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Reassessing Antimicrobial Strategies: Antibiotics Outperform Nanoparticles in Controlling Bacterial Growth

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ABSTRACT

The purpose of this work was to investigate the possibility of using genetically modified E. coli as a platform for the large-scale production of metal nanoparticles (NPs) with particular morphological characteristics. Our findings defied the popular idea that nanomaterials always work better than traditional antibiotics by showing that antibiotics were more successful than nanoparticles at stopping the development of germs. Azithromycin, in particular, showed notable inhibitory zones in comparison to Ag-silver and silver nanoparticles. These results highlight the necessity of critically reevaluating the effectiveness of nanoparticles in antimicrobial applications and taking into account different approaches when intended results are not obtained. The demonstrated efficiency of conventional antibiotics underscores their ongoing significance.

KEYWORDS: *E. coli*, metal nanoparticles, antimicrobial applications, antibiotics, azithromycin, morphological characteristics

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INTRODUCTION

Silver ions (Ag+) are recognized as an eco-friendly antimicrobial agent effective against various bacteria, including Escherichia coli. Recent studies on silver nanoparticles (Ag-NPs) have revealed their antimicrobial potential at lower concentrations compared to Ag+ ions, with effective concentrations reported in the nanomolar and micromolar ranges, respectively [1]. Nanoparticles possess unique characteristics such as large specific surface area, modified structure, and controlled surface composition, which confer remarkable physical, chemical, and biological properties [2]. New preparation methods yielding high concentrations and stable dispersions of Ag-NPs have expanded their antibacterial applications. While Ag-NPs effectively deactivate bacteria and hinder microbial growth, the exact mechanism remains incompletely understood[3]. The bactericidal action of Ag-NPs shares similarities with silver ions, as both attach to phosphate and sulfur groups in the bacterial cell membrane or membranal proteins, leading to severe cellular damage and disruption of vital functions such as permeability, enzymatic signaling, and cellular oxidation processes [4]. Ag-NPs can penetrate bacterial cells, accumulating to toxic levels that induce organismal death. Moreover, they can bind to bacterial DNA, inhibiting replication, or interact with bacterial ribosomes. Both Ag+ ions and free radicals generated by Ag-NPs are implicated in their antimicrobial activity [5].

MATERIAL AND METHODS

Escherichia coli isolates were obtained from stool samples of patients and subsequently cultured on both nutrient and MacConkey agar. After diagnosis using the Vitk2 method, antibiotic sensitivity was assessed using gentamicin and azithromycin, comparing them with the effects of silver nanoparticles and potassium permanganate on Muller-Hinton agar.

RESULT AND DISCUSSION

The objective of this study was to offer initial support for utilizing engineered E. coli as a framework for the mass production of metal nanoparticles (NPs) with precise morphological characteristics. Contrary to expectations, the results indicated that the effectiveness of antibiotics surpassed that of nanoparticles, underscoring the notion that

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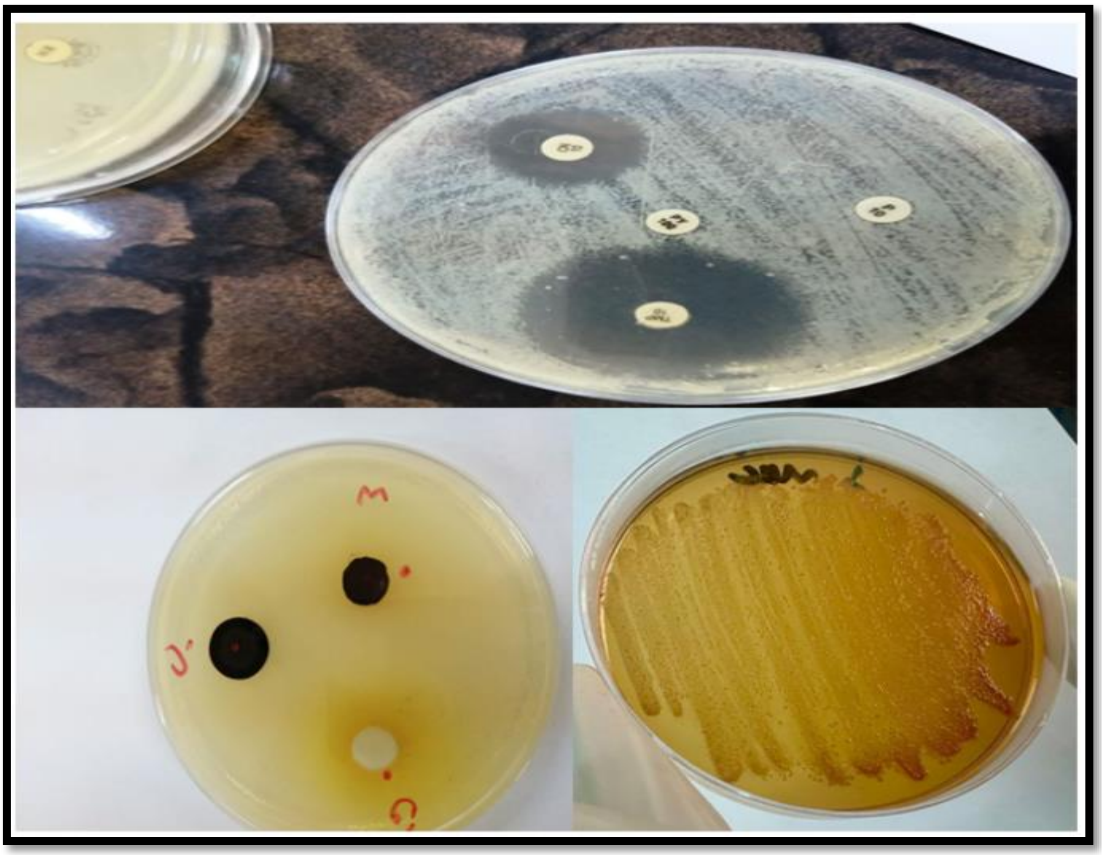
nanomaterial's may not consistently offer superior outcomes, as suggested by some research. Azithromycin demonstrated notable inhibition zones compared to silver nanoparticles, including Ag-silver nanoparticles. The investigation into different methods of treating bacterial infections is not a recent development in medical research. Nonetheless, there has been limited research confirming that patients with such infections are consistently utilizing these new approaches. The significance of having various treatment options has never been more evident than in the present era. For instance, dealing with chronic wound infections has posed significant challenges for healthcare providers. However, several new antimicrobial treatments now offer clinicians a variety of options to effectively manage bacterial infections and promote faster healing of a wide range of wounds.



The findings of this study challenge the prevailing assumption that nanomaterials always offer superior antimicrobial effects compared to conventional antibiotics. Despite the initial goal of utilizing engineered E. coli for mass production of metal nanoparticles with controlled morphological properties, the results revealed that antibiotics exhibited greater efficacy in inhibiting bacterial growth [6]. This highlights the importance of critically assessing the potential of nanomaterials in antimicrobial applications and considering alternative approaches when they may not provide the desired outcomes. The notable inhibition zones observed with azithromycin compared to silver nanoparticles, including Ag-silver nanoparticles, suggest that traditional antibiotic treatments may still hold significant value in combating bacterial infections [7]. While it may be incorrect to assume that alternative treatments like nanomaterials are not being explored, the healthcare industry is currently undergoing significant changes, with older methods being replaced by evidence-based approaches. There is a pressing need to focus on investigating new methods, and stakeholders in the medical field must work together to facilitate the implementation and delivery of emerging treatment options, including the use of nanomaterials. The increasing acceptance of alternative therapies and the allocation of resources for research are driving medical professionals and society towards more advanced forms of treatment. Therefore, the future of combating bacterial infections likely lies in utilizing alternative and emerging therapies such as nanomaterials. While these treatments have already been employed in various medical fields, there is still much to discover about their benefits, which could significantly improve the healing and recovery process for infected patients while alleviating the burden on healthcare providers. This underscores the need for further investigation into the comparative effectiveness of different antimicrobial agents and the factors influencing their efficacy, including nanoparticle characteristics and bacterial strains. Overall, these findings prompt a reevaluation of the assumptions surrounding the use of nanomaterials in antimicrobial applications and emphasize the importance of considering a diverse range of treatment options to effectively combat bacterial infections [8]. This includes the use of both local and systemic antimicrobial agents, which allow for more proactive wound management compared to the traditional method of allowing wounds to heal naturally. As a result, healthcare professionals now have multiple choices of wound dressing materials and antimicrobial agents to select from when treating infections. The current standard practice involves administering mainstream therapies for up to two years, giving families the opportunity to decide whether to continue with nanomaterials or opt for an alternative therapy. This approach enables periodic monitoring of antimicrobial levels in the blood and places a greater responsibility on patients wishing to switch from their current therapy. When it comes to treating bacterial pneumonia, the emphasis is primarily on tropical antibiotics and systemic antimicrobials. It is crucial to prioritize strategies that prevent antibiotic resistance, particularly for infections commonly found in community settings like pneumonia, rather than those acquired in hospitals..Further research is warranted to elucidate the mechanisms underlying the observed differences in efficacy and to optimize the utilization of both conventional antibiotics and nanomaterials in clinical practice [9].

CONCLUSION

This study prompts a reevaluation of the assumptions surrounding the use of nanomaterials in antimicrobial therapies and emphasizes the importance of exploring diverse treatment options to effectively manage bacterial infections. Further investigation is warranted to elucidate the mechanisms underlying differences in efficacy and to optimize the utilization of both conventional antibiotics and nanomaterials in clinical practice.

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