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Contemporary strategies in the prevention, diagnosis, and management of cardiovascular implantable electronic device infections

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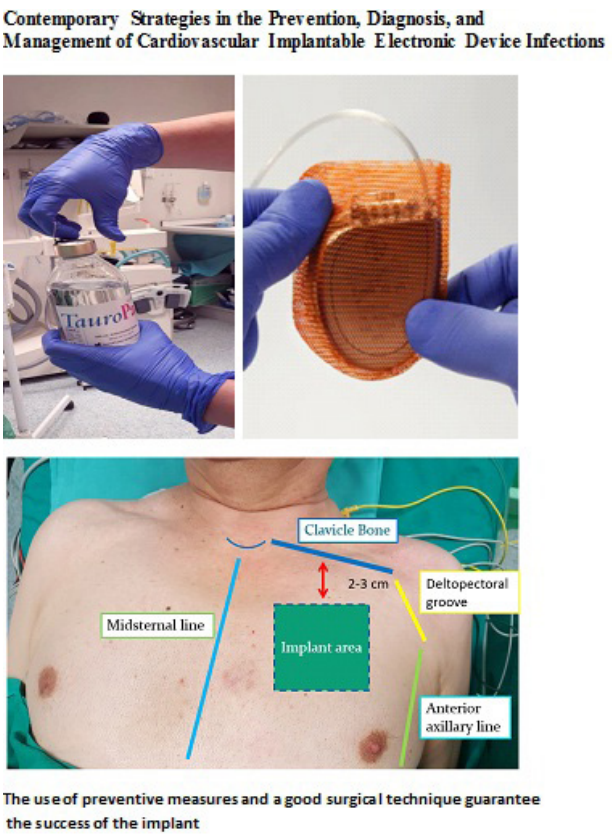
Graphical abstract



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Various cardiac arrhythmic conditions necessitate the placement of cardiac implantable electronic devices (CIEDs). Nonetheless, this procedure carries inherent risks of adverse events (AEs). These encompass procedure-related issues such as pneumothorax, vascular damage, and hematoma formation, and device-related AEs, such as lead dislodgement or malfunction (1, 2).

Among these, CIED-related infections (CIEDIs) stand out as particularly concerning, given their potential to escalate comorbidity, mortality rates, and healthcare resource utilization (3, 4). The considerable morbidity, mortality, and strain on healthcare resources attributed to CIEDIs in the medical literature prompted the implementation of performance-enhancing measures (5).

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Western healthcare systems, surveillance mechanisms for monitoring hospital quality and patient satisfaction have been established (6). Reported rates of CIEDIs are utilized to withhold reimbursement for providers whose patients contract these infections. Understandably, significant efforts have been dedicated to formulating evidence-based guidelines aimed at preventing and treating CIEDIs, such as the update of the AHA consensus by Baddour et al. (7). This newest guideline version meticulously evaluates and implements measures with the objective of reducing the occurrence of CIEDIs worldwide.

The Centre for Disease Control and Prevention (CDC) primarily focuses on hospital-acquired infections, which encompass CIED-related infections; however, reporting from contributing centers lacks consistency (8).Rates of CIEDI exhibit considerable variability and may not be adequately monitored, resulting in misunderstandings and underutilization of guideline-recommended treatments. Discrepancies in reported rates across various studies make it challenging to interpret the data accurately, particularly when attempting to ascertain the true prevalence of CIEDI. Studies examining this specific issue have documented escalating rates of CIEDIs over recent decades. CIEDI is a clinical diagnosis that necessitates laboratory tests and imaging procedures. These tests aim to pinpoint the CIED and its hardware, such as leads, as the source of the infection. Major CIEDI encompasses any infection involving the surgical site, such as localized generator pocket infection, as well as lead-related infective endocarditis. In a thorough and comprehensive way, Baddour et al.(7) elaborate on current evidence and future potentials to meet this unmet problem in their recently published update on how to prevent, diagnose and manage CIEDI.

According to Baddour et al. (7) prevention of CIEDI is crucial, with hematoma formation posing a significant risk. Strategies include judicious management of anticoagulation during device procedures and maintaining a therapeutic INR for warfarin users. Preprocedural cefazolin is standard, though vancomycin is an alternative for certain patient groups. Avoiding routine postoperative antibiotics and employing saline irrigation during implantation may be recommended to reduce infection risks. If we expand to a broader view when it comes to preventing complications associated with CIEDs besides demanding rigorous measures outlined by Baddour et al. (7) we must embrace continuous improvement in healthcare practices. Training healthcare personnel and implementing evidence-based protocols for CIED placement play pivotal roles in reducing infection rates. Continuous monitoring and robust reporting mechanisms are essential to accurately assess infection rates and evaluate the effectiveness of prevention strategies. Careful assessment of the necessity for CIED placement is crucial, emphasizing re-evaluation for secondary prevention or consideration of alternative therapies such as optimal medication regimens, which may reduce the need for devices altogether. When CIED placement is indicated, alternatives with no transvenous lead proportions are extensively elaborated on by Baddour et al (7). Proper programming of CIEDs not only maximizes their therapeutic benefits but also extends battery life, thereby minimizing the risk of premature replacements and associated infections. Infection prevention during CIED placement relies on standardized practices including meticulous selection of implant sites, guided imaging techniques, pre-operative antibiotic administration, rigorous skin disinfection, adherence to strict sterile techniques, and effective pain management strategies. Utilization of comprehensive CIED procedure packs and adherence to stringent hygiene protocols are essential for ensuring procedural integrity. Additional measures may include pre-procedural antiseptic body baths for MRSA decolonization, adherence to specialized care algorithms for temporary pacing wires, and the use of antibiotic-eluting mesh envelopes for high-risk procedures (9) or taurolidine-based antimicrobial adjuncts universally (10, 11). Ongoing research aims to refine risk assessment tools and explore novel techniques like regional antibiotic or antimicrobial delivery systems. In frail individuals, biological envelopes might provide further mitigation against complications following procedures.

The diagnosis of CIEDI requires detailed assessment, identifying clinical manifestations such as fluctuation or purulent discharge. Essential diagnostic modalities include blood cultures, device swab cultures, transthoracic echocardiography (TTE), and transesophageal echocardiography (TEE), each having limitations in differentiating infectious from noninfectious conditions. [18F] fluorodeoxyglucose positron emission tomography/ Computed tomography (FDG PET/ CT) enhances traditional imaging methods, particularly in complex cases. Management strategies involve promptly removing the device to enhance outcomes, postponing reimplantation until the infection subsides. Recent insights highlight significant opportunities for improvement in this area (12).

Leadless pacemakers and subcutaneous implantable cardioverter-defibrillators (S-ICDs) serve as viable options in high-risk situations, enabling expedited reimplantation following device extraction.

Additionally, continuous, localized delivery of high-concentration antibiotics during conservative management or antimicrobial adjuncts during meticulous surgical revision may emerge as crucial tools in our arsenal for treating CIED infections, especially in frail patients (3, 13, 14).

A recent pandemic has significantly impacted healthcare systems worldwide, precipitating a decline in routine healthcare admissions while intensifying demand for critical care resources

This strain has potentially exacerbated rates of CIEDIs, which have already been on the rise in recent decades (15). Provider-related factors, including shifts in care protocols amidst resource constraints, may have worsened this trend. The pandemic has also exposed vulnerabilities in healthcare infrastructure,

disrupting data collection and hindering research efforts. All of this underscores the critical need for streamlined medical data collection and analysis, advocating for digitalization and potentially integrating artificial intelligence (AI). Standardizing data collection methods and employing unique identifiers for medical devices could enhance the reliability and scalability of infection surveillance efforts. Addressing rising CIEDI rates necessitates robust, adaptable strategies capable of mitigating evolving challenges in diverse healthcare settings, which Baddour (7) strive to provide.

Although high-income countries may implement extensive infection-prevention technologies, such as sterile barriers, procedure packs, regional anesthesia techniques, and antimicrobial or antibiotic-eluting adjuncts, there is a critical need for globally accessible measures like simplified care algorithms, now addressed by Baddour et al. (7). Ensuring the scalability and adaptability of these strategies is essential to enhance resilience and improve outcomes in response to evolving healthcare environments.

Several questions that persist in this consensus document underscore the need for ongoing research aimed at advancing the prevention, diagnosis, and treatment of CIEDI.

In conclusion, advancing strategies to prevent and manage complications associated with CIEDs requires a multifaceted approach integrating evidence-based practices, ongoing training, robust surveillance, and innovative technologies. Collaboration across disciplines and leveraging digital solutions are crucial in achieving sustainable improvements in patient care and outcomes.

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