RESEARCH PAPER

Study Of Vancomycin Resistant Enterococci In Catheter Associated Urinary Tract Infections With Special Reference To Biofilm Formation

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ABSTRACT

One of the most prevalent hospital-acquired infections are catheter-related urinary tract infections (CAUTIs) and prolonged urinary catheterization is a common cause. Enterococcus species are among the pathogens that most often cause CAUTIs, but the clinical relevance of enterococci has become more pronounced because they can withstand extreme conditions and develop antibiotic resistance. In addition, the emergence of vancomycin-resistant enterococci (VRE) provides little to no options for treatment and increases the morbidity of patients in hospitals. The ability of enterococci to develop biofilms on the surfaces of urinary catheters allows them to survive longer, continue to infect the patient, and decrease the effectiveness of antimicrobial agents. The purpose of this research was to determine how frequently VRE were isolated from catheter-related urinary tract infections and to examine how well they created biofilm. Urine specimens taken from patients with catheters and suspected of having a urinary tract infection tested for Enterococcus spp. using standard microbiological methods to isolate and identify the Enterococcus spp. Antibiotic susceptibility testing was performed to identify vancomycin resistance; and phenotype methods were used to evaluate biofilm production. In the research, there was a combined total of 100 cases of catheter-associated urinary tract infections and there were 100 cases of non-catheterized urinary tract infections that were analyzed as control cases. Bacterial microbiological protocols were conducted for both bacterial identification and testing of antimicrobial susceptibility to bacteria. The simple tube method was used to determine biofilm formation on all of the isolated bacteria from cultures. Of all cultures positive for bacteria, there was a total of 28% that were from patients with catheter-associated urinary tract infections. The predominant pathogen isolated was Enterococcus sp. (39.28%) and the second most common pathogen isolated was E. coli (35.71%). The prevalence rate of vancomycin resistant Enterococcus in this study was 17.86%. Strong biofilm production was primarily seen in the resistant isolates (36.36%). Additionally, statistically significant ($p = 0.02$) biofilm formation was determined to be associated with vancomycin resistant Enterococcus. Infections caused by vancomycin resistant Enterococcus were also significantly more common in patients with catheter-associated urinary tract infections ($p = 0.000003$).

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INTRODUCTION

The most common type of hospital acquired infection around the world is catheter associated urinary tract infections (CAUTIs). Indwelling urinary catheters are one of the most used devices in hospitals, especially in critically ill patients and patients in long-term care facilities, and can lead to a higher chance of colonization and infection with germs due to prolonged time in place, disruption of host defenses through breaking down the natural barriers to infection, and direct routes for bacteria to enter the urinary tract and potentially cause infection. *Enterococcus* species have become established uropathogens responsible for CAUTIs, and are gram-positive cocci commonly found in the intestines; however, these organisms have significance due to their ability to survive in extremely hostile conditions (high salt, bile and varied temperature), as well as their intrinsic and acquired antibiotic resistance. In addition, the emergence of vancomycin-resistant *Enterococcus* (VRE) in the past few years has greatly impacted healthcare and infection control. The use of vancomycin is limited to last-resort therapy for serious Gram-positive infections. Due to vancomycin-resistant *Enterococcus* (VRE) bacteria being increasingly prevalent, therapy options are limited. The morbidity associated with VRE infections is greater than that observed with other Gram-positive organisms, resulting in higher healthcare costs and longer stays in hospital settings. Additionally, resistance gene transfer, particularly vanA and vanB, continues to complicate the issue by allowing resistance to be

continued to spread within the resident bacterial flora of patients over time. The formation of biofilms in this group of bacteria is another important virulence factor associated with the pathogenesis of catheter-associated urinary tract infections (CAUTI). Biofilms are identified as microbial communities that develop a structure and live within an extracellular polymeric matrix (EPM) that is self-produced and adheres to both living (biotic) and nonliving (abiotic) surfaces, such as the surfaces of urinary catheters. The formation of biofilms plays a role in enhancing the persistence of bacteria by shielding them from host immune responses as well as decreasing the effectiveness of antimicrobials. Thus, infections caused by organisms that form biofilms are generally chronic, recurrent and difficult to treat. Despite increased awareness, comprehensive studies on the prevalence of vancomycin-resistant *Enterococcus* (VRE) in patients with catheter-associated urinary tract infections (CAUTIs), and the relationship between VRE and the formation of biofilm in hospitals, are still needed. The understanding of how antibiotic resistance and the formation of biofilms interact is crucial for designing optimal infection control policies and improving patient outcomes. The objective of this study is to examine the prevalence of VRE in cases of CAUTIs, as well as evaluate biofilm production potential of enterococci, to provide guidance for improved management and prevention of these infections.

Epidemiology of Catheter-Associated Urinary Tract Infections (CAUTIs)

Urinary tract infections (UTIs) caused by urinary catheters (CAUTIs) are one of the most common types of infections acquired in the hospital, and they place significant stress on the healthcare system. They make up a large proportion of hospital-acquired infections, and especially in intensive care units and long-term care facilities. Studies have indicated that as each day passes while a person has a urinary catheter in place, there is a 3-7% higher chance of developing bacteriuria. Because indwelling urinary catheters bypass natural defenses against urinary tract infections, such as the flushing action of urine and mucosal immunity, they offer an easy pathway for bacteria to enter the urinary tract. It has been estimated that between 70% and 80% of UTIs acquired in the hospital are due to the presence of a urinary catheter (Hooton, 2010). In addition to catheterization, the incidence of CAUTIs can be increased by additional factors, including the length of time spent in the hospital, advanced age, immunosuppression, diabetes mellitus, and poor handling of catheters. In addition to causing increased morbidity, CAUTIs also result in longer hospital stays and additional costs to the healthcare system.

Role of *Enterococcus* Species in Nosocomial Infections

The most common type of enterococci involved with healthcare-associated infections are *Enterococcus faecalis* and *Enterococcus faecium.* These two species are part of the normal microbiota of the human gastrointestinal tract; however, they cause significant morbidity and mortality in patients who have received long-term treatment with broad-spectrum antibiotics due to common traits such as resistance to multiple antibiotics and the ability to survive under extreme environmental conditions (e.g., pH, temperature). *Enterococcus faecalis and E. faecium* have been shown to survive at high temperatures (approximately 60°C), in solutions with very acidic or alkaline pH (pH 4-9), in 8% NaCl solutions, and are resistant to the effect of many commonly used disinfectants. Enterococci, therefore, frequently become hospital-acquired pathogens because they can adapt genetically and share their resistance factors with other organisms through horizontal gene transfer. The recent increase in the isolation of enterococci from urinary tract infections, especially in patients with urinary catheters, represents a change in the type of organisms that are most often responsible for these infections; historically, the majority of urinary tract infections have been caused by Gram-negative organisms. This pattern is the result of increasing selective pressure on Gram-positive bacteria because of the widespread use of antibiotics to treat patients in health care facilities.

Vancomycin-Resistant Enterococci (VRE)

The development of Vancomycin Resistant *Enterococcus* (VRE) is quickly becoming one of the most serious challenges to public health that we currently face. For many years Vancomycin has been considered to be one of the final options for treating severe Gram positive bacterial infections; however the emergence of resistant strains via the acquisition of resistance genes such as vanA and vanB has severely limited the efficacy of this medication. Y Cetinkaya et al (2000) reported that the presence of VRE in hospitalized patients was associated with increased morbidity, mortality, length of stay, and cost of treatment when compared with patients infected or colonized by VRE who were seen in outpatient settings. The hospital setting has a big influence on the development and spread of VRE, in part because the usage of a high number of antibiotics puts a selective pressure on bacteria that are resistant to those types of antibiotics. In addition to developing resistance through mutations, enterococci possess a number of different ways to transfer resistance genes both between themselves and to other, clinically significant pathogens through plasmids and transposons. This ability to exchange their genetic material increases their ability to survive and thrive in a hospital setting, making it difficult to manage infection control.

Biofilm Formation as a Virulence Factor

The pathogenic potential of *Enterococcus* species is influenced by one of its most important virulence factors: the ability to form biofilms - especially for catheter-associated infections. Biofilms are complex, multispecies communities of microorganisms that develop into a structured form and are embedded within a self-produced extracellular polymer. Biofilms can form on a variety of surfaces, including catheters. According to Donlan R. M. and Costerton J. W. (2002), biofilms provide bacteria with a protective environment from host immune responses and significantly decrease the access of antimicrobial agents to the bacteria within the biofilm. Bacteria in biofilms also have different metabolic activities and gene expression, which makes them more resistant to antibiotics, resulting in persistent, recurrent and chronic infections - most of which require prolonged or combination therapy to eradicate. With regard to CAUTIs, the formation of biofilms on catheter surfaces is critical for establishing and sustaining the infection.

Association Between Biofilm Formation and Antibiotic Resistance

Numerous studies have shown a strong correlation between the formation of biofilm and increasing antimicrobial resistance among *Enterococcus* species. Aside from acting as physical barriers that inhibit antibiotic penetration, biofilms also serve as dynamic environments for the exchange of genetic material, including genes involved in resistance. Mohamed J.A. and Huang D.B. (2007) demonstrated that enterococci that form biofilms have much higher levels of antibiotic resistance relative to enterococci that do not form biofilms. The close proximity of individual bacterial cells within biofilms promotes horizontal gene transfer, and as a consequence accelerates the dissemination of resistance determinants such as vanA and vanB. The relationship between biofilm formation and antibiotic resistance complicates treatment options for patients, resulting in therapeutic failure and recurring infections.

Need for Surveillance and Infection Control

Because there are so many cases of VRE and the role that biofilm formation has for keeping an infection around, it is critical to keep monitoring for this, along with keeping tight infection control measures, in the healthcare environment. There are effective strategies for this, such as using the right amount of antibiotics (antimicrobial stewardship programs), using strict aseptic techniques when inserting and maintaining catheters, and minimising catheter use duration. It has been shown that the sooner an unnecessary catheter is removed, the lower the incidence of CAUTIs will be. Hooton T. M. et al (2010) stated that preventive measures are the most important part of reducing infections and improving patient outcomes. New innovations will help combat these types of infections e.g. antimicrobial-coated catheters and anti-biofilm agents. To reduce the ongoing difficulty with CAUTIs and antimicrobial resistance, we must use a multidisciplinary approach. This would involve all disciplines of health care (i.e. clinicians, microbiologists, and infection control specialists).

MATERIALS AND METHODS

The present study is a prospective observational case-control done in the Department of Microbiology at a tertiary hospital from September 2024 to February 2025. The study was approved by the Institutional Ethics Committee before commencement. A total of 200 patients suspected to have urinary tract infections (UTIs) were included, consisting of 100 catheterized patients with catheter-associated UTIs (CAUTIs) categorized as the case group and100 non-catheterized patients with UTIs categorized as the control group. Inclusion criteria consisted of patients of both sexes and all age groups. Patients were excluded for recent antibiotics (within the previous 48 to 72 hours) or with incomplete clinical information. Urine specimen collection was performed using strict aseptic techniques. In catheterized patients specimen was obtained from the catheter sampling port using a sterile syringe. For non-catheterized patients specimens were collected as midstream clean catch. All specimens were sent to the microbiology laboratory without delay for processing. Samples were cultured using Blood Agar and MacConkey Agar with a calibrated loop technique and incubated aerobically at 37°C for 24-48 hours. The presence of significant bacteriuria was determined according to standard colony counting criteria for culture-based laboratory testing procedures. Isolation was accomplished using standard microbiological procedures such as colony morphology, Gram stain, catalase test, bile esculin hydrolysis, growth in 6.5% NaCl, and other biochemical tests to identify *Enterococcus* species. Antimicrobial susceptibility testing was performed based on CLSI approved recommendations for disk diffusion susceptibility testing using Mueller Hinton agar (modified). Testing for vancomycin resistance was completed with discs, and confirmed by MIC testing; biofilm formation among *Enterococcus* isolates was determined using a tube method where the organism was inoculated in glucose-supplemented tryptic soy broth and incubated at 37 degrees C for 24 hours.

The broth was then decanted after incubating for a period of time. After that the tubes were washed, dried, stained with crystal violet, and subsequently evaluated visually with respect to the formation of biofilms. The evaluation criteria for determining the biofilm-forming ability of a bacteria species were visual evidence of how much of a biofilm was formed. Biofilms were either judged to have formed very well or moderately well, if they exhibited a high or moderate amount of visual staining, respectively, or not at all (weak/non-producer) if they had little or no

staining. Data collected during the experiment were recorded systematically and analyzed statistically. The proportion of VRE to the amount of biofilm-producing organisms was expressed in percentage terms. The relationship between vancomycin resistance and the formation of biofilm was assessed with the chi-square test, using a significance level of $p<0.05$.

In the culture-positive cases analyzed for microorganisms, the *Enterococcus* species were found to be by far the most frequently isolated pathogen from those samples with 39.28% (*Enterococcus* spp.) of all samples. *Escherichia coli* (35.71%) is the second most common, and still the most common cause of urinary tract infections. *Klebsiella* spp. (14.28%) and *Pseudomonas* spp. (10.71%), all Gram-negative organisms, also contribute to the overall number of uropathogens found in these cases, however at a much lower level than *Enterococcus* spp. Overall, these results indicate that *Enterococcus* spp. are emerging as important nosocomial infections, particularly among catheter-associated infections; the presence of additional organisms, however, illustrates the polymicrobial nature and diversity of uropathogens isolated in hospital settings.

RESULTS

100 catheterized urine samples (cases) and 100 non-catheterized urine samples (controls) were analyzed together to determine if there was a difference in the incidence of urinary tract infections related to catheter usage. Twenty-eight (28) of the catheterized urine samples were found to have significant bacterial growth; thus, the overall positivity rate for urine culture in the catheterized population (28%) represents a major source of urinary tract infection in patients who had been catheterized. It is reasonable to conclude that the higher rate of urine culture positivity in patients with indwelling urinary catheters results from multiple variables including: longer duration of being catheterized, disruption of natural host defense mechanisms, and development of a direct pathway for microbial entry into the bladder via the catheter. Indwelling urinary catheters provide a surface area upon which bacteria can adhere and grow, thus forming biofilms which provide shelter for pathogens from host immune defenses and antimicrobial agents. Therefore, improper manipulation of indwelling urinary catheters and breaks in the techniques utilized for sterile placement of indwelling urinary catheters have an additional negative impact on the incidence of urinary tract infections in hospitalized patients. According to the data collected so far, there is a higher incidence of positive cultures in non-catheterized patients than catheterized patients. This indicates that the use of an artificial device markedly increases the chance of infection. Therefore, it is crucial to strictly adhere to infection control measures (e.g., only using catheters when absolutely necessary; maintaining proper care and hygiene of catheters; and removing catheters in a timely manner). In summary, the culture positivity rate identified in this study illustrates that CAUTIs are clinically significant and warrant the need for specific preventive interventions within healthcare facilities.

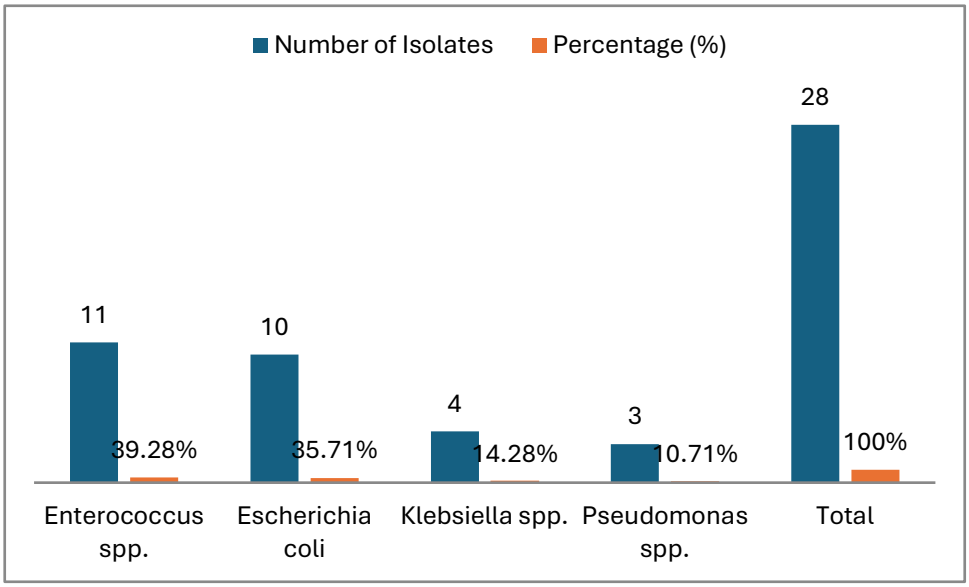
Table 1: Culture Positivity in Study Groups

Study Group	Total Samples	Positive Cultures	Percentage (%)
Catheterized (Cases)	100	28	28%
Non-catheterized (Control)	100	18	18%

The prevalence of culture-positive cases was considerably higher among patients with catheters (28%) compared to patients without catheters (18%). Therefore, catheter use is associated with a significantly increased risk of developing urinary tract infections (UTI). This finding supports that indwelling urinary catheters are important predisposing factors for developing urinary tract infections. This is due to the ability of catheters to disrupt the normal anatomical and physiological defenses of the urinary tract, including normal urine flow and regulation of mucosal barrier protection, thereby enhancing access of microorganisms into the urinary tract. Additionally, catheters are considered foreign bodies and provide a surface on which microorganisms can adhere and form biofilms. Biofilms provide a favorable environment for microorganisms, promoting their survival, replication and resistance to host immune responses and antimicrobial treatment. The longer catheters are in place, the greater the risk of developing an infection as the length of time increases the opportunity for colonization by microorganisms on both the inner and outer surfaces of the catheter. Plus, the existence of poor catheter care or breaks in asepsis when inserting or handling a catheter can also add to the rate of infection in patients with catheters, while patients without catheters are naturally designed to prevent bacteria from entering and colonizing, which leads to a lower incidence of infection.

Table 2: Distribution of Isolated Organisms in CAUTI

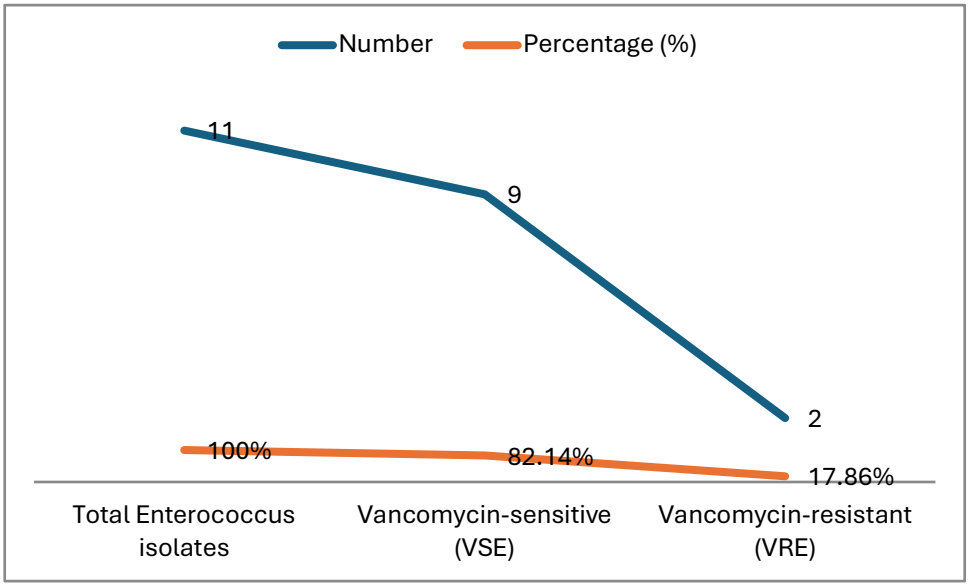
Organism	Number of Isolates	Percentage (%)
Enterococcus spp.	11	39.28%
Escherichia coli	10	35.71%
Klebsiella spp.	4	14.28%
Pseudomonas spp.	3	10.71%
Total	28	100%



For the catheter-associated urinary tract infection cases, enterococci were the most prevalent pathogens (39.28%) isolated; this is followed closely by *Escherichia coli* (35.71%). The shift in distribution of pathogens is notable because historically *E. coli* has been known as the main pathogen associated with urinary tract infections, including those that are acquired in the community. In hospital settings, particularly among those patients who are catheterized, enterococci increasingly dominate. It is believed that the prevalence of enterococci in CAUTIs is due to multiple innate and acquired characteristics that allow them to survive and persist in the hospital environment. Enterococci have demonstrated a high degree of resilience and can endure extreme conditions such as high salinity, desiccation, and exposure to disinfectants. Additionally, their ability to adhere to non-biological surfaces, such as urinary catheters, allows them to colonize and eventually lead to infection. The biofilm-forming ability of bacteria is attributed to an important virulence factor that aids in their pathogenic nature. The biofilm allows bacteria to colonize and create stable communities on the surfaces of catheters, which helps to create chronic infection and makes it difficult for them to be treated with antibiotics. In addition, *Enterococcus* species are also exceptionally successful at acquiring and transferring genes that confer antibiotic resistance, including those that confer resistance to glycopeptides such as vancomycin. This not only complicates treatment but also adds to the bacteria's ability to survive in environments with high levels of antibiotic pressure (e.g., hospitals). The increasing use of broad-spectrum antibiotics has also aided in the selection for these resistant strains, which then can out-compete other uropathogens. Although *Escherichia coli* continues to be an important pathogen causing CAUTIs (35.71% of isolates), the relatively lower percentage of *E. coli* isolates compared to Enterococcus isolates suggests that the trend of antibiotic-resistant organisms in healthcare settings is progressing towards more virulent, hospital-adapted types of organisms. This demonstrates that the epidemiology of urinary tract infections is continually changing within the healthcare environment.

Table 3: Prevalence of Vancomycin-Resistant Enterococci (VRE)

Category	Number	Percentage (%)
Total *Enterococcus* isolates	11	100%
Vancomycin-sensitive (VSE)	9	82.14%
Vancomycin-resistant (VRE)	2	17.86%



In this study, 17.86% of recovered *Enterococcus* isolates were vancomycin-resistant enterococci (VRE). While this is a small percentage; it represents a significant clinical issue with regard to nosocomial infections, as vancomycin is a valuable treatment option for serious infections caused by Gram-positive bacteria, especially in patients who have resistance to other antibiotics. The emergence of VRE will significantly reduce the number of effective antimicrobial agents and increase the difficulty of managing patients clinically. In patients with catheter-associated urinary tract infections who have already been compromised by underlying disease, prolonged hospital stay, or invasive procedures, VRE-related infections usually result in greater morbidity and longer hospital stays as well as increased cost to healthcare. There are very few therapeutic alternatives available to treat VRE infections, such as linezolid or daptomycin, both of which are relatively expensive and/or potentially toxic and not necessarily accessible or appropriate for every patient. An additional component to be discussed relates to *Enterococcus* species' capacity for obtaining/responsible for gene transfer which includes acquiring genotypic resistance including (but not limited to) vanA and vanB by way of transposon or plasmid mechanisms. In doing so, resistances are not only distributed through a population of enterococci, there is also an increased opportunity for horizontal transfer of genes of resistance from enterococci to any other Gram-positive pathogen. Furthermore, the hospital environment - with its abundance of antibiotics and selective pressure - supports the survival of and distribution of resistant organisms. While a relatively low prevalence of vancomycin-resistant enterococci (VRE's) has been verified in this study, one should not ignore how these may be an early warning system for the emergence of a resistance trend. If left uncontrolled, these organisms will proceed unchecked and cause outbreaks that could overwhelm hospitals. Therefore, ongoing surveillance, strict implementation of infection control practices, and appropriate antibiotic use is critical to limit the development of vancomycin resistance and manage enterococcal infections effectively.

Table 4: Biofilm Production Among Enterococcus Isolates

Biofilm Category	Number of Isolates	Percentage (%)
Strong	4	36.36%
Moderate	3	27.27%
Weak/Non-producer	4	36.36%
Total	11	100%

There are many *Enterococcus* isolates from this study that produce biofilms. There were identified as strong biofilm producers. Approximately 36.36% of these isolates were considered strong biofilm production. This emphasizes how important the biofilm production is as a key virulence factor in terms of the long-term persistence of an infection and the chronic development of some infections through biofilm formation, especially with CAUTIs. Biofilms consist of groups of microorganisms that are assembled in a self-created extracellular polymer/matrix and are firmly adhered to the surfaces of urinary catheters, allowing the bacteria the opportunity to produce long-term colonization. The clinical aspect of enterococci producing strong biofilms is that it will protect the bacterial cells from host defense systems, but also provide a significant decrease in the ability of antimicrobial therapeutic agents to penetrate and be effective against the bacteria that are part of a biofilm. Those bacteria exist in the bio-film under altered metabolic mode and often have reduced rates of growth. Therefore providing increased tolerance to the effects of antimicrobial agents. Infections due to Enterococcus strains that produce biofilms are difficult to eradicate and often lead to recurrences or chronic infections even with proper antimicrobial therapy. The surface of a urinary catheter is well-suited for the initial adhesion of bacteria and the subsequent development of mature biofilms that will release free-floating (planktonic) bacterial cells into the urinary tract. This process increases the likelihood of developing infections and rising to ascendance by causing subsequent infections, and also increases the chances of complications from the combination of both actions. Biofilms can also serve as reservoirs of organisms that are resistant to treatment, promoting the transfer of genetic material, including genes that confer resistance to antibiotics, between different bacterial strains. The results of this study regarding biofilm producers support the need for preventative measures to limit biofilm formation, including antimicrobial coatings on catheters, strict adherence to aseptic insertion practices, timely removal of indwelling catheters, and so forth. Ultimately, the presence of biofilm is a key contributor to the pathogenicity of *Enterococcus* species and one of the major factors in the establishment and resistance to treatment of catheter-associated infections.

Table 5: Association Between VRE and Biofilm Formation

Category	Strong Biofilm	Moderate/Weak	Total
VRE (n = 2)	2	0	2
VSE (n = 9)	2	7	9
Total	4	7	11

Statistical Analysis: p = 0.02 (Significant)

Research findings indicate a significant connection between strong biofilm production and vancomycin resistance (p=0.02). All vancomycin-resistant *Enterococcus* (VRE) isolates produced strong biofilms, suggesting biofilm formation may be involved in persistence of infection and antimicrobial resistance. The study results indicate that catheterization is a major risk factor for urinary tract infections, as evidenced by increased culture positivity of catheterized patients. *Enterococcus* spp. were found to be the leading pathogens causing urinary tract infections in this group of patients, emphasizing the increasing role of these organisms in nosocomial infections. There is a moderate prevalence of vancomycin-resistant enterococci, which raises some concern regarding the lack of available treatment options. A large proportion of isolates also had the ability to form biofilms, and there was a significant relationship between vancomycin resistance and biofilm production. The results of this research demonstrate that vancomycin resistance and biofilm production pose a significant, combined risk in the treatment of catheter-associated urinary tract infections by contributing to the persistence, chronicity, and difficulty in treating these types of infections.

DISCUSSION

For a longer period of time than previously reported, institution-acquired C-Diff infection rates continue to represent a high volume of account for hospital-acquired infections (HAIs) (>30 percent). Therefore, forceful catheterization has demonstrated to be a predisposing factor of highly elevated incidence rates of HAIs, as indicated by results produced from this study. A positive relationship is also exceedingly evident from a statistical standpoint, 28 percent from urinary cultures obtained from cat-noncat patients compared to 18 percent of h. Noncat patients obtaining urine cultures within the same time period. Additionally, data obtained from this project parallels prior research regarding the impact of indwelling urinary catheters on the natural host defense system and verified through the increased risk of CAUTI in indwelling urinary catheterized patients (Hooton et. al., 2010). The additional analysis conducted on the distribution of various types of organisms identified during this study found *Enterococcus* species (39.28 percent) to be the most prevalent compared to traditional *E.coli* (35.71 percent), which had resulted in both biomarkers used to classify CAUTIs having experienced a shift in the distribution of microorganisms within the majority of CAUTIs identified. Previous research has validated this shift with the emergence of enterococci as significant bacteria and their increase in prevalence as nosocomial device related infections have continued to evolve (Arias & Murray, 2012). VRE (Vancomycin-resistant enterococci) was seen in this study at 17.86%, while this rate itself is not particularly high, it is still clinically significant as Vancomycin has long been known as the last line of defense against serious infections caused by Gram-positive bacteria and the emergence of resistance limits available treatment options considerably. This finding is supported by other studies which have shown a similar level of prevalence (Cetinkaya et al 2000), and suggest that VRE represents an emerging problem for various healthcare settings. The fact that *Enterococcus* species have the potential to acquire and transfer resistance genes such as vanA and vanB will also contribute to the problem, and increase the risk of rapid spread amongst hospital settings. Another significant finding from this study, is that biofilm formation contributes to the pathogenicity of *Enterococcus* species. A substantial percentage of isolates exhibited biofilm-forming capabilities with 36.36% of isolates identified as strong biofilm formers. Biofilms contribute significantly to the persistence of an infection, by providing bacteria protection against the host's immune system and also reduce penetration of antibiotics through the biofilm layer. This is in agreement with several previous studies which have identified biofilm formation as an important virulence factor for device-associated infections (Donlan & Costerton 2002). This is a fact that is well-supported by data the study found a significant correlation between vancomycin resistance and the ability to produce biofilms ($p = 0.02$), in fact, biofilm formation was strong in all VRE isolates. This indicates that the ability to form biofilms may lead to higher levels of antimicrobial resistance and chronic infection. Besides being physical barrier, biofilms also promote genetic exchanges among bacteria, including the spreading of resistance genes. Other researchers who have investigated biofilm formation and antibiotic resistance also came to the same conclusion about the clinical relevance of this linkage (Mohamed & Huang, 2007). The simultaneous presence of drug resistance and biofilm formation in *Enterococcus* species is therefore a double-edged sword for CAUTI treatment. These attributes result in ineffective therapies, frequent infection relapse, and added healthcare expenses. Thus, infection prevention measures that are effective, such as adherence to aseptic catheter insertion, reducing unnecessary frequency of catheterization and prompt removal of catheters, are paramount to lowering the occurrence of CAUTIs. Antimicrobial stewardship programs need improvement to reduce the growth and spread of resistant bacteria. Even though research finds important results, it's weaknesses. These include a small number of patients and reliance on phenotypic testing for biofilm detection, which might miss key genetic factors. More research using molecular tools and bigger patient groups is advised to better understand how VRE spreads and develops resistance in biofilms. It seems clear that *Enterococcus* species - Mostly vancomycin-resistant ones - are becoming more common in catheter-related urinary infections. The link between biofilm development and resistance is strong. This means infection prevention, monitoring, and careful antibiotic choices must work together. That approach is necessary to stop these infections from spreading further.

CONCLUSION

Catheter-associated urinary tract infections are a major problem in hospitals. *Enterococcus* species are now common causes of these infections. More patients with catheters test positive for bacteria, showing catheters clearly increase infection risk *E. Coli* used to be the most common cause, but *Enterococcus* is growing faster in hospital settings. Vancomycin-resistant *Enterococcus* (VRE) is found in a moderate number of cases, but treatment options are limited. VRE can spread quickly in healthcare environments. Making it dangerous. Many *Enterococcus* species can grow biofilms, which stick to surfaces and protect bacteria. Biofilm presence links strongly with vancomycin resistance. This connection raises serious concerns for patient safety and infection control. Resistance spreads fast when infections aren't managed well. Hospitals must act quickly to stop the rise of VRE and biofilm-related infections. Routine

monitoring and proper catheter care can reduce risks greatly. A simple step like changing catheters on time helps prevent outbreaks. The problem affects both patients and staff directly through higher infection rates. Plus, these findings support better policies for managing catheter use in hospitals. This issue shows how hard it's to fight infections when bacteria resist antibiotics and stick together in protective layers, both of which can cause treatment to fail, long-term illness, and more strain on hospitals. At least in theory, good infection prevention steps like using catheters only when needed, following clean procedures, and removing them early help reduce risks. For now, hospitals should improve antibiotic use programs to stop resistant germs from spreading. Ongoing tracking and more studies using modern tools are necessary to learn how resistance and biofilm grow. A team-based strategy is important to handle and stop catheter-associated urinary tract infections in patient care settings.

REFERENCES

1. Hooton, T. M., et al. (2010). Diagnosis, prevention, and treatment of catheter-associated urinary tract infection. Clinical Infectious Diseases.
2. Arias, C. A., & Murray, B. E. (2012). The rise of the Enterococcus: Beyond vancomycin resistance. Nature Reviews Microbiology.
3. Cetinkaya, Y., Falk, P., & Mayhall, C. G. (2000). Vancomycin-resistant enterococci. Clinical Microbiology Reviews.
4. Donlan, R. M., & Costerton, J. W. (2002). Biofilms: Survival mechanisms of clinically relevant microorganisms. Clinical Microbiology Reviews.
5. Mohamed, J. A., & Huang, D. B. (2007). Biofilm formation by enterococci. Journal of Medical Microbiology.
6. Hooton T. M., Bradley SF, Cardenas DD, Colgan R, Geerlings SE, Rice JC, et al. Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults. Clin Infect Dis. 2010;50(5):625–663.
7. Arias C. A., Murray B. E.. The rise of the Enterococcus: Beyond vancomycin resistance. Nat Rev Microbiol. 2012;10(4):266–278.
8. Cetinkaya Y., Falk P, Mayhall CG. Vancomycin-resistant enterococci. Clin Microbiol Rev. 2000;13(4):686–707.
9. Donlan R. M., Costerton J. W.. Biofilms: Survival mechanisms of clinically relevant microorganisms. Clin Microbiol Rev. 2002;15(2):167–193.
10. Mohamed J. A., Huang D. B.. Biofilm formation by enterococci. J Med Microbiol. 2007;56(12):1581–1588.
11. Hooton, T. M., et al. (2010). Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults. Clinical Infectious Diseases, 50(5), 625–663.
12. Arias, C. A., & Murray, B. E. (2012). The rise of the Enterococcus: Beyond vancomycin resistance. Nature Reviews Microbiology, 10(4), 266–278.
13. Cetinkaya, Y., Falk, P., & Mayhall, C. G. (2000). Vancomycin-resistant enterococci. Clinical Microbiology Reviews, 13(4), 686–707.
14. Donlan, R. M., & Costerton, J. W. (2002). Biofilms: Survival mechanisms of clinically relevant microorganisms. Clinical Microbiology Reviews, 15(2), 167–193.
15. Mohamed, J. A., & Huang, D. B. (2007). Biofilm formation by enterococci. Journal of Medical Microbiology, 56(12), 1581–1588.