁵ reviewed 40 medical records of patients with fungal mediastinitis following cardiac surgery. They reported that tissue or mediastinal fluid specimens were obtained from these patients, primarily for mycological studies.

Blood cultures are considered the gold standard for microbiological diagnosis. As previously mentioned, blood samples should be obtained from all patients presenting signs or symptoms of IFI, using peripheral venipuncture, both for culture and for serological and molecular testing. In the specific case of fungal endocarditis, blood cultures together with cultures of prosthetic heart valves are the most important tests for establishing the etiological diagnosis, and their results influence the assessment of fungal viability during surgery and treatment efficacy.³ With proper technique, the isolation rate from the first blood culture may be 60-80%, increasing to 80-90% with two blood cultures and reaching up to 99% with a third. Obtaining an adequate blood volume is crucial (10-30 mL per arm in adult patients), particularly in *Candida* spp. IFI, in which the yeast burden in the bloodstream is low but continuous, unlike *Aspergillus* spp., for which bloodstream dissemination is intermittent.^{5,16,17} Nevertheless, when fungal endocarditis is clinically suspected and blood cultures remain negative after 72 hours, consultation with a microbiologist is necessary. Meena et al.¹⁸ conducted a systematic review including 220 articles involving 250 patients with fungal endocarditis. *Candida* spp. (50%) and *Aspergillus* spp. (30%) were the most frequently identified etiological agents among patients with positive blood cultures. In the Mycology Section of the Microbiology Laboratory at Hospital Provincial Gineco-Obstétrico Universitario «Mariana Grajales» in Santa Clara, Villa Clara, six blood culture specimens were received between 2020 and 2024. The genus *Candida* predominated, with a 50% positivity rate (Source: Department of Medical Records and Statistics, Hospital Provincial Gineco-Obstétrico Universitario «Mariana Grajales», 2025).

Given that these specimens are irreplaceable, difficult to obtain, and their collection may pose life-threatening risks to the patient, it is recommended to contact the microbiology laboratory before collecting them to prevent potential errors by the attending physician, clinical service, or hospital. Culture results should be interpreted in conjunction with clinical and imaging findings, blood culture results, and, when performed, serological and molecular studies. Worldwide, serological tests are used to improve the diagnostic accuracy of IFIs, particularly in the presence of negative blood cultures. Tests are available for the detection of galactomannan, a component of the cell wall of *Aspergillus* spp., and β -D-glucan, a component of the cell wall of *Candida* spp. and *Aspergillus* spp. Both tests are performed on serum and other body fluids. In published studies, galactomannan showed a sensitivity of 83% in fungal

endocarditis caused by *Aspergillus* spp., whereas β -D-glucan showed a sensitivity of 100% for *Candida* spp. infection, highlighting their value as key diagnostic tools.^{5,16,18,19}

Last but not least, molecular diagnostic tests based on polymerase chain reaction (PCR) are also available. These tests detect fungal DNA in microbiological specimens through sequencing and amplification of conserved regions of fungal ribosomal DNA (18S-28S rDNA). They offer high sensitivity and specificity and can detect resistance genes, thereby facilitating the selection of the appropriate antifungal agent. However, these tests are not included in the modified Duke criteria.^{3,16}

Treatment

In recent years, new treatments have emerged for IFIs associated with prosthetic heart valves and pacemakers, offering potential benefits in cases of drug resistance, intolerance, or treatment failure.^{5,19,20} It is crucial to bear in mind that antifungal therapy alone is rarely sufficient; surgical intervention is often necessary and has become increasingly common over the past 20 years, together with prolonged medical therapy to improve survival rates.

For *Candida* spp. endocarditis, early valve replacement or vegetectomy is recommended, combined with systemic antifungal therapy. Amphotericin B with or without flucytosine is recommended as initial antifungal therapy. Both agents have fungicidal activity and can eradicate biofilms, but renal function monitoring is required. Alternatively, high-dose echinocandins (caspofungin, micafungin, and anidulafungin) may be used, all for six weeks.^{5,19}

However, recent studies have highlighted the growing role of echinocandins. These agents inhibit the enzyme 1,3- β -D-glucan synthase and are fungicidal against most *Candida* species, except the *Candida parapsilosis* complex. They may be administered as monotherapy or in combination with fluconazole, flucytosine, or amphotericin B, depending on drug availability.¹⁹

Kurland et al.²¹ describe an interesting study comparing groups of patients who received different treatment regimens. Overall, 24 episodes (47%) were treated with antifungal therapy alone, whereas 21 (41%) underwent concomitant valve surgery and 6 (12%) underwent device extraction. Regarding the treatment of *Candida* spp. endocarditis, echinocandins were the most frequently used initial therapy, accounting for 43% of cases, without the need for combination with another antifungal agent. Meanwhile, 59% of patients ultimately received long-term therapy, including sequential therapy, referred to as suppressive therapy.

Amphotericin B, on the other hand, was administered in 21 episodes (41%); in 6 cases, it was

combined with another antifungal agent, and 15 cases (71%) concluded with suppressive therapy. Sixteen percent of patients received an azole as initial therapy, and none received combination therapy. Thirty-eight percent ultimately received suppressive therapy; however, these patients experienced the highest rate of clinical complications, including hemorrhage and central nervous system involvement, with a statistically significant association.²¹

Another study describes a patient with *Candida albicans* endocarditis involving bioprosthetic mitral and aortic valves. She received combined treatment consisting of surgical replacement of both prosthetic valves and antifungal therapy with amphotericin B and flucytosine for six weeks⁷. Sahra et al.²² reported a patient who had undergone implantation of bovine mitral and tricuspid prosthetic valves six months earlier and who, similarly to the previously reported case, developed *Candida albicans* endocarditis. She was treated with intravenous micafungin for six weeks; however, fungemia persisted, and amphotericin B combined with flucytosine was subsequently administered.

Step-down therapy to azoles such as fluconazole or voriconazole is used after two to four weeks of induction therapy in patients with azole-susceptible isolates, once the patient is clinically stable and blood cultures are negative^{5,19}. Cabrera-Hernández et al.¹⁰ reported a patient with fungal endocarditis caused by *Candida auris*. She received caspofungin for 42 days and was subsequently maintained on lifelong fluconazole therapy.

Endocarditis and infection of pacemaker leads or other intracardiac devices caused by *Aspergillus* spp. present a distinct set of challenges. Aggressive surgical resection of infected tissue and valve replacement are required because of the pathogen's propensity to form large vegetations and cause systemic emboli. These interventions should be combined with systemic antifungal therapy, preferably voriconazole (a parenteral azole) or amphotericin B (lipid formulations). Following surgery, lifelong antifungal therapy with voriconazole is recommended because of the high risk of recurrence.¹⁹

It is important to emphasize the need to monitor the trough serum concentrations of this antifungal agent to minimize the risk of toxicity, such as hepatotoxicity and visual disturbances. Amphotericin B may be used as an alternative in cases of azole resistance or voriconazole intolerance. However, combination therapy with voriconazole and an echinocandin (caspofungin) may provide better outcomes. Other treatment options include isavuconazole and posaconazole.^{19,23}

Contributions of the Review

The article constitutes an updated and contextualized narrative review that synthesizes the available knowledge on invasive fungal infections associated with intravascular devices. Its main contributions include the integration of the modified Duke criteria with the approaches and expert judgment of specialists in Microbiology, Cardiac Imaging, Cardiology, and Cardiovascular Surgery, providing a practical framework for clinical management. The importance of combining blood cultures with cultures of periprosthetic tissues, serological tests, and molecular methods is emphasized, particularly in cases of negative blood cultures.

In addition, the article summarizes current treatment strategies, including the use of echinocandins as an initial option for *Candida* spp. infections, the role of voriconazole in aspergillosis, and the need for prolonged suppressive therapy with azoles. It also incorporates data from two provincial hospitals in Santa Clara, Villa Clara, thereby providing a regional context for this clinical problem.

Conclusiones

In invasive fungal infections associated with intravascular devices, *Candida* spp. and *Aspergillus* spp. are the main etiological agents. Diagnosis requires a multimodal approach that integrates blood cultures as the gold standard with cultures of valves, vegetations, and periprosthetic tissues, together with serological and molecular tests. Treatment requires a combined strategy of early surgical intervention and prolonged systemic antifungal therapy, within a multidisciplinary approach integrating Microbiology, Cardiac Imaging, Cardiology, and Cardiovascular Surgery with the modified Duke criteria to optimize clinical management and improve survival in these high-risk patients.

REFERENCIAS BIBLIOGRÁFICAS:

1. Fernández-Andreu CM, Martínez-Machín G, Perurena-Lancha MR, Illnait-Zaragozí MT, Velar-Martínez R, San Juan-Galán JL. Aportes del Laboratorio de Micología del Instituto de Medicina Tropical "Pedro Kourí" al desarrollo de la especialidad en Cuba. *Rev Cubana Med Trop* [Internet]. 2017 [cited 2026 jun. 5];69(3):1-18. Available in: <https://revmedtropical.sld.cu/index.php/medtropical/article/view/292/184>
2. Özbek L, Topçu U, Manay M, Esen BH, Bektas SN, Aydın S, et al. COVID-19-associated mucormycosis: a systematic review and meta-analysis of 958 cases. *Clin Microbiol Infect*. 2023;29(6):722-731. doi: 10.1016/j.cmi.2023.03.008.
3. de Cueto-López M, del Pozo-León JL, Franco-Álvarez de Luna F, Marín-Arriaza M. Diagnóstico microbiológico de las infecciones asociadas a dispositivos bio-

- médicos. *Enferm Infecc Microbiol Clin*. 2016;34(10):655-660. doi:10.1016/j.eimc.2015.02.012.
4. Sociedad Europea de Cardiología. 2023 ESC Guidelines for the management of endocarditis [Internet]. 1.^a ed. Inglaterra: Oxford University Press; 2024. doi:10.1093/eurheartj/ehad193.
5. Thompson GR, Jenks JD, Baddley JW, Lewis JS, Egger M, Schwartz IS, et al. Fungal endocarditis: pathophysiology, epidemiology, clinical presentation, diagnosis, and management. *Clin Microbiol Rev*. 2023;36(3):e0001923. doi:10.1128/cmr.00019-23.
6. Naguthevar S, Ravindra A, Kumar D, Meena DS, Bohra GK, Jain V, et al. Emerging trends in fungal endocarditis: clinical complexity, diagnostic challenges, and therapeutic implications—a case series and literature review. *Ther Adv Infect Dis*. 2024;11:20499361241293655. doi:10.1177/20499361241293655.
7. Arnaiz-García ME, Arnaiz-García AM, Iscar-Galán A, Arnaiz J, González-Santos JM. Bioprosthetic mitral and aortic valve endocarditis associated with *Candida albicans*. *Turk Kardiyol Dern Ars*. 2021;49(5):424. doi:10.5543/tkda.2021.78176.
8. Bonifaz-Trujillo JA. Candidosis. [Internet]. 5.^a ed. México: Editorial McGraw-Hill/Interamericana; 2015 [cited 2026 jun. 1]. *Micología Médica Básica*; p.377-408. Available in: <https://booksmedicos.org/micologia-medica-basica-alexandro-bonifaz/>
9. Brito-Monteiro M, Sismeiro R, Negro C, Jonet M, Simoa G. Fungal endocarditis: a case report. *Cureus* [Internet]. 2021 [cited 2026 jun. 11]; 13(12):e20156. Available in: <https://pmc.ncbi.nlm.nih.gov/articles/PMC8721965/pdf/cureus-0013-00000020156.pdf>
10. Cabrera-Hernández JS, Rodríguez-Cerón Á. Endocarditis fúngica, más que una indicación quirúrgica y hallazgos ecocardiográficos. Reporte de caso. *Rev Eco-cardiogr Pract Otras Tec Imag Card (RE-TIC)*. 2026;9(1):57-62. doi:10.37615/retic.v9n1a11.
11. Gopal K, Bhaskaran PN, Moni M, Shashindran N. *Aspergillus* endocarditis. *Indian Heart J*. 2024;76(4):240-246. doi:10.1016/j.ihj.2024.08.003.
12. Reischies F, Hoenigl M. The role of surgical debridement in different clinical manifestations of invasive aspergillosis. *Mycoses*. 2014;57(Suppl 2):1-14. doi:10.1111/myc.12224.
13. Fernández-Guerrero M, Alarcón A, Fortún J, Llinares P. Infecciones relacionadas con los marcapasos [Internet]. 1.^a ed. España: Sociedad Española de Enfermedades Infecciosas y Microbiología Clínica; 2025 [cited 2026 jun. 1]. Endocarditis e infecciones cardiovasculares; p.9-12. Available in: <https://seimc.org/wp-content/uploads/2025/06/seimc-procedimientoclinicov.pdf>
14. Phillips P, Krahn AD, Andrade JG, Chakrabarti S, Thompson CR, Harris DJ, et al. Treatment and prevention of Cardiovascular Implantable Electronic Device (CIED) infections. *CJC Open*. 2022;4(11):946-58. doi:10.1016/j.cjco.2022.07.010.
15. Hariri G, Genoud M, Bruckert V, Chosidow S, Guérot E, Kimmoun A, et al. Post-cardiac surgery fungal mediastinitis: clinical features, pathogens and outcome. *Crit Care*. 2023;27(1):6. doi:10.1186/s13054-022-04277-6.
16. Solé-Morales L, Hernández-Quiroa CJ, Sajmolo-Ruiz IL. Actualización en el diagnóstico de la endocarditis fúngica pediátrica y sus limitaciones en Latinoamérica. *Rev Latin Infect Pediatr*. 2024;37(1):44-56. doi:10.35366/115486.
17. Rodríguez-Díaz JC, Guna-Serrano R, Larrosa-Escartín N, Marín-Arriaza M. Diagnóstico microbiológico de la bacteriemia y la fungemia: hemocultivos y métodos moleculares. *Procedimientos en microbiología clínica* [Internet]. España: Sociedad Española de Enfermedades Infecciosas y Microbiología Clínica; 2017 [cited 2026 jun. 5]. Available in: <https://seimc.org/wp-content/uploads/2025/06/seimc-procedimientomicrobiologia62.pdf>
18. Meena DS, Kumar D, Agarwal M, Bohra GK, Chudhary R, Samantaray S, et al. Clinical features, diagnosis and treatment outcome of fungal endocarditis: a systematic review of reported cases. *Mycoses* [Internet]. 2022 [cited 2026 jun. 11];65(3):294-302. doi:10.1111/myc.13398.
19. Akritidou O, Peristeri AM, Lymperatou D, Prokopidou A, Christaki E, Nikopoulou A. A review of current insights in fungal endocarditis. *J Clin Med*. 2025;14(17):6149. doi:10.3390/jcm14176149.
20. Jain R, Yadav S, Naik-Bukke SP, Kumar-Chettupalli A, Thalluri C. Post-operative

- infection treatment in cardiac surgery: current practices and future directions. *Perioperative Med.* 2025;14:110. doi:10.1186/s13741-025-00580-2.
21. Kurland S, Furebring M, Löwdin E, Olaison L, Sjölin J. Antifungal therapy in *Candida* infective endocarditis: a comparison of echinocandins and other treatment regimens in a nationwide cohort study. *Clin Infect Dis.* 2026;82(3):e455-e461. doi:10.1093/cid/ciaf312.
22. Sahra S, Javed A, Jahangir A, Thind SK. Pharmacological options for *Candida albicans* endocarditis at the roadblock with irrecoverable prosthetics and drug interactions: a case report and review of literature. *BMC Infect Dis* [Internet]. 2023 [citado 2026 jun. 11];23:304. doi:10.1186/s12879-023-08267-z.

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23. Cheng J, Han H, Kang W, Cai Z, Zhan P, Lv T. Comparison of antifungal drugs in the treatment of invasive pulmonary aspergillosis: a systematic review and network meta-analysis. *Front Microbiol.* 2024;15:1504826. Disponible en: doi:10.3389/fmicb.2024.1504826.

