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A Review Based on Recent Advances in the Novel Drug Delivery Systems (NDDS)

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ABSTRACT

Novel drug delivery system refers a target-oriented drug delivery that minimizes the dose and facilitates the effectiveness with damaging other organs. A drug's effectiveness may change significantly depending on how it is administered. Microcapsules, cells, cell ghosts, lipoproteins, liposomes, and micelles are only some of the drug carriers that have been developed over the years. The present review was based on the exploring the different novel drug delivery systems. It was undergone through literature review using various reputed and scientific platforms i.e., Scopus, PubMed, Springer etc. Novel drug delivery system includes numerous pathways of drug delivery i.e., mucoadhesive, hydrogel, nano particles, fast dissolving tablets, transdermal, liposomes, niosomes, emulgel, Erythrocytes loaded with drug, Chronotherapeutics, Cubosomes and Osmotic drug delivery. It has proved for numerous advantages over conventional routes of drug administrations in terms of greater patient compliances, site-specific action, decreased dose, frequency and side effects as well. Patient preferences, drug characteristics, disease site accessibility, and drug efficacy all play a role in deciding which delivery method to employ. There is always potential for development, and any emerging drug delivery systems will necessitate extensive characterization and investigation prior to being licensed for use in people. It is highly promising research area to make the treatment most effective and safe.

INTRODUCTION

Novel drug delivery system refers a target-oriented drug delivery that minimizes the dose and facilitates the effectiveness with damaging other organs. A drug's effectiveness may change significantly depending on how it is administered. Certain medications have a therapeutic window, wherein they are most effective, and beyond of which they can be either harmful or ineffective. It has raised the prospect that a multidisciplinary strategy is required to effectively deliver medicines to their intended targets in tissues [1]. It regulates pharmacological effects such as pharmacokinetics, pharmacodynamics, non-specific toxicity, immunogenicity, biorecognition, and therapeutic value. Polymer science, pharmaceutics, bio-conjugate chemistry, and molecular biology have all come together to form these cutting-edge methods, which are collectively known as drug delivery systems (DDS) [2].

Microcapsules, cells, cell ghosts, lipoproteins, liposomes, and micelles are only some of the drug carriers that have been developed over the years. The carriers can be designed to break down slowly, react to stimuli (such as pH or temperature), and be targeted (e.g., by conjugating them with specific antibodies against certain characteristic components of the area of interest). The ability to guide the drug-laden system to the desired location is known as "targeting" [3].

There are primarily two methods for targeting medication release sites-

i. Active

ii. Passive

Drug delivery carriers

Small particles of 10-400 nm in diameter dispersed in a colloidal drug carrier system as a micellar solution, vesicle, or liquid crystal show significant potential as drug delivery systems. It is important to achieve optimal drug loading and release qualities, a long shelf life, and low toxicity while creating these formulations. When a drug is integrated into a system, it becomes a part of the microstructure and may potentially affect it through molecular interactions, particularly if the drug has amphiphilic and/or mesogenic qualities [4].

Hydrogels

Hydrogels are hydrophilic polymeric networks that may absorb huge volumes of water or biological fluids in a three-dimensional form. These networks are made up of insoluble homopolymers or copolymers and are held together by chemical crosslinks or physical crosslinks. Because of their thermodynamic compatibility with water, hydrogels expand when exposed to liquid. They function as carriers in swellable and swelling controlled release devices or as reservoirs in systems that precisely control the rate at which drugs are released. Hydrogels, as environmentally intelligent and stimuli-sensitive gel systems, are at the forefront of controlled drug delivery, modulating release in response to changes in pH, temperature, ionic strength, electric field, or specific analyte concentration [5]. Certain places or bodily regions (pH range in the digestive tract) might be chosen for release in these systems (adhesive or cell-receptor specific gels via tethered chains from the hydrogel surface). When paired with molecular imprinting, hydrogels present great potential as drug delivery methods [6].

Liposomes

Lipid (or fat) molecular pouches are commonly employed in clinical settings to treat cancer. Liposomes, which come in a variety of forms, are used frequently in the fight against infectious diseases and in the delivery of some vaccinations [7].

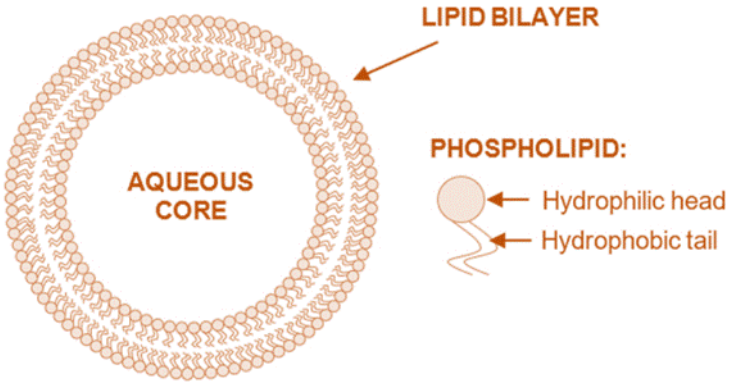

Fig 1. Depiction of liposomes

Vesicles can have many, few, or even single phospholipid bilayers. Encapsulation of polar medicinal molecules is made possible by the polar nature of the liposomal core. Depending on their affinity for phospholipids, amphiphilic and lipophilic compounds can be solubilized inside the phospholipid bilayer. When used to treat cancer, these encapsulations protect

healthy cells from the toxicity of medications and keep pharmaceuticals from building up in organs like the kidneys and liver. Several of the unpleasant consequences of cancer treatment, such nausea and hair loss, can be mitigated or even eliminated when liposomes are used [8].

Nanoparticles

Nanospheres and nanocapsules (ranging in size from 10 to 200 nm) exist in a solid form and can be either amorphous or crystalline. They can encapsulate or adsorb a medicine, making it resistant to breakdown by chemicals and enzymes. With their potential for controlled drug release, targeting of specific organs and tissues, use as DNA carriers in gene therapy, and peroral delivery of proteins, peptides, and genes, biodegradable polymeric nanoparticles have gained a lot of attention as drug delivery devices in recent years [9].

Dendrimers

Dendrimers are man-made nanoparticles with a uniform size and shape, typically between 5 and 10 nm in diameter. A control core is sandwiched between layers of polymer in these. Several alternative drug-binding sites and attachment sites for materials like PEG exist on the dendrimer surface, allowing for the modification of the dendrimer's interaction with the body. Attaching PEG to dendrimer serves to "mask" it from the body's defense system, so delaying its degradation. The potential for this intriguing particle to aid in cancer treatment is substantial. Because of its elaborate branching structure, it readily accepts molecules attached to its outside. A molecule designed to bind to cancer cells, another that fluoresces upon locating genetic mutations, a third to aid in imaging tumor shape using x-rays, a fourth to carry drugs released on demand, and a fifth that would send a signal when cancerous cells are finally dead are all carried by these dendrimer "machines" created by researchers. These dendrimers have shown promise in vitro against cancer cells, and their developers are gearing up to test them in vivo on animals. [10]

Nanotubes

Carbon atoms are arranged into hollow cylinders. They can also be used to create test tubes or prospective drug delivery devices by being filled and sealed e.g., cisplatin nanotubes [11].

Cisplatin nanotubes

It is possible to tailor carbon nanotubes for efficient intravascular transport. To make these adjustments, either covalent or non-covalent bonding might be used. The time it takes for blood to circulate through the body might be lengthened or shortened depending on the adjustments made. Modifying carbon nanotubes so that they are soluble in aqueous, body-type fluids eliminates their toxicity. It's easy for them to get inside the cells. Tumor cells that harbor cancer are abnormally big and leaky. Cancer cells may be able to absorb and store large chemicals despite their poor circulation. This effect of carbon nanotubes loaded with active substances has been shown in animal investigations. Prodrugs like cisplatin's inactive phosphate group have also been delivered via carbon tubes [12].

Nanowires

One strand of human hair is illuminated by a nanowire made of luminescent silica. It seems fragile. It's around 5% the size of a virus. Nanowires have a variety of uses, including cancer detection in the breast and ovaries [13].

Cantilever

The fly's eye is the honey comb mesh behind this tiny carbon cantilever. Cantilever beams are those that are supported at only one end. They are excellent sensors in the nanoscale environment, able to detect the presence of teeny, tiny molecules in bodily fluids.

Nano shells

Anoshells are gold-coated spheres of hollow silica. Antibodies can be attached to their surfaces by scientists, making them effective against specific targets like cancer cells. Polymers carrying drugs may one day be inserted into nano shells [14].

Quantum dots

Quantum dots, which are minuscule semiconductor particles, can act as markers for specific cellular or molecular processes. This is because, depending on the cadmium composition of their cores, they emit radiation at varying wavelengths. There's cadmium sulfide for the infrared to far-infrared spectrum, cadmium selinide for the visible part of the spectrum, and cadmium [15].

Nanopores

The use of nanopores in the study and therapy of cancer has been demonstrated. Particles with holes so small that individual DNA strands can flow through them unimpeded have been engineered, opening the door to rapid, accurate DNA sequencing. Drug producers can utilize nanopores to influence the pace of drug diffusion in the body by building nanopores into the surface of drug capsules that are only slightly larger than medicines molecular structure [16].

Nanoparticles- gold

This transmission electron micrograph clearly shows that the core of these nanoparticles is solid. North-western University scientists are employing gold particles in super sensitive detection techniques for DNA and protein markers linked to a wide variety of cancers, including breast and prostate cancers.

Bucky balls

The buckminsterfullerene molecule, often known as a bucky ball, was discovered in 1985 and is comprised of 60 carbon atoms arranged in the shape of a hollow ball. Bucky balls and other fullerenes are exceptionally stable and can tolerate high temperatures due to their chemistry and their peculiar hollow, cage-like form [17].

Fast dissolving tablets

Fast dissolving tablets are an innovative tablet design that facilitates oral dosing and has been shown to boost patient compliance (FDT). These tablets are made to be taken orally without the need for additional liquids. Such pills break up in your mouth or dissolve in your saliva very quickly, typically in under a minute. When placed on the tongue, this pill dissolves instantly, releasing the medication. Chemical stability holds up well. Useful when you're on the road and access to clean water is uncertain [18].

Chronotherapeutics

In order to achieve the best possible therapeutic outcomes with the least possible adverse effects, the timing of in-vivo drug availability to match the rhythms of disease is called chronotherapeutics. Rate-controlled release, delayed-release, and pulse-release formulations

are all examples of controlled-release subtypes. Traditional L-dopa/benzocaine treatment for Parkinson's disease has included the use of enteric coatings as a layer device [19].

Erythrocytes loaded with drug

One emerging and promising system for the delivery of medicines and enzymes is drug-loaded erythrocytes. Erythrocytes can be loaded with a wide range of biologically active chemicals, are biocompatible and biodegradable, and have a long half-life in circulation. Blood is drawn from the target organism, and the erythrocytes are separated from the plasma to create the carrier erythrocytes. Resealed erythrocytes are carriers that contain drugs that were previously entrapped in damaged cells utilizing a variety of physical and chemical techniques. Red blood cells filled with medication can be reinjected to act as slow-moving drug storage facilities that deliver their payload to the reticulo-endothelial system [20].

Miniaturized drug delivery system (for intra-corporeal use)

Current diagnostic and therapeutic practices are concerned with improving the standard of care provided to patients and have pain reduction as a primary goal. The goal of micro endoscopy research is to improve the functionality of an endoscope by incorporating tiny systems into its tip. The common name for endoscopic wireless devices is "endoscopic pills" [21].

Iontophoresis

Iontophoresis and phonophoresis are two cutting-edge topical delivery techniques. It is an electrochemical technique that uses an applied electrical current or voltage to create a potential gradient through the skin, thereby facilitating the movement of a solute molecule. Electrostatic repulsion at the active electrode causes ionic medicines to migrate deeper into the skin. The cathode provides negative ions, whereas the anode provides positive ones. Battery, microprocessor controller, drug reservoir, and electrodes are the standard components of iontophoresis systems [22].

Phonophoresis

The use of high-frequency sound waves, also known as ultrasonophoresis or ultraphonophoresis, to penetrate the skin and deliver medications is known as phonophoresis. To achieve therapeutic drug concentrations at specific areas on the skin, ultrasonic therapy is

often combined with topical drug therapy. Physiotherapists frequently employ its use. These days, people typically apply the medicine topically to their skin and wait for the drug to begin absorption. After that, an ultrasonic device is used. The device emits an ultrasonic wave, which is audible to animals but not humans [22].

Molecular imprinting technology (MIP)

The potential of molecular imprinting technology for developing effective dosage forms of drugs is immense. Pre-polymerization complexes are formed in molecular imprinting by combining a template molecule with functional monomers or functional oligomers (or polymers) with specific chemical structures designed to interact with the template. The polymerization reaction, which determines the final polymer's shape and macroporous structure, takes place in the presence of a cross-linking monomer and a suitable solvent after the pre-polymerization complex has been produced. In its place, a heteropolymer matrix containing recognition components tailored to the template molecule is left. Rate-programmed drug delivery, in which drug diffusion out of the system must follow a predetermined rate profile; activation-modulated drug delivery, in which the release is triggered by some physical, chemical, or biochemical processes; and feedback-regulated drug delivery, in which the rate of drug release is controlled by the concentration of a triggering agent, such as a biochemical substance, are all examples of MIP-based drug delivery systems. The incorporation of the molecular imprinting technique for the development of DDS is still in its early stages, despite the already developed fascinating uses of MIPs. Nonetheless, it is expected that significant development will be made in this field in the coming years, capitalizing on the advancements of this technology in other domains. The development of molecular imprinting in water and the use of predictive techniques for the design of imprinted systems are two evolutionary paths that could significantly improve imprinting's utility for drug administration [23].

Niosomes

These are an innovative drug delivery technique since they enclose the medicine inside of a vesicle. Niosomes get their name from the fact that they are bilayers of non-ionic surface-active substances and are bilayer structures that are structurally similar to liposomes. In contrast to liposomes, whose bilayer is composed of phospholipids, niosome’s bilayer is composed of non-ionic surface-active substances. Micellar structures are the result of putting

most surface-active chemicals in water, however some surfactants can produce niosomes, which are bilayer vesicles. A new method of administering drugs, niosomes enclose the substance within a vesicle. The name "niosomes" comes from the fact that the vesicle is made up of a bilayer of non-ionic surface-active molecules. Niosomes share structural similarities with liposomes, in that they are also bilayer vesicles. In contrast to liposomes, whose bilayer is composed of phospholipids, niosomes' bilayer is composed of non-ionic surface-active substances. Micellar structures are formed when most surfactants are introduced to water, however some surfactants can also produce bilayer vesicles called niosomes [24].

Emulgel

Opioid medication is frequently used to treat both localized and systemic ailments. The medicine is absorbed via the skin and transported to the site of action where it can have a therapeutic impact in a topical delivery system. The physiological properties of the carrier 2 have a direct impact on the drug's release rate from a topical preparation. Avoiding first-pass metabolism is the main advantage of a topical administration technique. Microemulsion is a particle-size-based classification. The tiny particles allow the medicine to diffuse through the skin and reach its target. The microemulsion can be held in the gel for an extended period of time, which helps with the slow release of the medicine. Many fungal infections are on the rise, posing a serious threat to modern society. Severe fungal infections of the skin include tinea capitis, tinea pedis, and tinea corporis. Emulgel is a technique that can help the medicine quickly take effect after being applied to the skin [25].

Microparticles

Microencapsulation is a frequently utilized technology for targeting drugs, as it can increase bioavailability and stability while also allowing for a more controlled and sustained release of the medication. Benefits of using microparticles in the treatment of breast cancer include less medication toxicity to healthy cells and tissues and increased therapeutic potency. Microparticles made of poly(lactic-co-glycolic acid) (PLGA) and containing prodigiosin, which was produced by bacteria, were manufactured using a single emulsion solvent evaporation process [26].

Cancer gene therapy involves the transfer of genetic material to malignant tumor cells. A direct or indirect effect is triggered by the introduction of genes into a patient's cancer cell. It's a way of fixing broken genes that help diseases progress. Gene therapy involves the

surgical insertion of healthy copies of genes in place of defective ones. Oncogene inactivation and tumor suppressor gene substitution are two methods for attacking mutated genes at their source.

Cubosomes

Cubosomes are an efficient biocompatible carrier for drug delivery; they are a nanostructured liquid crystalline dosage form made from amphiphilic lipids and polymer-based stabilizers. Bicontinuous lipid bilayers constructed in a honeycomb-like three-dimensional structure with two internal aqueous channels serve as the delivery form, allowing for the inclusion of numerous s biologically active substances. In contrast to liposomes, they have a huge surface area that can be used to carry a wide range of substances. As a novel drug delivery technology, cubosomes have been the technique of choice in sustained release, controlled release, and targeted release dosage forms due to their particular benefits of biocompatibility and thermodynamic stability [27].

Osmotic drug delivery

The net movement of water through a semi-permeable membrane caused by a difference in osmotic pressure is the classic definition of osmosis. The membrane's selectivity prevents any molecules or ions other than water from flowing through. Liquid from the environment penetrates an osmotic device, creating an osmotic pressure that controls the release of bioactive chemicals. In addition, the osmotic pressure at the center has a direct correlation to the amount of medication that is released. Factors such as medication solubility, osmotic pressure, delivery orifice size, and membrane characteristics all play a role in how quickly or slowly an ODDS releases its contents. Maintaining the osmotic agent's saturation in the compartment is crucial to achieving a constant osmotic pressure differential between the inner and outer compartments. Almost 75 years after the discovery of the osmosis principle, in 1955, Rose and Nelson developed the first medicine delivery device based on the concept of osmotic pressure. [28].

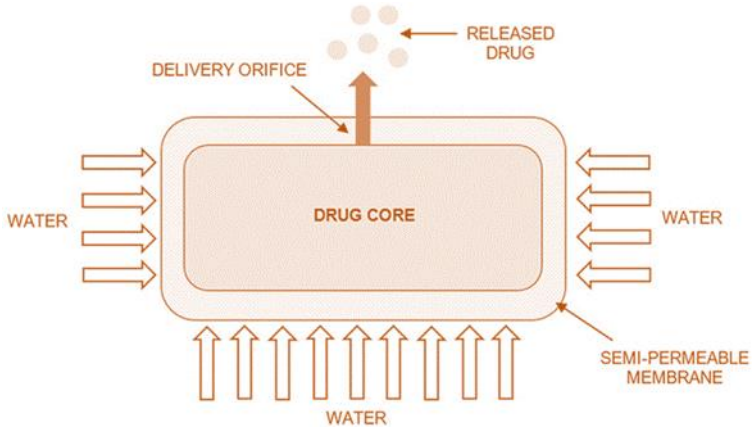

Fig 2. Depiction of drug liberation from osmotic pump consisting drug core, semi-permeable membrane, and delivery orifice

Solid lipid-based nanoparticles

Solid lipid-based nanoparticles were designed with the intention to accomplish a substitute drug delivery system to polymeric nanoparticles, liposomes and emulsions. In fact, there are two key types differing in the constitution of the solid particle matrix observed in solid lipid nanoparticles and nanostructured lipid carriers [29].

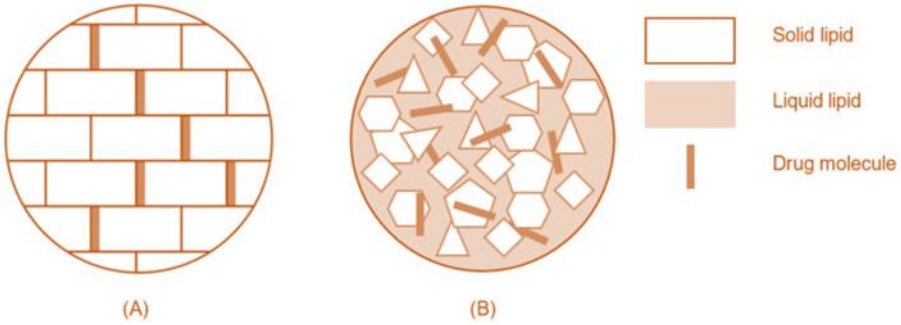

Fig 3. Depiction of (A) Solid lipid nanoparticles; (B) Nanostructured lipid carriers

Mucoadhesive drug delivery

Mucoadhesion is a term used in the pharmaceutical sciences to describe the phenomena of an adhesive attachment to mucus or a mucous membrane. Evidence from ocular, nasal, vaginal, and buccal drug delivery systems demonstrated the utility of mucoadhesive polymers, which dramatically increased the residence time of sustained release delivery systems on these mucosal membranes. Delivery systems capable of sticking to specific GI segments have long been of interest, and so has the development of oral mucoadhesive delivery systems [30].

Transdermal drug delivery

When applied to healthy skin, transdermal dosage forms release the medicine into the bloodstream at a controlled rate through the skin and into the body's circulatory system. The transdermal drug delivery system (TDDS) has solidified its place among the most recent generation of drug delivery methods. Because transdermal delivery is so simple and risk-free, it's worth considering [31].

Drugs absorbed through the skin have several benefits, including-

- Improved physiological and pharmacological response
- Predictable and prolonged activity
- Elimination of first-pass metabolism
- It is simple to stop therapy at any time
- Greater patient compliance by minimizing different dose intake
- Easy to self-administration

Advantages of NDDS [32]

- Increased adherence from the patient.
- Maintaining a Prescribed Drug Concentration at a Regulated Rate
- Dosing precision
- improved reliability and safety
- Optimization of pharmacological dosing for a given site or target
- Lower toxicity and fewer adverse effects
- Boosts patient's quality of life and ease of suffering.

CONCLUSION

In sum, drug delivery technologies have gone a long way and will continue to develop at a lightning pace. The inclusion of drug molecules into innovative drug delivery systems has numerous clinical and commercial benefits. It's clear that new channels for administering both established and emerging pharmaceuticals have been introduced. Patient preferences, drug characteristics, disease site accessibility, and drug efficacy all play a role in deciding which delivery method to employ. There is always potential for development, and any emerging drug delivery systems will necessitate extensive characterization and investigation prior to being licensed for use in people. It is highly promising research area to make the treatment most effective and safe.

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Nil.

CONFLICT OF INTEREST

None' conflict of interest was given by authors.

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