Egypt. J. Chem. **Vol. 68**, No. 2. pp. 127 –134 (2025)

Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

Vancomycin-Resistant Enterococci-An Updated Review for Pharmacists and Medical Secretary.

Hamed Ateeq Alshammari[1], Hatem Mazyad Alshammri[2], Sami Khalid Alanazi[2], Faris Abdullah Alanazi[2], Meshal Ateeq S Alanazi[2], Abdulaziz Khalid Alzaaqi[3], Abdulaziz Yahya Awaji[4], Hanan Mara M Alshehri[5], Ahmed Nasser Batt[5], Thamer Mohammed Baloud Al-Ruwaithi[1], Sahar Sowaid Alanazi[5], Majed Raji Alshammari[1],

[1]Hail General Hospital, Ministry of Health, Saudi Arabia
[2]Northern Area Armed Forces Hospital, Ministry of Defense, Saudi Arabia
[3]King Saud Medical City, Ministry of Defense, Saudi Arabia
[4]King Faisal Air College, Ministry of Defense, Saudi Arabia
[5]Prince Sultan Military Medical City, Ministry of Defense, Saudi Arabia

Abstract

Background: Vancomycin-resistant Enterococci (VRE) represent a significant challenge in hospital settings, contributing to increased morbidity, mortality, and healthcare costs. Enterococci are normally harmless gut commensals but can become pathogenic under certain conditions, leading to infections such as urinary tract infections (UTIs), bacteremia, endocarditis, and intra-abdominal infections. VRE, particularly strains of *Enterococcus faecium*, have developed resistance to vancomycin, complicating treatment options and requiring focused antimicrobial stewardship.

Aim: This review provides an updated overview of VRE, focusing on its etiology, resistance mechanisms, epidemiology, clinical manifestations, and treatment strategies, with particular emphasis on the role of pharmacists in managing these infections. The review also focus on the main role of medical records in documentation of this issue.

Methods: A comprehensive review of current literature was conducted to examine the mechanisms of resistance in Enterococci, the clinical impact of VRE infections, and the available therapeutic options. The review also highlights the role of pharmacists in optimizing antimicrobial therapy and infection control practices.

Results: VRE infections are primarily caused by *E. faecium*, which exhibits high resistance to vancomycin and other antimicrobial agents. Resistance mechanisms, including modifications in cell wall synthesis, complicate treatment regimens. Pharmacists play a key role in selecting appropriate antibiotics, optimizing dosages, and providing infection control advice. The use of linezolid and daptomycin is recommended for managing VRE infections, with careful monitoring of adverse effects.

Conclusion: The increasing prevalence of VRE necessitates comprehensive strategies involving surveillance, targeted therapy, and robust infection control. Pharmacists are essential in guiding appropriate treatment choices, monitoring therapeutic efficacy, and mitigating adverse effects, ultimately improving patient outcomes.

Keywords: Vancomycin-resistant Enterococci, antimicrobial resistance, medical records, infection control, pharmacists, treatment, linezolid, daptomycin.

.

1. Introduction

Antimicrobial resistance (AMR) is rapidly emerging as a critical concern within healthcare, presenting a significant challenge for clinicians and medical providers. Among the many forms of antimicrobial resistance, vancomycin-resistant Enterococcus (VRE) is particularly problematic in hospital settings. Enterococci, which are gram-positive, facultative anaerobic cocci typically found in pairs or chains, are naturally present in the gastrointestinal (GI) tract of humans, where they normally exist as commensals, performing beneficial functions. Despite their generally harmless nature in the GI tract, these bacteria can become pathogenic under certain conditions, leading to a wide range of infections. These infections most commonly include urinary tract infections (UTIs), intra-abdominal infections, bacteremia, and endocarditis. Although less common, enterococci can also cause more severe conditions such as meningitis, osteomyelitis, septic arthritis, and pneumonia. One of the main challenges in managing vancomycin-resistant Enterococcus infections is that these bacteria often exist as colonizers, meaning they may be present without causing active infection, which complicates the decision-making process about when to initiate

*Corresponding author e-mail: Halshammari50@moh.gov.sa. naif.f.almarshadi@gmail.com ;(Hamed Ateeq Alshammari)
Receive Date: 17 November 2024, Revise Date: 19 January 2025, Accept Date: 19 January 2025
DOI: 10.21608/ejchem.2025.337098.10815

treatment. Furthermore, infection with vancomycin-resistant Enterococcus has been shown to result in higher treatment costs and increased mortality when compared to infections caused by vancomycin-susceptible strains. This increased risk and burden necessitate heightened attention to antimicrobial stewardship and aggressive treatment strategies using targeted antibiotics. As the incidence of vancomycin resistance among Enterococcus isolates continues to rise, clinicians must implement robust infection control practices and optimized antimicrobial interventions to manage this increasingly prevalent hospital-acquired pathogen [1][2][3].

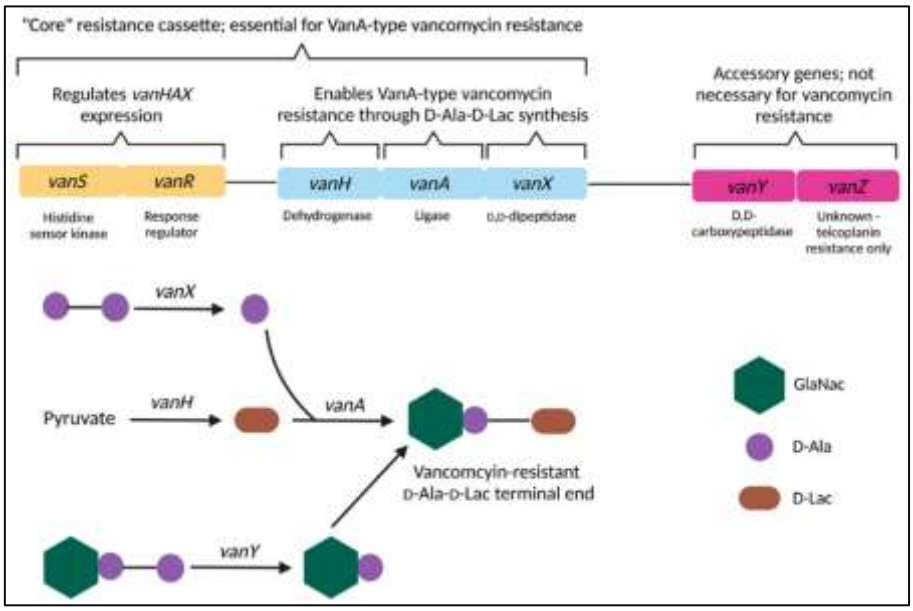

Figure 1: Vancomycin-Resistant Enterococci and Staphylococci.

Etiology and Mechanisms of Resistance in Enterococci

Enterococci have developed a range of sophisticated mechanisms of resistance to various antibiotic classes, including aminoglycosides, beta-lactams, tetracyclines, quinolones, and vancomycin, a glycopeptide antibiotic. These organisms are inherently resistant to some antibiotics due to their structural characteristics. For instance, enterococci naturally possess penicillin-binding proteins (PBPs) that have a low affinity for beta-lactam antibiotics, making these drugs less effective. Additionally, they can produce beta-lactamases, enzymes that degrade beta-lactam antibiotics, further contributing to their resistance profile. In addition to these intrinsic mechanisms, enterococci can also acquire resistance to other antibiotics through horizontal gene transfer. Specifically, the resistance to vancomycin in Enterococcus arises from alterations in the biosynthesis of peptidoglycan, a critical component of the bacterial cell wall. Normally, vancomycin binds to the D-Ala-D-Ala terminus of the peptide chains that form the peptidoglycan, inhibiting the synthesis of the bacterial cell wall. However, in vancomycin-resistant Enterococcus, the D-Ala-D-Ala terminus is replaced with D-Ala-D-lactate, which reduces vancomycin's binding affinity and allows the bacteria to survive despite the presence of the antibiotic. This resistance mechanism is mediated by several genotypes, which are categorized from VanA to VanG. Among these, VanA and VanB, which are plasmid-mediated, are the most commonly encountered in clinical settings. These are followed, albeit less frequently, by chromosomal resistance phenotypes such as VanD and VanC. Furthermore, enterococci exhibit variable resistance patterns to aminoglycosides. For all aminoglycosides, except streptomycin, resistance is primarily due to the presence of inactivating enzymes like 2"-phosphotransferase-6′-acetyltransferase. Streptomycin resistance, on the other hand, arises through the production of streptomycin adenyltransferase, an enzyme that modifies the drug and reduces its effectiveness. These complex and diverse mechanisms of resistance make managing infections caused by vancomycin-resistant Enterococcus challenging and underscore the importance of using targeted antibiotics and effective infection control strategies to combat these resistant strains [4][5][6][7].

Epidemiology of Vancomycin-Resistant Enterococcus (VRE)

The emergence of vancomycin-resistant Enterococcus (VRE) can be traced back to the 1980s, initially identified in Europe, where its proliferation was likely associated with the use of the glycopeptide antibiotic avoparcin in livestock to promote growth. This practice may have led to the zoonotic transmission of resistant strains. In contrast, the rise of VRE in the United States is generally linked to the increased use of vancomycin within clinical settings, particularly in hospitals. During the 1990s and 2000s, VRE became a significant concern for healthcare facilities, resulting in several hospital outbreaks primarily due to person-to-person transmission. Fecal shedding of VRE is a key factor in its spread, as the organism often colonizes the skin and can be transferred through contact with contaminated surfaces or direct exposure. According to the National Healthcare Safety Network, between 2011 and 2014, Enterococcus species ranked as the second leading cause of healthcare-associated infections, with *E. faecalis* responsible for 7.4% of these cases. Additionally, Enterococcus was identified as the primary pathogen in central line-associated bloodstream infections (CLABSI), third for catheter-associated urinary tract infections (CAUTI),

eleventh for ventilator-associated pneumonia (VAP), and second for surgical site infections (SSI). While *E. faecalis* is the predominant Enterococcus species, *E. faecium* is the major culprit in vancomycin-resistant infections. Resistance rates for *E. faecium* to vancomycin were alarmingly high, with 83.8% of isolates found in CLABSI and 86.2% in CAUTI cases. In 2013, the Centers for Disease Control and Prevention (CDC) classified vancomycin-resistant Enterococcus as a "serious threat," urging heightened surveillance and the implementation of stringent prevention measures. The risk of VRE colonization and infection is particularly high in individuals with prior antimicrobial use, underlying severe illness, immunosuppression, prolonged hospital stays, admission to long-term care facilities, extended antibiotic usage, and proximity to infected patients [8][9].

Clinical Manifestations of Vancomycin-Resistant Enterococcus Infections

Infections caused by vancomycin-resistant Enterococcus (VRE) can present with a broad spectrum of clinical manifestations, which depend on the site of infection and the patient's overall health status. The most common presentation of VRE infection is bacteriuria, although it is increasingly recognized that many of these cases are more likely due to colonization rather than true infection. In clinical practice, the identification of bacteriuria should prompt careful consideration of whether the patient is experiencing active infection or merely colonization, as asymptomatic pyuria or bacteriuria does not require treatment unless accompanied by symptomatic infection or signs of sepsis. Beyond urinary tract infections, VRE is also a frequent cause of bacteremia, particularly when there is no associated endocarditis, and it can lead to severe conditions like infective endocarditis. Another common clinical manifestation of VRE infection is intra-abdominal and pelvic infections, often occurring as part of polymicrobial infections in which VRE is one of the contributing pathogens, frequently accompanied by other gram-negative or anaerobic organisms. These infections can manifest as abscesses, peritonitis, or infected surgical wounds, necessitating the use of broad-spectrum antibiotics to cover the range of potential pathogens, including Enterococcus. VRE bacteremia, particularly caused by *E. faecium*, is associated with a higher mortality rate, partly due to the increased resistance of these isolates to treatment. Additionally, infective endocarditis caused by Enterococcus is notable for its association with central venous catheters, gastrointestinal (GI) or genitourinary (GU) tract manipulations, and heart valve diseases, particularly in patients with preexisting comorbidities. The condition presents with subacute symptoms, including fever and a new murmur, though signs such as petechiae and Osler nodes, which are classic indicators of endocarditis, are less commonly seen in the case of Enterococcus [7].

Risk Factors and Impact of Vancomycin-Resistant Enterococcus Infections

Vancomycin-resistant Enterococcus (VRE) colonization and infection are associated with several risk factors, which contribute to the increased susceptibility of certain patient populations. One of the most significant risk factors is prior antimicrobial therapy, particularly the prolonged use of broad-spectrum antibiotics. This therapeutic approach can disrupt the natural microbiota, allowing for the overgrowth and colonization of resistant pathogens such as VRE. Patients with severe underlying medical conditions, those undergoing immunosuppressive therapy, and individuals with extended hospital stays or admissions to long-term care facilities are also at increased risk for VRE colonization. The presence of indwelling medical devices, such as central venous catheters and urinary catheters, further heightens the risk, as these devices provide a direct route for bacterial entry into the bloodstream or urinary system. Close proximity to other colonized or infected patients within healthcare settings also facilitates the transmission of VRE. In particular, patients who have received multiple courses of antibiotics or who are hospitalized in intensive care units are more likely to harbor resistant strains. The impact of VRE infection is substantial, as it leads to increased morbidity, prolonged hospital stays, and higher healthcare costs due to the need for more intensive and prolonged antimicrobial therapy. Additionally, the management of VRE infections requires careful stewardship of antibiotics to avoid further resistance development, and infection control measures must be rigorously followed to prevent cross-transmission in healthcare settings. These measures include strict hand hygiene, isolation precautions, and the use of contact precautions to limit the spread of VRE [8][9].

Evaluation

The diagnostic workup for vancomycin-resistant Enterococcus (VRE) should commence with confirming the presence of an underlying infectious disease. Following this, it is essential to identify the potential source of infection. Specimens should be collected from the suspected source and sent for routine microbiological cultures prior to initiating empiric antibiotic therapy. This approach facilitates precise identification of the causative species and assessment of their antimicrobial susceptibilities. It is important to note that sensitivities for antibiotics such as fosfomycin, daptomycin, nitrofurantoin, and chloramphenicol may not be routinely tested in all laboratories; thus, these should be specifically requested when clinically relevant [10][11].

Treatment / Management

The management of vancomycin-resistant Enterococcus infections is contingent upon the type of infection and the antimicrobial susceptibility of the implicated organism(s). In cases of monomicrobial infections, antibiotic selection should be individualized based on tissue penetration capabilities, culture results, and prevailing local resistance patterns. Treatment decisions may become more complex, as VRE can often exist as a colonizer within polymicrobial infections. As such, the initiation of therapy targeting VRE should be considered when there is clinical suspicion or failure of prior antimicrobial regimens [12][13][14]. Most enterococcal infections are attributable to *E. faecalis*, which generally remains susceptible to beta-lactams and aminoglycosides. Resistance to vancomycin occurs more frequently in undifferentiated *E. faecalis* than resistance to aminopenicillins, thus beta-lactams should remain the first-line choice for most infections pending culture results. In contrast, *E. faecium* strains exhibit high resistance to both beta-lactams and aminoglycosides. For cases of vancomycin-resistant Enterococcus with high resistance to other antimicrobial classes, the primary therapeutic options are linezolid and daptomycin.

A meta-analysis comparing these two agents revealed no significant differences in mortality, clinical cure, microbiological cure, or relapse rates. It is important to note that the predominant genotypic causes of vancomycin resistance are the VanA and VanB genes, both of which are inducible, meaning that patients with vancomycin-sensitive isolates that fail to respond to treatment should undergo re-culturing. When VRE is isolated and exhibits high susceptibility to treatment, therapy should be tailored accordingly. In cases of urinary tract infections (UTIs), monotherapy with high-dose ampicillin (18 to 30 g/day intravenously) is appropriate. For uncomplicated UTIs resistant to ampicillin, nitrofurantoin (100 mg orally twice daily) or fosfomycin (3 g orally as a single dose) are preferred agents. It is critical to recognize that UTIs may be secondary to colonization, and in such cases, removal of the catheter may suffice as a therapeutic measure. For bacteremia, monotherapy with ampicillin is often effective, but since it lacks bactericidal activity, an aminoglycoside, such as gentamicin, is typically added. An alternative regimen, ampicillin in combination with ceftriaxone, is similarly effective, with the added benefit of being less nephrotoxic.

In instances where sensitivities are unavailable or where there is high resistance to beta-lactams or aminoglycosides, linezolid (600 mg orally or intravenously twice daily) can be utilized. This synthetic oxazolidinone antibiotic functions by binding to the bacterial ribosome, thereby inhibiting peptide bond formation. While linezolid has proven effective as a first-line agent for infective endocarditis, it is a bacteriostatic drug. Notably, prolonged use may result in adverse effects, including thrombocytopenia, anemia, peripheral neuropathy, and an increased risk of serotonin syndrome. Thus, alternative therapies should be considered for patients on serotonergic medications. Another option for treatment is the off-label use of high-dose daptomycin (8 to 12 mg/kg intravenously once daily, with renal adjustment). This lipopeptide antibiotic is bactericidal, exerting its effect by causing cell membrane depolarization. In cases of persistent bacteremia or high minimum inhibitory concentrations (MICs) for daptomycin, combination therapy with ampicillin or ceftaroline may be indicated. Given the potential for myopathy, patients should be monitored for this condition, and weekly creatine kinase levels should be measured. Daptomycin is ineffective for pulmonary infections, as surfactant inactivates it; however, this is rarely a concern in cases of vancomycin-resistant Enterococcus due to the rarity of enterococcal pneumonia.

Tigecycline, a glycylcycline antibiotic, may be considered for patients intolerant to other therapies or for those with concomitant infections. This agent is particularly useful for polymicrobial intra-abdominal infections, though it is off-label for VRE. It has broad activity against gram-positive bacteria, some gram-negative organisms, and anaerobes. However, it should not be used for VRE bacteremia due to its limited serum concentrations. Typical dosing involves 100 mg intravenously initially, followed by 50 mg intravenously twice daily. Patients should be monitored for common adverse effects, including nausea and vomiting. Chloramphenicol, dosed at 50 to 100 mg/kg/day (divided into doses every 6 hours, with a maximum of 4 g/day), has been effectively utilized to treat VRE bacteremia, particularly in resource-limited settings where other antibiotics may not be available. Due to its excellent tissue penetration, including into the central nervous system, chloramphenicol remains an option for VRE treatment despite its significant toxicity profile, which includes risks of aplastic anemia and bone marrow suppression. Consequently, it should not be used as a first-line agent when alternatives exist and should typically be employed under the guidance of an infectious disease specialist [7][15][16][7].

Differential Diagnosis

When evaluating a case of suspected vancomycin-resistant Enterococcus (VRE) infection, several conditions must be considered in the differential diagnosis. Bacterial sepsis is a leading contender, as it shares many symptoms with VRE infections, such as fever, chills, and hypotension, necessitating prompt identification and appropriate management. Hospital-acquired infections (HAIs) are also frequently encountered, as VRE is often associated with nosocomial settings, particularly in patients with prolonged hospital stays or prior antibiotic use. Infective endocarditis, characterized by fever, heart murmurs, and embolic phenomena, should be considered, especially in patients with a history of heart disease or prosthetic valves. Peritonitis and abdominal sepsis, often resulting from gastrointestinal perforation or other intra-abdominal infections, should be ruled out, as they can present similarly with abdominal pain and fever. Pyogenic hepatic abscesses may mimic symptoms of VRE infections, especially in patients with risk factors such as diabetes or immunosuppression. Septic arthritis, commonly affecting large joints and presenting with localized pain, swelling, and fever, should also be considered in the differential diagnosis. Urinary tract infections (UTIs) in both males and females are prevalent causes of infection and should be differentiated from VRE, with females being particularly prone to cystitis. Additionally, wound infections, often resulting from surgical procedures or trauma, must be assessed for potential VRE colonization or infection. Early identification and differentiation of these conditions are crucial for initiating appropriate therapy and preventing complications [10][11].

Complications

The complications associated with vancomycin-resistant Enterococcus (VRE) infections can be severe and diverse, potentially affecting various organ systems. Endocarditis, a significant complication, occurs when VRE infects the heart valves, leading to fever, heart murmurs, and potential embolic events. This condition can cause prolonged illness and significant morbidity if not managed promptly with appropriate antibiotics. Colitis, particularly caused by the overgrowth of *Clostridium difficile*, is another potential complication, particularly in patients undergoing prolonged antibiotic therapy. This condition is characterized by diarrhea, abdominal pain, and, in severe cases, toxic megacolon. Osteomyelitis, the infection of bone tissue, can result from hematogenous spread of VRE, leading to localized pain, fever, and potential joint involvement. If left untreated, osteomyelitis can result in chronic infection and bone damage. Sepsis, a systemic inflammatory response to infection, is one of the most concerning complications of VRE. This condition is marked by fever, hypotension, and multi-organ dysfunction, and it can lead to death without prompt recognition and aggressive therapy. Pneumonia, while less common, can result from the aspiration of VRE-contaminated material into the lungs, leading to respiratory symptoms such as cough, dyspnea, and hypoxia. Management of these complications requires early identification, appropriate antibiotic therapy, and close monitoring to prevent long-term sequelae and improve patient outcomes [12][13][14].

Consultations

For patients with suspected or confirmed vancomycin-resistant Enterococcus (VRE) infections, consultation with an infectious disease specialist is highly recommended. An infectious disease consultant can provide invaluable expertise in selecting the most appropriate antibiotic regimen based on the resistance profile of the isolate and the patient's clinical condition. These specialists can also guide the management of complex cases, such as those involving multi-drug resistant organisms, co-infections, or patients with underlying comorbidities that may affect treatment decisions. In addition, the consultant can advise on infection control measures to limit the spread of VRE, especially in hospital settings, where the risk of transmission is heightened. By working with an infectious disease consultant, healthcare providers can ensure that they are utilizing the latest evidence-based practices for diagnosis, treatment, and prevention of VRE-related infections. Their guidance can also assist in the interpretation of laboratory results, including antimicrobial susceptibility testing, and help to navigate difficult clinical scenarios, such as when first-line treatments fail, or complications arise. Collaboration with an infectious disease consultant ultimately improves patient outcomes and helps prevent the spread of resistant infections within healthcare settings [12][13].

Patient Education

Effective deterrence of vancomycin-resistant Enterococcus (VRE) infections hinges on stringent infection control measures and patient education. Hand hygiene remains the cornerstone of infection prevention, as VRE is primarily transmitted via the hands of healthcare workers. Handwashing with soap and water, or the use of alcohol-based hand rubs, before and after patient contact is essential in reducing transmission rates. In addition to hand hygiene, good personal hygiene practices, including the proper cleaning of wounds and maintaining a clean environment, are crucial in preventing VRE colonization and infection. Patients should also be educated about the importance of completing the full course of antibiotics as prescribed, even if they feel better, to prevent the development of antibiotic resistance. Healthcare workers should use contact precautions, such as wearing gowns and gloves, to prevent cross-contamination between patients. For high-risk individuals, active surveillance cultures can help identify VRE carriers early, enabling isolation precautions to be implemented promptly. Patient isolation, combined with terminal cleaning of rooms after discharge, further reduces the risk of transmission. Education should also focus on the importance of these measures not only for patients but for family members and visitors, who can unknowingly contribute to the spread of VRE. By adhering to these preventative strategies, healthcare settings can significantly reduce the incidence of VRE infections and protect vulnerable patients [10][11].

Enhancing Healthcare Team Outcomes

While the complete epidemiological profile of vancomycin-resistant Enterococcus (VRE) remains incompletely understood, it is well established that patients in intensive care units (ICUs) are at significant risk for both colonization and infection with VRE. Studies indicate that VRE can be transmitted through direct patient contact, the handling of contaminated surfaces and equipment, or via hand transfer following interaction with infected individuals. The emergence of VRE has become a critical issue in virtually every hospital in the United States, with healthcare institutions recognizing the need for enhanced infection control strategies. In response to the growing epidemic, the majority of hospitals have established infectious disease committees tasked with overseeing antibiotic stewardship and auditing bedside practices to ensure sterility. This is where the contributions of infectious disease nurses and pharmacists are essential in managing the crisis. Current best practices emphasize 1) the judicious use of vancomycin, with authorization required from board-certified infectious disease specialists and pharmacists; 2) the comprehensive education of healthcare workers regarding VRE; 3) the implementation of stringent infection control protocols, including hand hygiene, and the use of gloves and gowns when interacting with VRE-positive patients; and 4) the maintenance of a sanitized working environment, adhering to strict aseptic techniques. Evidence supports the efficacy of an interprofessional approach in mitigating the nosocomial transmission of VRE. Consequently, many hospitals have enforced protocols for contact isolation and routine surveillance cultures to identify and prevent the spread of VRE [17][18][19].

Outcomes

Despite the implementation of proactive measures, VRE remains a persistent challenge in many healthcare settings. Short-term data indicate that the most effective strategy to prevent VRE transmission involves the cautious administration of antibiotics coupled with strict adherence to infection control protocols, particularly among high-risk patient populations. These measures, while essential, have not completely eradicated VRE, underscoring the complexity of managing antibiotic-resistant infections in hospital environments. Compliance with infection control practices, including appropriate antibiotic usage, remains crucial in limiting VRE spread and ensuring patient safety. Regular surveillance and the use of isolation techniques for VRE-positive individuals further aid in reducing hospital-acquired infections, yet the ongoing presence of VRE in clinical settings calls for continued vigilance and refinement of infection control strategies. The persistence of VRE highlights the need for ongoing research and innovative approaches to tackle antimicrobial resistance, ensuring that healthcare environments remain safe for vulnerable patient populations [20][21].

Role of Pharmacists in Managing Vancomycin-Resistant Enterococcus (VRE)

Vancomycin-resistant Enterococcus (VRE) has emerged as a significant clinical challenge, particularly in healthcare settings, due to its resistance to conventional antibiotic therapies. As the incidence of VRE infections continues to rise, the role of pharmacists in managing and controlling these infections has become increasingly vital. Pharmacists are integral members of the healthcare team, contributing their expertise in antimicrobial stewardship, drug therapy management, infection control, and patient education. This essay explores the multifaceted role of pharmacists in addressing the challenges posed by VRE, emphasizing their contributions to patient care, infection prevention, and the broader healthcare system.

Antimicrobial Stewardship

Pharmacists play a crucial role in antimicrobial stewardship, a strategic approach to optimizing the use of antibiotics to improve patient outcomes, reduce resistance, and limit the spread of resistant organisms like VRE. One of the core responsibilities of pharmacists in this context is to guide the appropriate use of antibiotics. For VRE, the selection of the most effective antibiotic regimen is critical, as treatment failure can lead to poor patient outcomes and further resistance development. Pharmacists contribute to decision-making by assessing the patient's condition, reviewing microbiological data, and recommending suitable alternatives to vancomycin, especially when it is not indicated or when resistance is identified. They collaborate with physicians and infectious disease specialists to ensure that vancomycin is used only when absolutely necessary, as overuse can promote resistance. In addition, pharmacists monitor the ongoing effectiveness of prescribed antibiotics and adjust therapy based on culture and sensitivity results, promoting optimal therapeutic outcomes. Pharmacists also participate in the implementation of antibiotic restriction policies, which aim to minimize the misuse of antibiotics and ensure that they are only prescribed when warranted. These policies often require the intervention of an infectious disease pharmacist, who can help assess whether vancomycin or other antibiotics are appropriate, based on the patient's clinical condition and microbiological findings. By actively participating in these decisions, pharmacists help to reduce unnecessary antibiotic exposure, which in turn limits the selective pressure that contributes to the emergence of resistant pathogens like VRE.

Infection Control and Prevention

In the fight against VRE, pharmacists are instrumental in infection control and prevention efforts. VRE is primarily transmitted in healthcare settings through direct patient contact, contaminated surfaces, or improper hand hygiene. Pharmacists play a pivotal role in educating healthcare workers about the importance of infection prevention practices, including hand hygiene, the use of personal protective equipment (PPE) such as gloves and gowns, and the implementation of contact isolation for infected or colonized patients. By providing training and guidance on proper infection control protocols, pharmacists contribute to the reduction of VRE transmission rates within hospitals and other healthcare facilities. Pharmacists also collaborate with infection control teams to ensure that high-risk patients, such as those in intensive care units (ICUs) or those with weakened immune systems, are monitored for VRE colonization and infection. Active surveillance cultures, a practice in which routine screenings are performed to detect the presence of VRE in high-risk patients, are essential in identifying carriers before they develop symptomatic infections. Pharmacists help to establish and maintain these surveillance programs, ensuring that patients are appropriately tested and that appropriate precautions are taken to prevent the spread of VRE within healthcare environments. Furthermore, pharmacists are involved in the development and implementation of hospital policies related to VRE management. These policies may include guidelines for patient isolation, antibiotic use, and the cleaning and disinfection of contaminated surfaces and equipment. By contributing to the development of such policies, pharmacists help ensure that infection control measures are evidence-based, effective, and tailored to the specific needs of the institution.

Patient Education and Advocacy

Pharmacists also have an essential role in patient education, particularly for individuals diagnosed with VRE infections or those at high risk for colonization. Patients diagnosed with VRE may experience feelings of fear, confusion, and isolation due to the nature of the infection and its association with antibiotic resistance. Pharmacists can provide valuable counseling to patients, explaining the nature of VRE, the importance of adhering to prescribed treatment regimens, and the need to follow infection control measures to prevent the spread of the bacteria to others. Pharmacists help patients understand the rationale behind prescribed antibiotic therapies, including the choice of agents such as linezolid or daptomycin, which are commonly used to treat VRE infections. By ensuring that patients are fully informed about their treatment options, potential side effects, and the importance of completing the prescribed course of antibiotics, pharmacists contribute to improved adherence and better clinical outcomes. Furthermore, pharmacists advocate for the use of appropriate and effective therapies while minimizing the risk of adverse effects. For instance, when prescribing linezolid, pharmacists monitor for potential side effects such as thrombocytopenia or serotonin syndrome, ensuring that patients are appropriately managed throughout their treatment course. In cases where patients are resistant to commonly prescribed antibiotics, pharmacists may also recommend alternative therapies, such as tigecycline or chloramphenicol, after carefully assessing the patient's medical history, comorbidities, and potential drug interactions. They also ensure that the prescribed antibiotics are done appropriately, considering factors such as renal function, which can affect drug metabolism and efficacy.

Collaborative Care and Clinical Decision-Making

The role of pharmacists in managing VRE extends beyond individual patient care to include active participation in collaborative, multidisciplinary teams. Pharmacists work closely with physicians, nurses, infection control specialists, and other healthcare professionals to develop individualized care plans for patients with VRE infections. This collaborative approach ensures that all aspects of patient care, from diagnosis to treatment and infection control, are optimized. Pharmacists contribute their expertise in pharmacology, drug interactions, and antimicrobial resistance to help guide clinical decision-making, ensuring that patients receive the most appropriate and effective care. In conclusion, pharmacists are essential members of the healthcare team in the management of vancomycin-resistant Enterococcus. Their contributions to antimicrobial stewardship, infection control, patient education, and collaborative care are integral to improving patient outcomes and reducing the spread of this dangerous pathogen. By actively participating in the management of VRE, pharmacists help to ensure the appropriate use of antibiotics, minimize resistance, and enhance the overall safety and quality of care for patients. As the threat of antimicrobial resistance continues to grow, the role of pharmacists in combating VRE and other resistant infections will only become more critical in the years to come.

Role of Medical Records and Medical Secretaries:

In the context of vancomycin-resistant Enterococci (VRE) infections, medical secretaries and medical records play crucial roles in managing these complex healthcare issues. Their contributions are fundamental to the effective diagnosis, treatment, and control of such infections within hospital settings.

Medical Secretary Role

A medical secretary is central to the administrative and communication processes that underpin the management of VRE infections. The medical secretary is typically responsible for scheduling patient appointments, ensuring timely medical records are available to healthcare providers, and maintaining proper documentation of patient visits, test results, and treatment plans. Their role becomes critical when VRE is suspected, as they help in coordinating referrals, ensuring that patients receive appropriate microbiological tests for detecting VRE colonization or infection. Additionally, the secretary must facilitate communication between the healthcare team, ensuring that the right specialists, such as infectious disease experts or microbiologists, are informed of any VRE concerns. Medical secretaries must also be proficient in managing patient data. They organize patient histories and ensure that relevant information, such as previous antibiotic use and underlying health conditions (e.g., immunosuppressive therapies or chronic illnesses), is easily accessible. This data is crucial for clinicians when determining whether a patient is at high risk for VRE colonization or infection. Furthermore, they assist in coordinating isolation protocols for VRE-positive patients, ensuring that the proper precautions are in place to prevent transmission within the healthcare environment. Moreover, the medical secretary supports the tracking of patient outcomes by ensuring that follow-up appointments are scheduled and that clinicians are alerted to any changes in a patient's condition. Given the high risk associated with VRE, particularly in immunocompromised individuals, medical secretaries ensure that any emerging concerns are flagged for immediate attention. Their organizational skills are key to maintaining an efficient workflow, which helps to prevent the spread of resistant infections and improve patient outcomes.

Medical Records Role

Medical records are an essential tool in managing and controlling VRE infections. Accurate, up-to-date, and comprehensive records are vital for tracking patient care, ensuring proper treatment, and monitoring infection control measures. The medical record serves as a central repository for all patient-related information, including diagnostic results, antibiotic prescriptions, infection histories, and treatment regimens. This is crucial in managing VRE infections, as it enables healthcare professionals to track the progression of colonization and infection, determine the most effective antibiotics based on culture and sensitivity reports, and monitor treatment efficacy.

Medical records also support antimicrobial stewardship efforts by documenting the use of antibiotics and alerting clinicians to inappropriate or excessive use. Since prior antimicrobial therapy is one of the most significant risk factors for VRE colonization, keeping accurate records of prescribed antibiotics allows healthcare teams to identify patterns and potential overuse, which can contribute to resistance. Medical records help identify patients who may require isolation to prevent the transmission of VRE, based on documented infection control measures and prior exposure to known VRE carriers. Furthermore, medical records are essential in the epidemiological tracking of VRE within healthcare facilities. These records can be used to generate reports on infection rates, identify clusters of VRE cases, and monitor the effectiveness of infection control practices. By maintaining a detailed account of patient care, medical records also support research initiatives aimed at understanding the spread and management of VRE, enabling continuous improvement of infection control policies. In conclusion, medical secretaries and medical records play a pivotal role in managing VRE infections. Medical secretaries ensure that critical patient information is effectively communicated and organized, facilitating timely and appropriate care. Meanwhile, medical records provide a comprehensive, accessible source of data that aids in treatment decision-making, antimicrobial stewardship, and infection control. Together, these roles are integral to the fight against VRE and other antimicrobial-resistant infections in healthcare settings.

Conclusion:

Vancomycin-resistant Enterococci (VRE) have emerged as a serious threat in healthcare settings, with significant challenges in both treatment and management. These bacteria, typically harmless as gut commensals, can cause severe infections when they acquire resistance to antibiotics, particularly vancomycin. The most common clinical manifestations of VRE infections include urinary tract infections (UTIs), bacteremia, and endocarditis, with higher mortality rates compared to infections caused by vancomycin-susceptible Enterococci. This increased risk, coupled with the complexity of diagnosing VRE infections due to colonization, underscores the importance of early detection and appropriate intervention. The mechanisms underlying vancomycin resistance in Enterococci are multifaceted and include modifications in the bacterial cell wall that reduce the drug's effectiveness. These resistance patterns are primarily driven by genetic elements such as the VanA and VanB genes, which complicate treatment strategies. Additionally, *Enterococcus faecium*, the most common pathogen involved in VRE infections, often exhibits resistance to multiple classes of antibiotics, necessitating the use of alternative treatments like linezolid and daptomycin. Pharmacists are pivotal in managing VRE infections. Their role extends beyond dispensing medications to actively participating in antimicrobial stewardship. Pharmacists help optimize the selection of appropriate antibiotics based on susceptibility profiles, ensure correct dosing, and monitor for adverse drug reactions. In addition, pharmacists contribute to infection control measures by advising on appropriate antibiotic use and by fostering a culture of antimicrobial stewardship within healthcare settings. A key challenge in the management of VRE infections is the increasing prevalence of these resistant strains, which are often associated with prolonged hospital stays, intensive care unit admissions, and prior use of broad-spectrum antibiotics. Risk factors such as immunosuppression, indwelling medical devices, and proximity to other infected or colonized

patients further increase the likelihood of VRE transmission. Therefore, infection control measures, including strict hand hygiene and isolation precautions, are essential in curbing the spread of VRE. Despite advances in treatment options, managing VRE infections remains complex. Pharmacists must remain vigilant in ensuring that treatment regimens are tailored to the specific strain and the clinical context. This involves continuous monitoring for treatment failure, adverse reactions, and the potential for further resistance development. Additionally, pharmacists must play an active role in educating patients and healthcare providers about the risks of VRE and the importance of adhering to infection control protocols. In conclusion, vancomycin-resistant Enterococci represent a significant challenge to healthcare systems worldwide. The role of pharmacists in managing these infections is indispensable, as they ensure that antimicrobial therapies are appropriately chosen, dosed, and monitored. Effective antimicrobial stewardship, coupled with robust infection control measures, is crucial in addressing the growing threat of VRE and improving patient outcomes in hospital settings.

References:

1. Vehreschild MJGT, Haverkamp M, Biehl LM, Lemmen S, Fätkenheuer G. Vancomycin-resistant enterococci (VRE): a reason to isolate? Infection. 2019 Feb;47(1):7-11.
2. Kampmeier S, Kossow A, Clausen LM, Knaack D, Ertmer C, Gottschalk A, Freise H, Mellmann A. Hospital acquired vancomycin resistant enterococci in surgical intensive care patients - a prospective longitudinal study. Antimicrob Resist Infect Control. 2018;7:103.
3. Hussain MS, Sattar A, Hussain M. In vitro efficacy of linezolid against vancomycin resistant Enterococci. Pak J Pharm Sci. 2018 Sep;31(5):1853-1857.
4. Rutala WA, Kanamori H, Gergen MF, Knelson LP, Sickbert-Bennett EE, Chen LF, Anderson DJ, Sexton DJ, Weber DJ., and the CDC Prevention Epicenters Program. Enhanced disinfection leads to reduction of microbial contamination and a decrease in patient colonization and infection. Infect Control Hosp Epidemiol. 2018 Sep;39(9):1118-1121.
5. Wassilew N, Seth-Smith HM, Rolli E, Fietze Y, Casanova C, Führer U, Egli A, Marschall J, Buetti N. Outbreak of vancomycin-resistant *Enterococcus faecium* clone ST796, Switzerland, December 2017 to April 2018. Euro Surveill. 2018 Jul;23(29)
6. Kreidl P, Mayr A, Hinterberger G, Berktold M, Knabl L, Fuchs S, Posch W, Eschertzhuber S, Obwegeser A, Lass-Flörl C, Orth-Höller D. Outbreak report: a nosocomial outbreak of vancomycin resistant *enterococci* in a solid organ transplant unit. Antimicrob Resist Infect Control. 2018;7:86.
7. Cetinkaya Y, Falk P, Mayhall CG. Vancomycin-resistant enterococci. Clin Microbiol Rev. 2000 Oct;13(4):686-707.
8. Lee T, Pang S, Abraham S, Coombs GW. Antimicrobial-resistant CC17 Enterococcus faecium: The past, the present and the future. J Glob Antimicrob Resist. 2019 Mar;16:36-47.
9. McDermott H, Skally M, O'Rourke J, Humphreys H, Fitzgerald-Hughes D. Near-patient environmental contamination of an intensive care unit with Vancomycin-resistant Enterococci (VRE) and Extended-Spectrum Beta-Lactamase-Producing Enterobacteriaceae (ESBL-E) before and after the introduction of chlorhexidine bathing for patients. Infect Control Hosp Epidemiol. 2018 Sep;39(9):1131-1132.
10. Ozbak HA. A novel high-resolution melting analysis approach for rapid detection of vancomycin-resistant enterococci. Ann Saudi Med. 2018 May-Jun;38(3):200-207.
11. Shokoohizadeh L, Ekrami A, Labibzadeh M, Ali L, Alavi SM. Antimicrobial resistance patterns and virulence factors of enterococci isolates in hospitalized burn patients. BMC Res Notes. 2018 Jan 02;11(1):1.
12. Habboush Y, Guzman N. StatPearls [Internet]. StatPearls Publishing; Treasure Island (FL): Jun 20, 2023. Antibiotic Resistance.
13. Lund LC, Holzknecht BJ, Justesen US. [Treatment of vancomycin-resistant enterococcal infections]. Ugeskr Laeger. 2018 Apr 16;180(16)
14. Yadav G, Thakuria B, Madan M, Agwan V, Pandey A. Linezolid and Vancomycin Resistant Enterococci: A Therapeutic Problem. J Clin Diagn Res. 2017 Aug;11(8):GC07-GC11.
15. O'Driscoll T, Crank CW. Vancomycin-resistant enterococcal infections: epidemiology, clinical manifestations, and optimal management. Infect Drug Resist. 2015;8:217-30.
16. Raza T, Ullah SR, Mehmood K, Andleeb S. Vancomycin resistant Enterococci: A brief review. J Pak Med Assoc. 2018 May;68(5):768-772.
17. García Martínez de Artola D, Castro B, Ramos MJ, Díaz Cuevas Z, Lakhwani S, Lecuona M. Outbreak of vancomycin-resistant *enterococcus* on a haematology ward: management and control. J Infect Prev. 2017 May;18(3):149-153.
18. Musau J, Baumann A, Kolotylo C, O'Shea T, Bialachowski A. Infectious disease outbreaks and increased complexity of care. Int Nurs Rev. 2015 Sep;62(3):404-11.
19. Tschudin-Sutter S, Pargger H, Widmer AF. Hand hygiene in the intensive care unit. Crit Care Med. 2010 Aug;38(8 Suppl):S299-305.
20. Linfield RY, Campeau S, Injean P, Gregson A, Kaldas F, Rubin Z, Kim T, Kunz D, Chan A, Lee DJ, Humphries RM, McKinnell JA. Practical methods for effective vancomycin-resistant enterococci (VRE) surveillance: experience in a liver transplant surgical intensive care unit. Infect Control Hosp Epidemiol. 2018 Oct;39(10):1178-1182.
21. Anderson DJ, Moehring RW, Weber DJ, Lewis SS, Chen LF, Schwab JC, Becherer P, Blocker M, Triplett PF, Knelson LP, Lokhnygina Y, Rutala WA, Sexton DJ., CDC Prevention Epicenters Program. Effectiveness of targeted enhanced terminal room disinfection on hospital-wide acquisition and infection with multidrug-resistant organisms and Clostridium difficile: a secondary analysis of a multicentre cluster randomised controlled trial with crossover design (BETR Disinfection). Lancet Infect Dis. 2018 Aug;18(8):845-853.