VESICULAR MODE OF DRUG DELIVERY: A PROMISING APPROACH FOR ANTI-INFECTIVE THERAPY

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ABSTRACT

Infections are caused by several microorganisms, which are mostly affecting the mucosal surfaces such as gastrointestinal tract, respiratory tract, vaginal tract etc. These microorganisms are treated with anti-infective drugs based on their severity of action in the individuals. The conventional anti-infectives have short residence time at the site of application and poor bioavailability, which leads to incomplete elimination of organisms causing reoccurrence and tolerance. Recently, vesicular mode of delivery of drugs has gained attraction because of its improved therapeutic efficacy and stability. Vesicles are bilayered structures formed by hydration of lipid molecules and can be used for incorporating both hydrophilic and lipophilic drugs. This paper focus on various vesicular systems such as liposomes, niosomes, ethosomes, transferosomes and their contribution towards overcoming the disadvantages of anti-infective drugs.

Key words: Vesicular systems, Anti-infectives, Bioavailability.

INTRODUCTION

Infection is the reaction of the host organism’s body tissue to the disease causing microbes and the toxins, they produce. These infections are transmissible or communicable caused by infectious agents such as bacteria, fungi, viruses, nematodes, macro-parasites, which are eliminated from the body by the immune system. Severe infections can be treated with anti-microbial agents1.

Antimicrobial agents

An agent that kills or inhibits the growth of the microorganisms is called antimicrobial agents. They can be classified according to their function and also based on the type of organism, they act upon. Agents that act against bacteria are called antibacterials and that acting against fungi are called antifungals.

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Antibacterial agents

Antibacterial agent kills or inhibits the growth of bacteria, and so called as antibiotics. Antibiotics denote a broader range of drugs and are classified by their mechanism of action, chemical structure and biological activity.

Based on the mechanism of action, they are classified by their ability to target the outer membrane of bacteria or that inhibit enzymes or nucleic acid and protein synthesis. Based on the biological activity they are classified as bactericidal (kills) and bacteriostatic (slows down) agents. Based on the chemical structure they are classified as beta lactums, cephalosporins and carbapenems. Other classes include aminoglycosides, quinolones, sulfonamides, macrolides, nitroimidazoles.

Antifungal agents

Antifungal agents are used to treat fungal infections and also to stop their development. They are used to treat mycoses such as athlete’s foot, candidiasis and also some serious diseases like cryptococcal meningitis. There are several classes of antifungals which are: polyene, imidazole, triazole, thiazole, allylamines, echinocandins etc. As fungal cells are similar to human cells (both are eukaryotes) targeting is difficult and so it may lead to some side effects.

These drugs discovered over the years do not have very good effectiveness due to factors such as drug resistance, their inability to reach target sites, short residence time, poor bioavailability, lack of penetration etc. So to overcome these challenges novel delivery systems are being investigated for effective delivery of these drugs. One such approach is vesicular delivery systems; these include liposomes, niosomes, ethosomes, transferosomes, pharmacosomes, sphingosomes, herbosomes, cubosomes, aquasomes, virosomes, enzymosomes, bilosomes etc.

Liposomes

Liposomes are bilayered structures composed of phospholipids and cholesterol that are used for the administration of nutrients and drugs. The core of liposomes entraps hydrophilic drugs and the membrane entraps hydrophobic drugs, which can be administered through oral, intravenous and topical delivery. The mechanism of delivering drugs is either by fusing with the cell membrane and releasing the drug or by endocytosis mechanism of the cells. The vesicles can be multilamellar, small unilamellar and large unilamellar depending on the method of preparation. For targeting, the surfaces of liposomes are attached with ligands specific to the target site.


Table 1: Types of liposomes used for different applications

<table>
<thead>
<tr>
<th>Types</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional liposomes</td>
<td>Targeted delivery to macrophages and in vaccines</td>
</tr>
<tr>
<td>Cationic liposomes</td>
<td>Gene delivery</td>
</tr>
<tr>
<td>pH sensitive liposomes</td>
<td>Targeting tumours and in endocytosis</td>
</tr>
<tr>
<td>Temperature Sensitive liposomes</td>
<td>Site specific delivery of solid tumours</td>
</tr>
<tr>
<td>Stealth liposomes</td>
<td>Selective targeting to pathological areas</td>
</tr>
<tr>
<td>Immuno liposomes</td>
<td>Receptor mediated endocytosis</td>
</tr>
<tr>
<td>Magnetic liposomes</td>
<td>Targeting antibodies to brain[6]</td>
</tr>
</tbody>
</table>

Fig. 1: Structure of vesicle

Antibacterial drugs in liposomes

Several antibacterial drugs were formulated as liposomes for increasing bioavailability, antibacterial activity, entrapment, prolonging release and permeation. Below Table 2 shows the drug, its composition and the method used for preparation.

These liposomes exhibit high antibacterial activity against Mycobacterium avium, pneumonia, S. aureus organisms and can be delivered through ocular, intravenous, topical and inhalation routes depending on the area infected.

Effect of surface charge

Shafaa et al. reported that surface charge of the liposomes affects their activity against S. aureus infections. Negatively charged liposomes prepared by using Dicetyl
phosphate showed high antibacterial behaviour compared to the positively charged liposomes made with stearyl amine and the neutral liposomes.

**Complexation with β-CD**

Salem et al.\(^8\) suggested that complexation of phospholipids with β-cyclodextrin and liposome encapsulation of Clarithromycin improved the solubility, which in turn may enhance the *in vivo* bioavailability of the drug thus making it available to the macrophages infected with Mycobacterium avium complex (MAC).

**Lung targeting**

Zhang et al.\(^9\) targetted lungs for treating pulmonary inflammation by injecting the liposomes loaded with Levofloxacin intravenously through caudal vein. High lung targeting efficiency was achieved reducing the side effects like hematotoxicity and neurotoxicity caused by direct injection of drug.

**Long circulation half life and prolonged release**

Sterically stabilized liposomes of Ciprofloxacin prepared by using polyethylene glycol (PEG) were not taken up by mononuclear phagocyte system (MPS) i.e., liver and spleen and thus showed high circulation half lives, which lead to localization of liposomes in the infected regions of *Klebsiella pneumonia*. But in rat models treatment with Ceftriaxone was found to be effective than the Ciprofloxacin encapsulated sterically stabilized liposomes\(^10\).

Prolonged release of Chloramphenicol was obtained by incorporating the drug into liposome carrier and again incorporating it into a bioadhesive gel of carbopol 974P. This lead to prolonged release of drug for more than 24 hrs and also good stability of the formulation\(^11\).

**Antifungal drugs in liposomes**

Antifungal drugs such as Clotrimazole, Miconazole, Itraconazole, Nystatin were formulated as liposomes and are used for treating infections caused by fungal organisms like *Candida albicans*.

**Better permeation and retention on skin**

Miconazole Liposomes prepared with saturated phospholipids showed better retention in the skin compared to unsaturated phospholipids. But the permeation of
liposomal formulations was high compared with non liposomal systems, which may be due to the dispersibility of the drug in the system in insoluble form\(^\text{12}\).

**Protecting erythrocytes with better antifungal activity**

Nystatin is a polyene that is highly toxic when given intravenously. Liposomes of Nystatin displayed high spectrum of activity against \(C. \text{ albicans}\) than amphotericin B. Also, encapsulation of drug with liposomal layer prevented the lysis of erythrocytes thus protecting the mammalian cells from damage\(^\text{13}\).

**Passive targeting**

Itraconazole liposomes administered by intravenous injection showed high distribution of drug in lungs, brain and liver than the drug dissolved in cyclodextrin or polyethylene glycol 2000. Better efficacy of drug was observed under \textit{in vivo} conditions. Hence, it was effective to treat systemic infections particularly in brain and lung\(^\text{14}\).

**Table 2: Liposome formulations of antibacterial and antifungal drugs**

<table>
<thead>
<tr>
<th>Drug</th>
<th>Composition</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Antibacterial drugs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cephalexin</td>
<td>L-(\alpha)-dipalmitoyl phosphatidylcholine</td>
<td>Thin film hydration technique(^\text{7})</td>
</tr>
<tr>
<td>Clarithromycin</td>
<td>(\beta\CD)-cyclodextrin, Egg yolk phosphatidylcholine</td>
<td>Thin film hydration technique and Complexation of drug with (\beta\CD)(^\text{8})</td>
</tr>
<tr>
<td>Gentamicin (intra venous administration)</td>
<td>Egg phosphatidylcholine phosphatidylerine, stearylamine, and dipalmitoylphosphatidylcholine</td>
<td>Film hydration method and Sonication(^\text{15})</td>
</tr>
<tr>
<td>Chloramphenicol (gel for vaginosis)</td>
<td>Egg phosphatidylcholine/egg phosphatidylglycerol-sodium</td>
<td>Proliposome method and the polyol dilution method(^\text{11})</td>
</tr>
<tr>
<td>Levofoxacin (injection)</td>
<td>Soybean phosphatides</td>
<td>Ammonium sulphate gradient method(^\text{9})</td>
</tr>
<tr>
<td>Ticarcillin</td>
<td>Egg lecithin</td>
<td>Thin film hydration followed by sonication and extrusion(^\text{16})</td>
</tr>
</tbody>
</table>

Cont…
Drug Composition Method

**Antifungal drugs**

<table>
<thead>
<tr>
<th>Drug</th>
<th>Composition</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miconazole (Topical)</td>
<td>Phosphatidyl choline</td>
<td>Thin film hydration technique</td>
</tr>
<tr>
<td>Itraconazole (intravenous)</td>
<td>Dipalmitoylphosphatidylcholine</td>
<td></td>
</tr>
<tr>
<td>Nystatin</td>
<td>Dimyristoyl phosphatidylcholine (DMPC) and Dimyristoyl phosphatidylglycerol (DMPG)</td>
<td>Thin film hydration technique</td>
</tr>
</tbody>
</table>

**Niosomes**

Niosomes are vesicular structures ranging from 10-1000 nm size, formed by incorporating non ionic surfactants, which can be used for delivering amphiphilic and lipophilic drugs. Niosomes are biodegradable, non-toxic, more stable and inexpensive. The chemical nature of the surfactants improves the stability of niosomes that makes them better than liposomes. The stability is increased by incorporating cholesterol and little of anionic surfactants. Steric stabilization of niosomes is done for preventing aggregation of vesicles using compounds like dicetyl phosphate, stearyl amine that introduce electrostatic or repulsive steric forces. They can be administered through intramuscular, intravenous, transdermal and also oral.

The cholesterol in the mixture acts as fluidity buffer and intercalator, provides rigidity and stability to the vesicles, decreases the permeability coefficient of membranes.

**Antibacterial drugs in niosomes**

**Penetration enhancement**

Drugs such as Bacitracin, Benzoyl peroxide and Erythromycin are formulated as niosomal gel for topical use to overcome side effects such as irritation, redness, itching, edema. Encapsulation of drug into niosomal gel improved the penetration of drug into the layers of skin and also prolonged its release.

**For ocular delivery without irritancy**

Eye infections are treated by frequent administration of drugs or by directly injecting drugs on the site of infection, which have its own disadvantages like poor patient compliance,
slow residence time, lacrimal discharge. To overcome these limitations, niosomes of drugs such as Gentamicin, Levofloxacin, Chloramphenicol were prepared that gave sustained release for more than 10 hours without affecting vision. Ocular irritation was also not observed\textsuperscript{22-24}.

**Effect of cholesterol and surfactant**

Addition of cholesterol enhances the fluidity of niosomes that is essential for the rigidity of vesicles. In Norfloxacin niosomes, amount of cholesterol added had an effect on the release of the drug. Low surfactant and high cholesterol content lead to the formation of leaky vesicle. Hence amount of cholesterol added to the formulation was found to depend on the nature of the surfactant and its HLB (Hydrophilic Lipophilic Balance) value\textsuperscript{25}.

**Effect of lipophilicity of surfactant**

Niosomes of Rifampicin prepared by using different sorbitan esters (Span 20, 40, 60, 80, 85) showed difference in release rates, which may be due to the varying lipophilic nature of the surfactants. Least lipophilic nature eases the access of media to the drug but highly lipophilic nature hinders the permeation of media\textsuperscript{26}.

**Lung targeting**

Rifampicin niosomes were prepared and studied for its characteristics, which showed localization of 65\% of drug in lungs for treating lung infections\textsuperscript{27}.

**Effective against tuberculosis infections**

Niosomes of Rifampicin and Gatifloxacin exhibited prolonged release of drug upto 16 hours, which could overcome the limitations such as frequent administration to patients, rheumatoid syndrome, allergy and hepatotoxic disorders. This also gave better bactericidal activity against *Mycobacterium tuberculosis* as that of the pure drug solutions\textsuperscript{28}.

**Antifungal drugs in niosomes**

**Effect of cholesterol, surfactant and ethanol content on entrapment**

The ratio of cholesterol: surfactant and the ethanol content in the formulation play significant role in the entrapment of drug into vesicle, which in turn altered the drug release. Itraconazole niosomes were formulated by varying the cholesterol: surfactant ratios and ethanol content. The entrapment of drug into vesicle increased with increase in ethanol content and decreased when cholesterol content was increased\textsuperscript{29}. 
Overcoming nephrotoxicity

Amphotericin B, a polyene compound was effective against several mycoses but caused renal dysfunctions. Lipid based formulations could be used as an alternative for treating infections with amp B. Niosomes are best choice rather than liposomes, as the niosomes were not subjected to oxidation and withstand heat. Almost 85% of drug was found to be entrapped in the long alkyl chains of surfactant (sorbitan esters and polyoxylated sorbitan esters) which gave slow and continuous delivery.

Effective for cancer treatment

Recently Ciclopirox, an antifungal agent has been proposed for cancer treatment. Cytotoxicity studies for liposomal and niosomal Ciclopirox were carried out on PC3 (prostate cancer), KB (oral cancer), Vero (kidney epithelial) and Siha (cervical cancer) cell lines by MTT assay. The IC50 (50% Inhibitory concentration) values were compared with the pure drug and standard doxorubicin to study the most efficient formulation. Niosomal formulation demonstrated cytotoxic effects at a much lower concentration than that of others, with signified pharmacological efficiency.

Enhanced cutaneous retention

Greater cutaneous accumulation of Fluconazole was achieved by loading the drug in niosomes. The vesicle size of formulations made with Span 40, Span 60, and Brij 72 were $0.378 \pm 0.022 \, \mu m$, $0.343 \pm 0.063 \, \mu m$, and $0.287 \pm 0.012 \, \mu m$, respectively. The small size of the vesicles and the nature of the surfactant affected the cutaneous accumulation and sustained delivery of drug.

Effective treatment for warts and corns

Penetration of drug into warts and corns was studied by preparing niosomal formulation of Salicylic acid with charged components such as veegum and cetylpyridium as it stabilizes the vesicle structure. The changes in molar and osmotic concentration of the release medium cause change in the entrapment efficiency. From the studies, it was concluded that niosomal formulation could be more successfully used for treating warts, corns and other inflammatory conditions.

Ethosomes

Ethosomes are soft, malleable lipid vesicles made of phospholipid, high concentration of alcohol (ethanol or isopropyl alcohol) and water. Ethanol (20 to 50%) acts as penetration enhancers and thus helps in delivering drugs to the deeper layers of the skin. High concentration of ethanol is said to be the reason for better penetration through the skin.
Ethanol increases the cell membrane fluidity and decrease the lipid density. Drugs including hormones, DNA, peptides can be incorporated in ethosomes. Ethosomes are prepared by 2 methods, namely Hot method and Cold method.41

<table>
<thead>
<tr>
<th>Table 3: Niosome formulations of antibacterial and antifungal drugs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drug</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td><strong>Antibacterial drugs</strong></td>
</tr>
<tr>
<td>Bacitracin (Topical)</td>
</tr>
<tr>
<td>Benzoyl peroxide (topical gel)</td>
</tr>
<tr>
<td>Cefuroxime axetil</td>
</tr>
<tr>
<td>Chloramphenicol</td>
</tr>
<tr>
<td>Ciprofloxacin</td>
</tr>
<tr>
<td>Erythromycin (Topical gel)</td>
</tr>
<tr>
<td>Gentamicin (Opthalmic)</td>
</tr>
<tr>
<td>Levofloxacin (ophthalmic gel)</td>
</tr>
<tr>
<td>Norfloxacin (proniosomes)</td>
</tr>
<tr>
<td>Rifampicin and Gatifloxacin</td>
</tr>
<tr>
<td>Rifampicin</td>
</tr>
<tr>
<td>Sulfadiazine (Transdermal)</td>
</tr>
</tbody>
</table>

**Antifungal drugs**

<p>| Amphotericin B (iv infusion) | sorbitan esters (Spans), polyoxylated sorbitan esters (Tweens) and cetyltrimethyl ammoniumbromide (CTAB) | |</p>
<table>
<thead>
<tr>
<th>Drug</th>
<th>Component</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ciclopirox olamine</td>
<td>Span 60</td>
<td>Ethanol injection method&lt;sup&gt;31&lt;/sup&gt;</td>
</tr>
<tr>
<td>Econazole (Transdermal)</td>
<td>Span 80</td>
<td>Thin film hydration technique&lt;sup&gt;37&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fluconazole (Cutaneous delivery)</td>
<td>Span and Brij</td>
<td>Film hydration method&lt;sup&gt;32&lt;/sup&gt;</td>
</tr>
<tr>
<td>Griseofulvin (oral)</td>
<td>Span 20,40,60</td>
<td>Lipid film hydration and ether injection technique&lt;sup&gt;38&lt;/sup&gt;</td>
</tr>
<tr>
<td>Itraconazole</td>
<td>Span 60</td>
<td>Hydration of proniosomes&lt;sup&gt;29&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ketoconazole (Niosomal gel)</td>
<td>Span, Tween</td>
<td>Thin film hydration technique&lt;sup&gt;39&lt;/sup&gt;</td>
</tr>
<tr>
<td>Salicylic acid</td>
<td>Polysorbate-20</td>
<td>Lipid Film Hydration Technique&lt;sup&gt;33&lt;/sup&gt;</td>
</tr>
<tr>
<td>Voriconazole</td>
<td>Span 80</td>
<td>Hand shaking method and Ether injection method&lt;sup&gt;40&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

**Antibacterial drugs in ethosomes**

**Enhanced permeation**

Bacitracin ethosomes labeled with fluorescein isothiocyanate (FITC) was prepared with 25% ethanol concentration and its permeation was studied in swiss albino mice fibroblasts, which showed more penetration of antibiotic into the cell membrane and releasing the drug into cells. Penetration of ethosomes into the skin layers was studied in human cadaver skin and rat skin, which demonstrated delivery of drug into deep layers up to 200 µm<sup>42</sup>.

**Effective against *S. aureus***

Skin infections with cellulites’, erysipelas and trauma caused by *S. aureus* could lead to complication and sometimes morbidity and mortality. Systemic treatments of these infections lead to side effects, poor patient compliance and allergic reactions. To overcome these problems, topical treatment of deep skin infections was suggested which could be achieved by ethosomes. Erythromycin ethosomes healed the deeper skin infections more efficiently in mice induced with *S. aureus* infections, compared to the hydroethanolic solution<sup>43</sup>. 
Antifungal drugs in ethosomes

Overcoming the barrier function

Skin is the perfect barrier for all particles protecting the body from infections. For treating deep skin infections, most drugs could not pass through the skin layers to deliver its activity. To overcome this limitation, Cavamax (α, β, γ-cyclodextrin) was used for preparing Clotrimazole ethosomes with 30% ethanol and soya lecithin (0.3, 0.5, 0.8%). Ethosomes with 0.8% soya lecithin and cavamax W7 was found to be more stable and was incorporated in carbapol gel, which showed better antifungal activity by permeating through the fungal cells in deep skin layers.

Reduction in lesion diameter

Topical skin infections caused by M. gypseum, M. canis, T. mentogrophytes, T. rubhum, C. albicans can be treated with ethosomal gels of Econazole, Fluconazole, Griseofulvin. Deposition of drug in the skin was high, which contributed to the reduction of lesions.

Ethosomal gel was also used in treating dandruff. Griseofulvin ethosomal gel achieved complete healing within 8 days of treatment and initiated growth of hair within 5-6 days.

Reduction of dose frequency

Terbinafine hydrochloride gave severe side effects when administered orally. Lotions, creams and sprays of the drug have slow residence time and high dose frequency. For overcoming these problems, vesicular systems of reduced size was recommended topically. Ethosomes were prepared and sonicated for size reduction. Reduction in size gave high skin penetration and localization, which in turn reduced the dose frequency.

Transferosomes

Transferosomes are ultra-deformable vesicles with bilayered structure and are widely used for delivering high molecular weight peptides, hormones and several drugs. Biogenic molecules such as insulin, vaccines, which are degraded in the gastrointestinal tract can be administered through transferosomes. Due to their high flexibility, permeation becomes easy through the stratum corneum. Transferosomes squeeze through the intracellular lipid of the stratum corneum and penetrate into the skin layers overcoming their barrier function. Also the osmotic gradients in the skin layers help in the movement of vesicles from the dry stratum corneum (top layer) to the hydrated deeper layers of the skin.
Table 4: Ethosome and Transferosome formulations of antibacterial and antifungal drugs

<table>
<thead>
<tr>
<th>Drug Component Method</th>
<th>Drug Component Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ethosomes</strong></td>
<td><strong>Antibacterial drugs</strong></td>
</tr>
<tr>
<td>Bacitracin</td>
<td>Fluorescent phospholipids (rhodamine red dihexadecanoylglycero-phosphoethanolamine), Phospholipon 90</td>
</tr>
<tr>
<td>Erythromycin</td>
<td>Phospholipon 90, Ethanol</td>
</tr>
<tr>
<td><strong>Antifungal drugs</strong></td>
<td></td>
</tr>
<tr>
<td>Clotrimazole</td>
<td>Soya lecithin, Cavamax W6, W7, and W8 (α-, β- and γ-cyclodextrin, respectively)</td>
</tr>
<tr>
<td>Econazole (topical gel)</td>
<td>Soya lecithin, ethanol (30%), Propylene glycol</td>
</tr>
<tr>
<td>Fluconazole</td>
<td>Soya Phosphatidyl choline, Ethanol</td>
</tr>
<tr>
<td>Griseofulvin</td>
<td>Phospholipon 90G, Ethanol</td>
</tr>
<tr>
<td>Ketoconazole</td>
<td>Phospholipid (1-3%), Ethanol (20-40%)</td>
</tr>
<tr>
<td>Terbinafine</td>
<td>Soya Phospholipid, Ethanol</td>
</tr>
<tr>
<td>Voriconazole (transethosomes)</td>
<td>Phosphatidylcholine (PC) from soybean lecithin, ethanol</td>
</tr>
<tr>
<td><strong>Transferosomes</strong></td>
<td></td>
</tr>
<tr>
<td>Neomycin</td>
<td>Soya phosphatidylcholine (97.1%) (Phospholipone @90G)</td>
</tr>
<tr>
<td>Nystatin</td>
<td>Phospholipone H 100</td>
</tr>
</tbody>
</table>

Stability of transferosomes is difficult to achieve because of its predisposition due to oxidative degradation. Natural phospholipids used for the preparation are not completely pure as its purification is a difficult process.
Antibacterial drug in transferosomes
Effective against staphylococcal infections

Neomycin elastic liposomes were prepared and incorporated into hydrogels for treating dermal infections of *S. aureus*. *In vivo* studies demonstrated high penetration of vesicles into the skin layers thus providing effective treatment for dermal infections.\(^5\)

Antifungal drug in transferosomes
Enhanced skin delivery

Surfactants in the formulation solubilised the lipids in the stratum corneum, which helped the vesicle to penetrate through the skin overcoming the barrier function. Nystatin transferosomes showed enhanced permeation through the skin lipid layer with improved anti-fungal activity than the liposomes.\(^3\)

![Fig. 2: Deformation of transferosomes through the stratum corneum](image)

There are also other types of vesicular systems such as virosomes, pharmacosomes, emulosomes, enzymosomes, aquasomes that can be used for delivering drugs more effectively each having its own advantages.

**CONCLUSION**

This article outlines about liposomes, niosomes, ethosomes and transferosomes of anti-infective drugs and its merits over the conventional formulations. Vesicular systems can be prepared by different methods which influence the size and structure of vesicle and also the entrapment of the drug. The amount of cholesterol and surfactant added to the formulation also affect the characteristics of the vesicles. The vesicular delivery systems give many advantages such as increasing bioavailability, targeting and better stability in delivering drugs. Since, it has many advantages over the conventional medicine, vesicular
mode of delivery can be used for efficient administration of anti-infective drugs in near future.

REFERENCES


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