Review Article

Comprehensive Review of the Potential Use of Mesenchymal Stem Cells as an Advanced Methodology for Combating Drug Resistance by Bacteria.

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Abstract

Antimicrobial resistance (AMR) represents one of the most serious and rapidly evolving problems and challenges in the fields of medicine and biological treatment, driving the acceleration of the development of more efficient and non-traditional treatment techniques and strategies. The trend is towards mesenchymal stem cells (MSCs) due to their immunomodulatory properties and antimicrobial activity. This brief review aims to identify the potential therapeutic role of mesenchymal stem cells in combating bacterial isolates and strains exhibiting drug resistance. This will be achieved by presenting the mechanisms of their direct and indirect effects and clarifying their interaction with immunogenic factors and the immune system. A systematic review of scientific and research articles was conducted based on reliable global databases, with an expansion of research that focused on the antimicrobial properties of mesenchymal stem cells and their pathways of action against drug-resistant bacteria, including studies published between 2010 and 2025. The results concluded that MSCs possess the ability to secrete potent antimicrobial peptides such as LL-37, with the potential to modulate the immune response and reduce bacterial biofilm formation. Experiments conducted on cases of sepsis, pneumonia, sepsis, and wound infection showed that these cells contribute to improving survival rates and reducing bacterial virulence without causing new drug resistance. Due to its antibacterial properties and its contribution to improving the immune response, it represents an effective therapeutic alternative within the techniques used to combat drug resistance. However, there are challenges and obstacles related to regulating protocols in the clinical field; therefore, further clinical trials and researches are needed.

Keyword: Antimicrobial Resistance, Immune Response, Mesenchyme Stem Cells, Stem Cell Therapy

Introduction

Fat cells, cartilage cells, and bone cells are examples of cell types into which mesenchymal stem cells differentiate, making them accessible for a wide range of therapeutic applications. In regenerative medicine, stem cells have shown promising therapeutic results, particularly in the repair of damaged tissues and organs [1,2]. The conditioned medium (CM) produced by stem cells exhibits direct antimicrobial effects. This effect is likely due to the release of antimicrobial peptides, especially LL-37 [3]. Stem cells also release proteins and peptides, and this antimicrobial effect has been linked to other molecules such as interleukin-17 and indo-leamine 2,3-deoxygenase [4,5]. According to preclinical research, stem cells help eliminate bacteria in cases of sepsis, acute respiratory

distress syndrome, and cystic fibrosis infection [6].

Stem cell types

In comparison to embryonic stem cells, that are sourced from early embryos and may differentiate into any cellular kind within an organism, MSCs are recognized for their multipotent talents. Consequently, MSCs are taken into consideration greater ethically permissible and are extra conveniently reachable for healing packages [7]. Bone marrow well-defined characteristics and relative simplicity in their isolation have facilitated their use in numerous preclinical and scientific investigations. Adipose tissue derived mesenchymal stem cells AD MSCs have also garnered a lot of interest due to their high availability and the less invasive methods needed to obtain them. Additionally compared to their sources, umbilical cord derived mesenchymal stem cells UC MSCs are more readily available and ethically acceptable source [8]. Table (1) below connects stem cell types with their mechanisms of action against infections and justify why certain MSCs are preferred for treating drug resistance infections. Adipose derived MSCs on other hand exhibit more beneficial proliferation capabilities and an additional capacity for differentiation, making them particularly useful for tissue engineering [7]. Furthermore, the robust paracrine effect of umbilical twine derived MSCs UCMSCs which are typified by the production of bioactive substances that might affect immune response and promote tissue regeneration make them exceptional [2].

Table 1: the different MSCs source and how they used in infection control, providing link between dtem cell types and their mechanism of action

MSC source	Description	Potential in drug resistance infection	Reference
Bone marrow	High differentiation, most studied type	Effective in immunomodulation and antimicrobial peptide secretion	(9)
Adipose derived MSCs	Abundant and easily harvested	Good for tissue repair and inflammation control	[10]
Umbilical cord MSCs	Highly proliferative, non-invasive source	Strong paracrine effect, producing antimicrobial exosomes	[11]
Placenta derived MSCs	High immune tolerance	Can be used in allogenic therapies without severe rejection	[12]
Dental pulp MSCs	Isolated from extracted teeth, high neurotrophic potentiall	Antimicrobial activity, neuroprotection, regenerative potential	[13,14]
Menstrual blood MSCs	Easily accessible with highly proliferation rate	Anti-inflammatory and antimicrobial properties	[11,15]
Amniotic fluid MSCs	Found in fetal fluid, low immunogenicity	Wound healing and bacterial infection control	[16]
Synovial membrane MSCs	Found in joint tissue, high regenerative capacity	Cartilage repair and joint infection treatments	[17,18,19]

Immunomodulatory properties

Mesenchymal stem cells MSCs ability to influence the immune system is one of their top therapeutic benefits. The known dynamic of infections, where an overactive immune response can cause significant infection and tissue damage, this immunomodulatory role is especially relevant. Mesenchymal stem cells MSCs are essential for regulating immunological responses in the phase of growth factors,

cytokines and extracellular vesicles because they influence the action of various immune cells [1]. T cells, which are essential to the adaptive immune response, can be inhibited in their proliferation and activation by mesenchymal stem cells MSCs. The secretions of immunosuppressive cytokines such as interleukin 10 (IL-10) and remodeling boom element beta TGF β, typically facilitates this inhibitory effect. Additionally, MSCs have the ability to cause macrophages to polarize toward an anti-inflammatory phenotype, which helps to reduce infection and encourage tissue repair [1]. These characteristics make MSCs ideal for treating disease including sepsis and autoimmune diseases that are linked to persistent inflammation [20]. The capacity of mesenchymal stem cells to demonstrate antimicrobial effects is significantly influenced by their immunomodulatory properties as shown in table (2) below. Furthermore, MSCs can release antimicrobial peptides that specially target and destroy germs, increasing their ability to treat disease that are resistant to drugs.

Table 2: immunomodulatory properties of MSCs in combating drug resistance pathogens.

Immune mechanism	Effect of MSCs	Impact on drug resistant pathogen	reference
Macrophage modulation	Activate macrophage from pro inflammatory M2 to anti-inflammatory M2 phenotype via secretion of TGF B ,IL 10 and PGE2	Reduces excessive inflammation while preserving bacterial clearance, preventing chronic infections	[**21**,**22**]
Cytokine secretion balancing	Increase anti-inflammatory cytokines (IL10, TGF B) and reduces pro inflammatory cytokines (TNF A, IL 6, IL 1B).	Control inflammatory response, preventing septic shock and tissue destruction.	**[**31,32**]**
Neutrophil function modulation	Enhancing neutrophil recruitment and bacterial killing through IL 8 secretion while reducing neutrophil mediated tissue damage.	Promotes effective pathogen clearance while preventing tissue injury in bacterial infections.	**[**28-30**]**
Natural kill NK cell Activation	Increase NK cell cytotoxicity against bacteria and viruses while suppressing overactive NK responses via HLA G and TGF B	Improves clearance of resistance bacterial and viral infection while reducing excessive NK driven inflammation	**[**26,27**]**
Dendritic cell modulation	Suppresses dendritic cell maturation and modifies antigen presentation by down regulation of CD 86 and MHC II molecules.	Helps pathogens avoid immune detection while enhancing immune tolerance, useful in severe infection.	[24,25]
T cell regulation	Inhibits hyperactive Th1 Th17 responses, promoting regulatory T-cells (tregs) through secretion of IDO, TGF-β AND HLA G.	Prevent immune overreaction, reducing tissue damage and cytokine storms.	[23]

B cell Regulation	Suppresses B cell proliferation while maintaining antibody production via IL 10, and PGE2 secretion.	Prevents autoimmune complications while maintaining protective immunity	[11,33]
Myeloid derived suppressor cells MDSCs Induction	Stimulates MDSCs that suppress excessive immune activation in chronic infection.	Helps maintain immune homeostasis, reducing autoimmune reaction and chronic inflammation.	[34]
Complement system regulation	Modulates complement activation by increasing factor H expression, reducing complement mediated damage	Protect host tissue while maintaining pathogen clearance	[9]
Exosome mediated immunoregulation	MSC derived exosomes contain microRNAs (miR 181a) and bioactive molecules that regulate inflammation.	Indirectly enhance immune system function and reducing pathogen induced immune suppression	[34]

Mechanisms of action

Mechanism by which MSCS combat pathogens that is resistant to drugs

The scientific community gives mesenchymal stem cells MSCs a lot of thought because of their potential to treat infections that are resistant to drugs. Numerous processes including immunological device regulation, paracrine interaction and antimicrobial peptide technology, are responsible for MSCs antimicrobial properties, figure (1) below. These processes demonstrate the multipurpose of character of MSCs as therapeutic agents and underscore their potential to address antibiotic resistant, one of the most pressing issue facing modern medicine [12]. Table (3) below will links the mechanism of action side with the clinical and preclinical models side to summarizes the core of mechanism used by MSCs therapy.

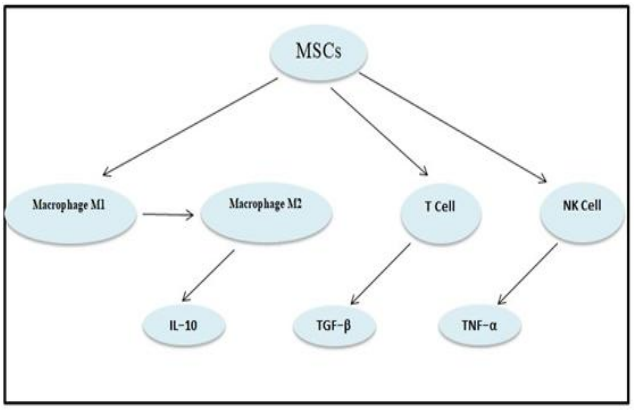

Figure 1: MSCs influence macrophage polarization, M1 are pro inflammatory, M2 are anti-inflammatory and produce cytokines which promote tolerance and tissue repair. MSCs modulate T-Cell response, promoting immune tolerance by TGF−β which suppress inflammatory responses. MSCs regulate NK cell activity leading to reduced cytotoxicity. TNF−α is involved in inflammation and immune signaling.

Antimicrobial peptide production

Antimicrobial peptides are gene encoded entities that fluctuate in length from 10 to 150 amino acid. These molecules showcase evolutionary conservation and are gift throughout a big selection of organisms, encompassing each prokaryotic and eukaryotic existence bureaucracy, such as humans. Some of those peptides are produced continuously, while others are generated in reaction to infections or inflammatory responses. The mechanisms by which AMPs act to eliminate microorganisms are varied and can be affected by external conditions such as pH, the concentration of the peptides, and the presence of salts [32, 35]. Human antimicrobial peptides (AMPs) connect

with multiple molecular targets that are present on the cell membrane or within the cellular context. By interfering with the integrity of bacteria' cell membranes, preventing the production of proteins or nucleic acids (DNA or RNA), and connecting with certain intracellular targets, antimicrobial peptides (AMPs) cause cell death. Although some of these peptides have modes of action that allow them to influence a wide range of microorganisms, they frequently show specific activity against a single class of pathogens, such as bacteria or fungus. Interestingly, many antimicrobial peptides have shown notable efficacy against diseases that are resistant to traditional antibiotics, such as bacteria that are resistant to several drugs. Multiple peptides represent a promising option and a strong candidate for developing therapeutic technologies due to their diverse properties. However, aspects such as biostable stability, high cost, methods of administration, and potential toxicity remain the only obstacles to their advancement in this field [30]. Antimicrobial peptides possess indirect biological effects that contribute to treating infections, in addition to their direct effect on the bacteria themselves. According to experiments, epithelial cell-produced peptides have multiple biological roles, such as chemokine-like activity, anti-endotoxin activity, increased bacterial immune deposition, protease inhibition, and stimulation of angiogenesis. Research indicates that 1l-37 can bind to and inhibit liposaccharide (LPS), thus providing protection against septic shock. In animal models, cathelicins attract immune cells such as neutrophils, monocytes, and lymphocytes. Similarly, through interaction with the CCR6 receptor, they attract neutrophil beta-defensins, phagocytes, and mast cells. Additionally, lipocalin-2 (Lcn2) and hepcidin both have a role in controlling iron availability, which is crucial for bacterial proliferation. According to recent research, the antibacterial properties of mesenchymal stem cells (MSCs) are linked to the release of proteins or peptides from the families of lipocalin, hepcidin, defensin, and cathelicidin [26, 27, 29].

Table 3: precise comparison of therapy with mesenchymal stem cells (MSCs) and treatment with traditional antibiotics, emphasizing the variations in terms of mechanisms of action, the potential for resistance development, and long-term therapeutic effectiveness.

Features	MSCs	Antibiotics	REF
Mechanism of Action	Immunomodulation/ direct antimicrobial activity through secretion of AMPs (LL 37, defensins), cytokines.	Direct bacterial targeting (cell wall disruption, protein synthesis inhibition, dna disruption)	[36]
Potential Resistance	Low: bacteria cant adapt due to host motivated immune modulation and multiple antimicrobial factors.	High: bacteria develop resistance by mutations, gene transfer and efflus pumps.	[14]
Tissue Regeneration Repair	Strong: promotes angiogenesis, cell proliferation.	Weak: dose not aid and may cause collateral damage to tissue.	[29]
Immune Modulation	Increase and balances immune responses by reducing excessive inflammation (TNF,IL-6) and promoting regulatory T cells.	It can disrupts the microbiome and weaken immune system.	[37]

Applications	Effectiveness against drug resistance Pathogens	Side effect	Long term efficiency	Virulence factor (biofilm)
Chronic wounds, sepsis, osteomyelitis, tuberculosis and MDR pathogen.	Works against MDR (multi drug resistance) bacteria, fungi and viruses by host direct therapy.	Minimum: low toxicity and immunogenicity. Except some undesirable immune activation in some cases.	High: increase host defense mechanism and lasting protection.	Degrades biofilms by using exosomes, matrix metalloproteinases MMPs and microRNAs
Works as first line treatment for bacterial infections	MDR strains already show resistance to many antibiotics.	Common: gut microbiome disruption, allergic reaction, kidney liver toxicity and antibiotic resistance.	Moderate; effectiveness decrease as resistance developed.	Antibiotic mostly fail to penetrate biofilms causing persistent infection and trigger to bacterial resistance.
[40]	[39]	[32,33]	[30]	[38]

Immune modulation

Mesenchymal stem cells (MSCs) are essential for controlling the host's immune response in addition to their direct antibacterial capabilities. Because an excessive immune response can worsen infection severity and cause subsequent tissue damage, this immunomodulatory feature is very crucial for the efficient management of infections, particularly those brought on by drug-resistant microbes. The release of a various institution of immunomodulatory cytokines through mesenchymal stem cells (MSCs), including interleukin-10 (IL-10) and remodeling increase thing-beta (TGF-β), is instrumental in dampening pro-inflammatory responses and cultivating an anti-inflammatory placing [1, 24, 41]. The immunomodulatory properties of (MSCs) are particularly advantageous within the control of continual infections and sepsis, conditions characterized by way of unfavourable hyperactivation of the immune machine. Mesenchymal stem cells (MSCs) promote the polarization of macrophages into an anti-inflammatory M2 phenotype even as concurrently inhibiting T cellular activation, thereby alleviating the detrimental results of chronic infection even as concurrently promoting the clearance of pathogens. This double functionality in immune regulation and antimicrobial movement positions MSCs as a significant asset in fighting drug-resistant pathogens [42].

Paracrine effects

Apart from their role in immune response regulation and antimicrobial peptide manufacturing, mesenchymal stem cells MSCs also exhibit healing effects through paracrine signaling pathways. The release of bio active substances, cytokines, growth factors and extracellular vesicles is known as paracrine signaling. These substances affect neighboring

cells and alter a variety of biological characteristics. By suppressing microbial multiplication, enhancing the immune response and promoting tissue regeneration, the substance generated during this process enhance the hosts ability to fend off infections [2]. The significance of paracrine signaling through MSCs is frequently mentioned in relation to wound healing and tissue regeneration approaches. In addition to helping to repair damaged tissue, these cells also help to lower the microbial burden. Angiogenesis and tissue repair depend on the release of essential growth factors, such as vascular endothelial growth factor VEGF and hepatocyte boom factor HBF, which aloe infected area to heal while the immune system controls the invasive pathogen [15]. Furthermore, research specifies that extracellular vesicles EVs originating from mesenchymal stem cells MSCs retains antimicrobial peptides and different bioactive molecules which can successfully eliminate pathogens or modulate immune responses [40, 43].

Clinical studies and preclinical models

In vitro studies

A significant portion of studies focused on the antimicrobial properties of (MSCs) has predominantly emerged from in vitro research involving bacterial pathogens. Despite this, there is a notable scarcity of information pertaining to the role of mesenchymal stem cells (MSCs) in relation to viral, fungal, and parasitic pathogens. It has been documented that mesenchymal stem cells (MSCs), whether unstimulated or stimulated, possess a direct antimicrobial effect. Although there have been notable differences in the modes of action and antibacterial range, mesenchymal stem cells (MSCs) originating from different tissue origins have been shown to have antimicrobial activity mediated by antimicrobial peptides (AMPs). Variations in MSCs' antimicrobial characteristics might be a sign of a focused adaptive response, in which these cells generate the strongest antimicrobial peptides based on the kind of pathogenic danger. Furthermore, in terms of the mechanisms of action controlling these cells' antimicrobial qualities, current research has shown notable qualitative variations between human MSCs and those generated from animal models, especially mice [16,44]. Among the various sources of mesenchymal stem cells (MSCs), bone marrow-derived mesenchymal stem cells (BMSCs) have been the focus of extensive research concerning their natural antimicrobial properties. The antimicrobial efficacy of bone marrow-derived stem cells (BMSCs) in human topics is basically attributed to antimicrobial peptides (AMPs) like LL-37 and hepcidin. Research has shown that those AMPs are found in both unstimulated and inspired BMSC cultures. In specific, LL-37 has been discovered to permit both BMSCs and their conditioned medium to effectively reduce the growth of diverse bacterial lines, including *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Streptococcus pneumoniae*. In a look at performed by Krasnodembskaya et al., it became confirmed that BMSCs can immediately inhibit bacterial proliferation, in addition to thru using conditioned tradition medium, even though this impact is contingent upon prior exposure of BMSCs to bacterial demanding situations [45,46].

In vivo studies

The antimicrobial houses of (MSCs) located in-vitro were corroborated with the aid of diverse in vivo investigations. MSCs derived from diverse sources exhibit the ability to diminish pathogen loads across multiple preclinical models, regardless of the administration route, dosage, or

timing of injections. This effect has been documented in various biological fluids, including blood, spleen, peritoneal fluid, lung tissue, and bronchoalveolar lavage (BAL) fluid. Table (4) provides a summary of the existing in vivo evidence concerning the antimicrobial effector functions of MSCs facilitated by antimicrobial peptides (AMPs) [47]. Although the in vivo effects of hepcidin remain inadequately explored, current in vitro studies suggest that hepcidin may play a significant role in exhibiting antibacterial properties that could be beneficial in the treatment of bacteremia According to Gonzalez-Rey, septic mice given adipose tissue-derived mesenchymal stem cells (AT-MSCs) had much fewer germs in their peritoneal cavities than the untreated mice. This observation suggests that AT-MSCs may enhance bactericidal activity either independently or in conjunction with other cellular entities. In a related study, Mei et al. observed that the administration of 2.5 × 10^5 muBMSCs six hours after the onset of (CLP) cecal ligation and pincture -induced sepsis resulted in enhanced bacterial clearance, which was partially due to increased phagocytic activity among host immune cells. Cystic fibrosis, a hereditary condition, is marked by a persistent conflict between pulmonary infections and inflammation, which is a leading cause of morbidity and mortality in a cystic fibrosis mouse [48,49]. Table (4,5) below associate the laboratory findings (in vitro) to (in vivo) and clinical trials, establishing the progression of MSCs therapy from experimental models to human application steps.

Table 4: show how researches of in vivo and in vitro progresses toward clinical application in MSCs therapy techniques for drug resistance infection.

Study type	Description	Findings	Relevance to drug resistance infections	Reference
In vitro studies	Lab based experiments using bacterial cultures co cultured with MSCs	MSCs secrete antimicrobial peptides, enhance phagocytosis and modulate immune response	Initial proof of concept for MSCs based antimicrobial therapy.	[50]
In vivo studies	MSCs conditioned media applied to biofilm of drug resistance pathogens	MSCs disrupt biofilms and enhance antibiotic susceptibility	Suggest potential synergy between MSC therapy and existing antibiotics	[51]
In vivo studies	Mouse models of drug resistance sepsis treated with MSCs	MSCs reduce systemic inflammation, bacterial load and mortality	Approves therapeutic potential in live organisms	[52,53]
In vivo studies	Rats with osteomyelitis induced by multidrug resistance *staph. aureus* MDR SA	MSC therapy promotes bone healing and bacterial clearance	MSCs could be used in chronic bone infection	[54,55]
In vivo Studies	Dogs with antibiotic resistance chronic wounds treated with MSCs	Enhance wound healing, reduce bacterial infection and regulate immune responses.	Proof potential clinical applications in veterinary medicine.	[56,57]

Clinical trials	Patient with sepsis treated with MSCs derived exosomes	Show safety and preliminary effectiveness	Provides data for regulatory approval	[58,59]
Clinical trials	MDR TB patients receiving MSC infusions	MSCs enhancing lung healing and reduce inflammation	Demonstrate MSC potential in intracellular bacterial infections.	[60]

Table 5: main antimicrobial mechanism used by MSCs in combating drug resistance pathogen.

Mechanism	Effect on Pathogens	Scientific confirmation	Reference
Antimicrobial peptides (AMP) production	MSCs secrete cathelicidins (LL37), defensins and which disrupt bacterial membranes and kill pathogen.	Results of in vivo studies	[**11**,61]
Immune modulation	MSCs regulate macrophages (m1..m2), T-cells, and dendritic cells, reducing inflammation and enhancing pathogen clearance.	Preclinical and clinical studies	[24,62]
Paracrine effect	MSCs release exosomes, cytokines and growth factors modifying immune environment to increase resistance toward pathogen and tissue repairing.	Demonstrated in animal models	[20]
Biofilm disruption	MSCs derived exosomes and matrix metalloproteinases MMPs breakdown bacterial biofilm make them susceptible to host defense.	Observed in chronic infection models	[**19**]
NK cell activation	MSCs enhance natural killer cell NK Cell activity improving clearance of intracellular bacteria and viruses.	Observed in viral and bacterial infected models	[63]
Toxin neutralization	MSCs secretes lipid mediators that neutralize bacteria toxins and prevent toxin induced immune suppression	Confirmed in chronic infection studies	[63]
Hypoxia indyced antimicrobial responses	Under low oxygen condition MSCs produce reactive oxygen species ROS to enhance pathogen clearance	Observed in tuberculosis models	[64]

Advantages of mscs in treating drug-resistant infections

A superb gain of mesenchymal stem cells (MSCs) in addressing drug-resistant infections is their considerable antimicrobial residences. In evaluation to standard antibiotics, which usually target particular bacterial traces, MSCs show off effectiveness in opposition to a numerous array of pathogens, encompassing microorganism, viruses, fungi, and parasites [65]. This big

antimicrobial functionality is facilitated via several mechanisms, which include the discharge of antimicrobial peptides (AMPs) inclusive of LL-37 and beta-defensins, which can directly remove pathogens by using compromising their mobile membranes [1]. Furthermore, MSCs have revealed the ability to inhibit the production of biofilm, which are bacterial communities that exhibit significant antibiotic resistance and are frequently linked to persistent infections. MSCs are situated as an excellent asset in the fight against drug resistant infections due to their varied approach to targeting a variety of pathogens and contamination associated pathways [66].

Discussion

Resident studies indicate that mesenchymal stem cells have significant potential and combating antibiotic resistance infections through both Direct and indirect mechanisms one of the most prominent mechanisms identified as their ability to secrete antimicrobial peptides (AMPs) such as LL-37, defensins and cathelicidins, which have antimicrobial‹ antifungal and antiviral properties. This websites disrupt bacterial biofilm weakening their resistance and increasing the effectiveness of conventional antibiotic when use it in combination. Data from laboratory experiments and animal modules indicate that the use of MSCs enhances the innate immune response leading to the stimulation of macro fates natural killer cells and NK cells and T cells‹ thereby improving the elimination of pathogens. Additionally most of us studies have demonstrated that MSCs had a powerful immune modulating effect reducing the secretion of inflammatory interleukins such as TNF a and IL-6, earned increasing the production of IL-10 and TGF B, which helps control the inflammatory response and prevent excessive immune tissue damage. One of the laboratory studies analyzed in this research showed that bone marrow derived mesenchymal stem cells exhibited remarkable ability to inhibit the growth of E coli and pseudomonas aeruginosa bacteria through the secretion of antimicrobial peptides. Other studies have shown that Umbilical cord-derive cells (UC-MSCs) have a similar effect but with a higher capacity to secrete immune molecules such as interleukins and immunoglobulin protein enhancing their effectiveness in fighting infection compared to sale from other sources. Additionally experiments conducted on mouse models of sepsis showed that treated with mesenchymal stem cells resulted in a significant reduction in mortality and improve it organ function compared to control groups. The sales also help to reduce bacterial loads in the lungs and liver, unimportant indicator of their effectiveness in eliminating systemic infections. The tables included in the research indicate that the effect of MSCs variable depending on their source and environmental condition in which they are grown. Adipose-derived cells (AD-MSCs) have higher immunomodulatory potential; while bone marrow derived cls (BMS Cs) we are more effective security antibacterial compounds. On other hand umbilical cord derived cells (UC-MSCs) demonstrated a balanced combination of immunomodulatory and pathogen fighting properties.

Conclusion

Despite these positive results challenge remain in the clinical application as optimal doses earned administration roads have yet to be determined to ensure optimal results. Some studies have shown variation in the effect of mesenchymal stem cell depending on their source and laboratory processing method which calls for standardization of a protocol to ensure constant results.

Analysis of current evidence showed that MSCs therapy offers an innovative and the promising approach to treat think antibiotic resistance infection combining immunomodulatory and antimicrobial properties, enhancing the effecti-veness of conventional treatments. The use of this cell could contribute to reducing mortality rates associated with severe infections such as sepsis respiratory infection and complication resulting from antibiotic resistance. However there are a number of challenges that must be addressed before this treatment can be wildly implemented in a clinical practice. This includes the need for more large scale clinical trials to determine the safety and efficacy of these treatments as well as the need to standardize sales source and the preparing technique to ensure maximum benefit. According to recent research, mesenchymal stem cells (MSCs) may be a viable treatment option in the future for treating illnesses that are resistant to antibiotics. However, a better knowledge of the basic processes controlling these cells' interactions with the immune system and the creation of methods to guarantee their safe and efficient usage are necessary for making this therapeutic strategy accessible and putting it into practice economically.

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